Implicit and Explicit Emotion Regulation: Modulation by Aggression Subtypes

Saz Ahmed

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Royal Holloway, University of London

Department of Psychology

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Declaration of Authorship

I, Saz Ahmed, hereby declare that this work was carried out in accordance with the Regulations of the University of London. I declare that this submission is my own work, and to the best of my knowledge does not represent the work of others, published or unpublished, except where duly acknowledged in the text. No part of this thesis has been submitted for a higher degree at another university or institution.

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Abstract

Emotion regulation consists of multiple processes that serve to modify emotional reactions. This thesis examines both implicit (automatic) and explicit (deliberate) processes and explores how their function and efficacy are modulated by individual differences in subtypes of aggressive behaviour. These questions are examined in both healthy adults and adolescents. Methods include cognitive testing, self-report, heart rate perception, skin conductance response and functional magnetic resonance imaging.

Using a paradigm where emotion is task-irrelevant, Chapter 2 explores how attention is implicitly captured by emotional faces and shows that core psychopathic traits are associated with reduced attention capture by fearful faces in a community sample. Chapter 3 investigates the conditions under which emotion can, and cannot, implicitly capture attention by varying cognitive load in a series of experiments.

From Chapter 4 onwards, explicit emotion regulation is investigated. In Chapter 4 the efficacy of three subtypes of psychological distancing, a form of cognitive reappraisal, is examined. It is shown that interoceptive awareness of bodily states influences the ability to use distancing to regulate emotion effectively. Chapter 5 focuses on the efficacy of one of these strategies, namely temporal distancing (e.g. ‘this too shall pass’), across the transition from adolescence to adulthood. Using a novel experimental task, temporal distancing was shown to be effective across the age range studied, but was reduced with increasing reactive aggression. Neural correlates of temporal distancing are discussed in Chapter 6, which employs an fMRI-adapted version of the task used in Chapter 5.

This thesis concludes that subtypes of aggression influence emotion regulation in different ways. It is therefore crucial to take aggression into account in order to understand individual differences in implicit and explicit emotion regulation.

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Contents

Abstract **3**

Publication of Findings **4**

Acknowledgments **5**

Contents **6**

List of Tables **11**

List of Figures **12**

CHAPTER 1: General Introduction **14**

1.1 What is emotion regulation? **14**

1.2 Models of emotion regulation **14**

1.2.1 Neural circuitry involved in emotion regulation **18**

1.3 Implicit emotion regulation **20**

1.4 Explicit emotion regulation **23**

1.5 A role for individual differences in emotion regulation **31**

1.5.1 Aggression **32**

1.5.2 Interoceptive awareness **45**

1.5.3 Adolescence **48**

1.6 Methods used in the thesis **52**

1.6.1 Interoceptive awareness **52**

1.6.2 Skin conductance **54**

1.6.3 fMRI **56**

1.7 Summary and the current thesis **60**

CHAPTER 2: Emotional capture by fearful expressions varies with psychopathic traits **62**

2.1 Introduction **62**

2.2 Method **66**

2.2.1 Participants **66**

2.2.2 Stimuli and procedure **66**

2.2.3 Questionnaires **67**

2.2.4 Data analysis **69**
2.3 Results **69**
2.3.1 Main task **70**
2.3.2 Relationships with psychopathic traits **71**
2.3.3 Anxiety **73**
2.4 Discussion **74**

CHAPTER 3: Modulation of emotional capture by varying cognitive load **79**
3.1 General Introduction **79**
3.2 Experiment 1 **85**
3.2.1 Introduction **85**
3.2.2 Method **85**
3.2.3 Results **88**
3.2.4 Discussion **90**
3.3 Experiment 2 **93**
3.3.1 Introduction **93**
3.3.2 Method **94**
3.3.3 Results **94**
3.3.4 Discussion **96**
3.4 Experiment 3 **97**
3.4.1 Introduction **97**
3.4.2 Method **98**
3.4.3 Results **98**
3.4.4 Discussion **100**
3.5 Experiment 4 **100**
3.5.1 Introduction **100**
3.5.2 Method **101**
3.5.3 Results **101**
3.5.4 Discussion **103**
3.6 General Discussion **104**

CHAPTER 4: Distancing as a reappraisal strategy for emotion regulation: efficacy, ease of use, and modulation by interoception and affective variables **107**

4.1 Introduction **107**

4.2 Method **112**

4.2.1 Participants **112**

4.2.2 Behavioural task and stimuli **112**

4.2.3 Interoceptive awareness and analysis **116**

4.2.4 Questionnaire measures **117**

4.3 Results **118**

4.3.1 Distancing efficacy **118**

4.3.2 Distancing: Ease of use **120**

4.3.3. Relationships between distancing and individual differences **121**

4.3.4 Interoceptive awareness **123**

4.3.5 Distancing and questionnaire measures **125**

4.4 Discussion **125**

CHAPTER 5: Using temporal distancing to regulate emotion in adolescence: modulation by reactive aggression. **131**

5.1 Introduction **131**

5.2 Method **134**

5.2.1 Participants **134**

5.2.2 Behavioural task and stimuli **135**

5.2.3 Skin conductance and analysis **139**

5.2.4 Developmental analysis **139**

5.2.5 Questionnaire measures **140**

5.3 Results **141**

5.3.1 Hypothesis 1: Distancing efficacy **141**

5.3.2 Hypothesis 2: Developmental effects **145**

5.3.3 Hypothesis 3: Distancing success and reactive aggression **147**

5.4 Discussion **150**

5.4.1 Hypothesis 1: Distancing efficacy **150**

5.4.2 Hypothesis 2: Developmental effects **152**
5.4.3 Hypothesis 3: Distancing success and reactive aggression **153**

CHAPTER 6: Neural mechanisms of temporal distancing 155
6.1 Introduction 155
6.1.1 Regulation and reactivity **155**
6.1.2 Future thinking **156**
6.1.3 Current study **159**
6.2 Method 161
6.2.1 Participants **161**
6.2.2 Experimental task and stimuli **161**
6.2.3 Questionnaire measures **164**
6.2.4 fMRI data acquisition **164**
6.2.5 Data analysis **164**
6.3 Results 167
6.3.1 Behavioural data **167**
6.3.2 fMRI data **168**
6.4 Discussion 175
6.4.1 Emotional responsivity **175**
6.4.2 Regulation **176**
6.4.3 Future thinking **178**
6.4.4 Individual differences **180**
6.4.5. Strengths, limitations and future directions **181**

CHAPTER 7: General Discussion 182
7.1. Overview 183
7.2 Chapter Summaries: main research questions and findings 184
7.2.1 Implicit emotion regulation **184**
7.2.2 Explicit emotion regulation **186**
7.3 Main implications of the thesis 189
7.3.1 What is the role of aggression in emotion regulation? **189**

7.3.2 Implications for the Process Model **192**

7.4 Limitations and future directions **196**

7.5 Conclusions **199**

References **201**

Appendices **232**

Appendix 1: Self-report questionnaires used in the thesis **232**

Appendix 2: Scenario stimuli used in Chapter 6 **239**

Appendix 3: Instructions given to participants in Chapter 6 **241**

Appendix 4: List of brain regions activated (*p*<.05 FWE corrected) for exploratory contrasts in Chapter 6. **244**

List of Tables

4.1	A selection of participants' written answers during the manipulation checks.	**122**
4.2	Strategy use reported during manipulation check trials.	**120**
4.3	Bivariate correlations between the individual differences measures.	**123**
6.1	Peak cluster activations in brain regions from each contrast reaching significance at *p*<.05 (FWE-corrected).	**169**
6.2	Peak cluster activations in the regions of interest for the Distant Future > Read Negative contrast reaching significance at *p*<.05 (FWE-corrected).	**171**

List of Figures

1.1	a) The Process Model (Gross & Thompson, 2007); b) The Extended Process Model of emotion regulation (Sheppes et al. 2015).	**17**
1.2	The processing steps (top) and neural systems (bottom) associated with the generation of emotion (pink boxes) and the cognitive control processes involved in regulating emotion (blue boxes).	**18**
2.1	Example displays for all-neutral, fearful distractor, and fearful target conditions (not to scale).	**67**
2.2	Mean reaction times (milliseconds) to correctly locate and indicate the tilt of the target face.	**71**
2.3	Graph showing that the relationship between mean reaction times during correct trials in the fearful distractor condition and affective-interpersonal traits is moderated by levels of lifestyle-antisocial traits.	**74**
3.1	Example of the experimental task stimuli.	**87**
3.2	Mean reaction times (RTs) in milliseconds (ms) for correct trials when all conditions are blocked.	**90**
3.3	Mean RTs (ms) for correct trials across all conditions when all trials were randomised.	**95**
3.4	Mean RTs (ms) for correct trials across all conditions when Compatibility was randomised and Emotion was blocked.	**99**
3.5	Mean RTs (ms) for correct trials across all conditions when Compatibility was blocked and Emotion was randomised.	**102**
4.1	Visual depiction of a Spatial Distancing trial.	**115**
4.2	Average a) distress and b) arousal ratings across all conditions.	**119**
4.3	Positive correlation between interoceptive awareness score and temporal distancing efficacy.	**124**

5.1	Visual depiction of a Distant Future trial.	**138**
5.2	Mean ratings for a) distress and b) arousal for all conditions.	**143**
5.3	Scatterplots depicting the relationship between distance in time adopted during the Distant Future condition and distancing success relative to free viewing.	**144**
5.4	Mean peak skin conductance amplitude for each condition.	**145**
5.5	Scatterplot showing that reactive aggression peaked during mid adolescence in the present sample.	**147**
5.6	a) Relationship between reactive aggression and distancing success; b) relationships between distress ratings for Distant Future and Read Negative conditions and reactive aggression.	**149**
6.1	Visual depiction of a Distant Future trial.	**163**
6.2	Mean distress ratings.	**167**
6.3	Top: Read Negative > Distant Future for a) left amygdala and b) right subgenual anterior cingulate cortex (sgACC). Bottom: Contrast estimates are shown relative to implicit baseline for the a) left amygdala ROI and b) sgACC ROI.	**172**
6.4	Left image: Right vlPFC cluster (Distant Future > Read Negative). Right: negative correlation between average distance in time adopted rating and right vlPFC activation (Distant Future > Read Negative).	**174**

Chapter 1: General Introduction

1.1 What is emotion regulation?

Emotions exert a powerful influence over our lives and serve a wide range of functions, from alerting us to a threat to helping us build relationships. They also serve an adaptive role by motivating us to take action to maximise our chances for functioning successfully in society. However emotions can become dysfunctional when they are exaggerated in intensity, last for long periods of time, occur unpredictably, or are evoked out of context. In these cases, emotions must be regulated to control our behaviour effectively. Emotion regulation is not a single process, but has been defined broadly as the monitoring, evaluation and modifying of emotional reactions in order to accomplish goals (Thompson, 1994). This can include both implicit emotion regulation, i.e. processes which occur automatically and largely outside conscious awareness and occur at very early stages of the emotion regulation process, and explicit emotion regulation, which involves using conscious strategies to down-regulate emotional responses. The current thesis will first focus on implicit emotion regulation processes followed by explicit emotion regulation, exploring how their function and efficacy are modulated by several factors including specific task demands, aggression, the ability to perceive internal bodily states, and age across the transition from adolescence to adulthood. This chapter will introduce these key topics covered in the thesis, and will provide an overview of emotion regulation processes and their neurocognitive underpinnings.

1.2 Models of emotion regulation

There are many strategies for regulating emotional responses, and the most prominent approach to organising these has been to focus on the time point at which regulatory processes are brought to bear on emotion-evoking situations. The Process Model of emotion regulation (*Figure 1.1a*) theorises that emotion generation and appropriate regulatory processes unfold in a particular sequence over time (Gross, 1998; Gross, 2014). The first two processes – Situation Selection and Situation Modification – both help shape the situation to which an individual will be exposed. Situation Selection involves choosing to avoid an emotionally relevant situation in order to prevent the generation of an emotional response. This process is commonly seen in psychopathology, e.g. where an individual with social anxiety disorder avoids social situations to regulate their emotions (Wells & Papageorgiou, 1998). If avoiding the situation is not possible, Situation Modification is employed, which involves efforts to modify the external features of the situation so as to change its emotional impact, such as shortening exposure time. Attention Deployment is then used to focus attention away from aspects of the situation that provoke undesired emotions. If this is not sufficient to regulate emotional responses, the emotional situation is then explicitly appraised and evaluated, either by engaging in Cognitive Change such as reappraisal (i.e. reinterpreting the meaning of the situation to reduce its negative impact, see section 1.4 for more detail) or Response Modulation, which refers to direct attempts to influence physiological, experiential or behavioural emotional responses once they have already been elicited. For example, exercise and relaxation techniques may be used to decrease physiological and experiential effects of negative emotions (Oaten & Cheng, 2006). One of the most researched forms of response modulation is expressive suppression, which entails inhibiting emotional expressions (Gross, 2002). The Process Model also contains a feedback loop, recognising that emotional responses can modify the situation that gave rise to the response in the first place, (e.g. a socially anxious individual may leave the social situation after experiencing intense anxiety during the situation), suggesting that the emotion generation process can occur recursively, is ongoing, and dynamic (Gross & Thompson, 2007). The processes identified in this model can be thought of as existing on a continuum from implicit to explicit emotion regulation: as awareness of emotional reactivity increases, regulation becomes more explicit. However, it is difficult to pinpoint the threshold at which regulation becomes explicit, as this likely varies between individuals and contexts.

It has been noted, however, that while the Process Model focuses mainly on implementation success (or failure) of particular emotion regulation strategies, adaptive emotion regulation actually involves a broader repertoire of skills, including flexible strategy selection (e.g. Bonanno & Burton, 2013). This has led to the recent development of an Extended Process Model (Gross, 2014; Sheppes, Suri, & Gross, 2015, see *Figure 1.1b*). This posits that emotion regulation occurs in three stages: (1) Identification, in which an emotional state is identified and the decision over whether or not to regulate this is made; (2) Selection, in which an appropriate regulatory strategy is selected and (3) Implementation, in which the strategy is implemented (corresponding to the original Process Model). Each stage involves perception of the state of the world, valuation as to whether this is positive or negative, and then action based on the valuation stage. For example, at the Identification stage, an individual might perceive that they are experiencing a negative emotion, evaluate that this exceeds a given threshold of negative affect and that regulation is required, and therefore decide to take action to select an appropriate strategy. This then feeds into the Selection stage, where the full range of regulatory strategies is perceived and evaluated, and appropriate action is taken. Such a procedure involves several cognitive control processes, which are underpinned by a broad network of brain regions, discussed in the following section.

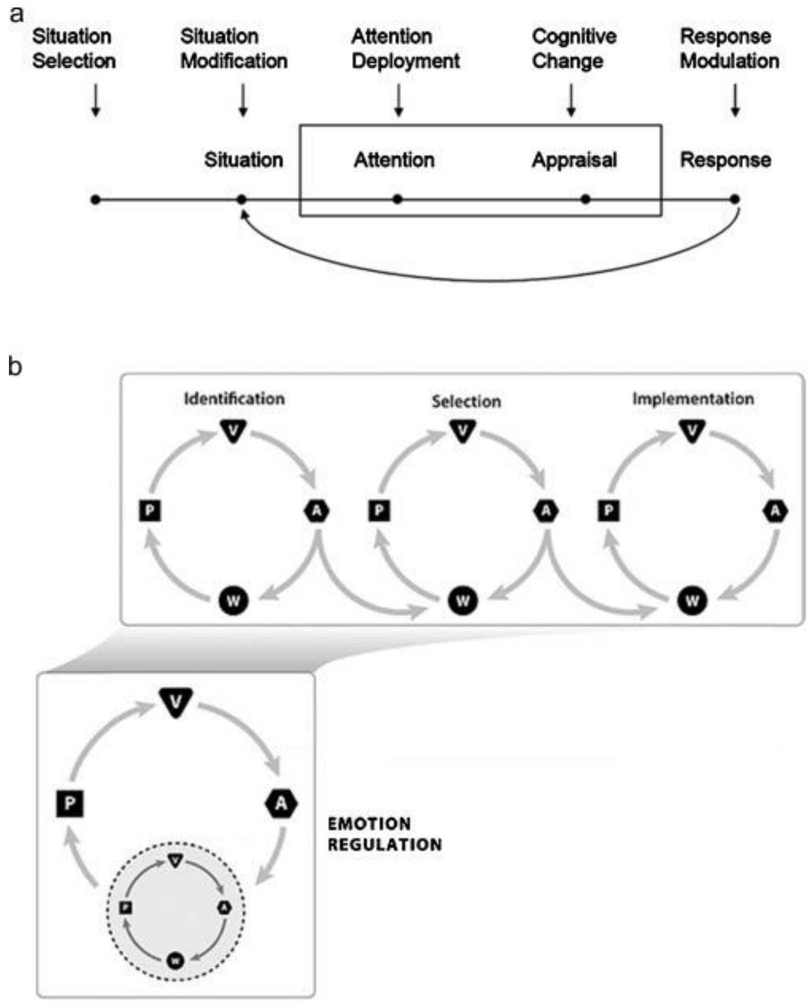


Figure 1.1. (a) The Process Model (Gross & Thompson, 2007) suggests five different aspects of emotion regulation (situation selection, situation modification, attention deployment, cognitive change and response modulation) that correspond to the regulation of a particular point in the emotion generation process. Reprinted with permission from Guilford Press and J. Gross. (b) The Extended Process Model of emotion regulation (Sheppes et al., 2015). The World (W) gives rise to Perception (P). When valued as either negative or positive, these Valuations (V; known as emotions) give rise to Actions (A) that can change the state of the World. The model classifies three stages of emotion regulation: identification (which involves deciding whether to regulate emotions or not), selection (which involves deciding which strategy to use), and implementation (which involves implementing the chosen strategy). This may change the first-level Valuation system. Reprinted with permission from Annual Reviews and G. Sheppes.

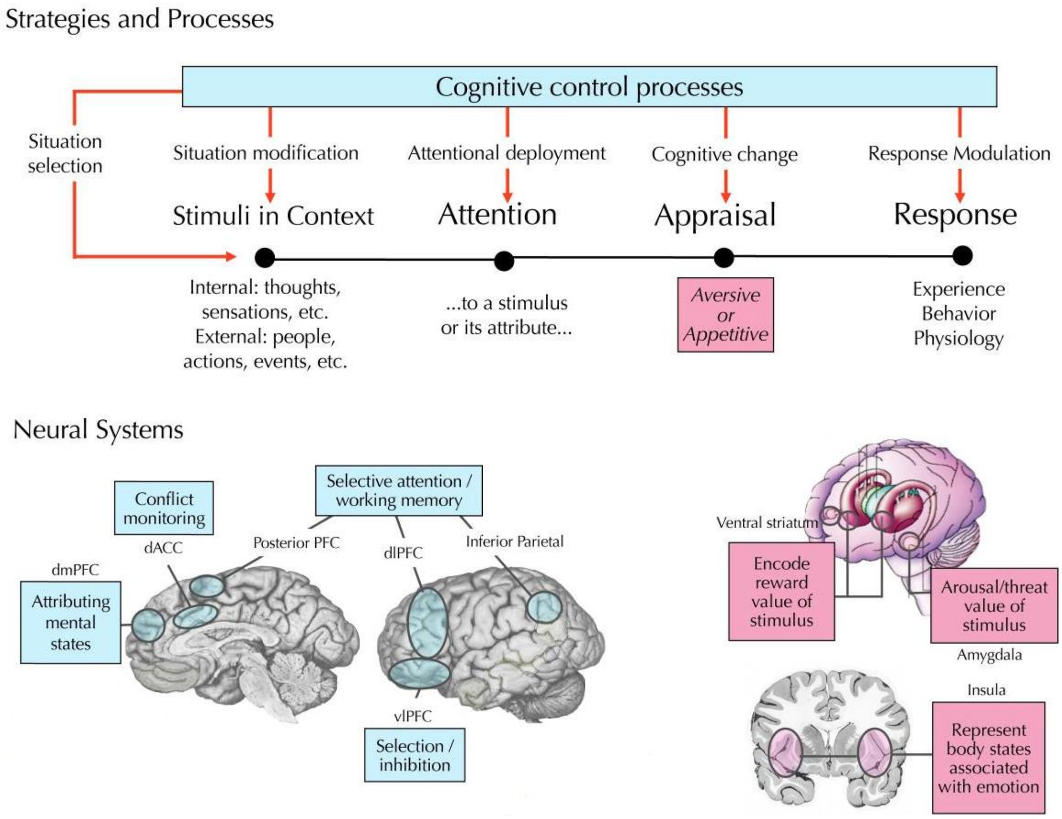


Figure 1.2. The processing steps (top) and neural systems (bottom) associated with the generation of emotion (pink boxes) and the cognitive control processes involved in regulating emotion (blue boxes). Diagram from Ochsner, Silvers, & Buhle (2012). Reprinted with permission from K. Ochsner and Wiley Publishing.

1.2.1 Neural circuitry involved in emotion regulation

Numerous studies in both healthy human participants and animals have helped delineate the neural circuitry involved in emotion processing and regulation. Firstly, as shown in *Figure 1.2*, a stimulus is perceived in its situational context. The stimulus could be internal, such as a thought or feeling, or an external cue involving other people or events. If the stimulus is particularly salient, whether attended to or not, it gives rise to emotional reactivity. This reactivity has been found to be generated in subcortical regions (see pink boxes in *Figure 1.2*) such as the amygdala, which has been linked to determining saliency of emotional stimuli (Adolphs et al., 2005) and both the learning and expressing of the fear response (LeDoux, 2000). The ventral striatum has also been implicated in the generation of emotion. For example, this region has been associated with emotional and motivational aspects of behaviour and learning which cues (e.g. social cues such as a smiling face), predict reinforcing or rewarding outcomes (Schultz, 2006, 2007). The insula, particularly the anterior insula, has been associated with negative affective experience in general (Craig, 2009) and has also been implicated in the emotion generation process.

As illustrated by the blue boxes in *Figure 1.2*, the cognitive control processes that underpin the stages defined by the Process Model engage several brain regions. To begin with, regions involved in selective attention and working memory, such as the dorsolateral (dlPFC) and posterior prefrontal cortex as well as inferior parietal lobe regions, direct attention to reappraisal-relevant features of the emotional stimulus and keep in mind reappraisal (or other regulatory strategy) goals (Miller, 2000; Wager, Jonides, & Reading, 2004). Following this, regions associated with performance monitoring, such as the dorsal anterior cingulate cortex (dACC), may help to detect the extent to which emotional responses are being changed in response to the regulatory strategy, and trigger adjustments to enhance performance (Botvinick, Cohen, & Carter, 2004). Then, the ventrolateral prefrontal cortex (vlPFC), which is thought to play a key role in selecting goal-appropriate (and inhibiting goal-inappropriate) information, may be engaged to help in selecting a new appropriate regulatory strategy in favor of one's initial appraisal of the emotional stimulus (Badre & Wagner, 2007; Thompson-Schill, Bedny, & Goldberg, 2005). Finally, the dorsomedial prefrontal cortex (dmPFC) may also be recruited. This region has been implicated in attributing mental states, and indeed the reinterpreting of one's own (or others) emotional states is required for certain emotion regulation strategies, such as reappraisal. During all this, responses in subcortical regions, particularly the amygdala, are modulated (Ochsner & Gross, 2008).

This neural circuitry is evident in both implicit and explicit emotion regulation; therefore, supporting neural evidence will be discussed in their respective sections below.

1.3 Implicit emotion regulation

The earliest form of emotion processing and reactivity is implicit, with implicit emotion regulation generally defined as "any process that operates without the need for conscious supervision or explicit intentions, and aims at modifying the quality, intensity, or duration of an emotional response" (Koole & Rothermund, 2011, p.1). While this definition does encompass the automatic and habitual use of strategies generally considered explicit, as discussed above, this section will focus on regulatory processes that occur at the very earliest stages of emotion perception and processing, and which occur even when individuals are unaware of feeling a subjective emotional response.

Emotional stimuli capture our attention (see Carretié, 2014 for a review), particularly via the activation of limbic regions such as the amygdala, which initiates an orienting response to salient stimuli (Gamer & Büchel, 2009). This can be adaptive as such stimuli are particularly likely to require swift action (e.g. to avoid a dangerous situation). However, emotional stimuli in the environment are also often irrelevant and can interfere with our current goals and responses, thus our responses to them need to be appropriately regulated.

One of the most commonly used methods of demonstrating emotional attentional bias is to show that performance can suffer as a result of attending to emotional stimuli on tasks where the processing of such information would be disruptive. The dot probe task is a frequently used paradigm to investigate selective attention to threat (MacLeod, Mathews, & Tata, 1986). In the task participants are shown an emotional stimulus and a neutral stimulus that appear side by side for 500 milliseconds (ms), after which a dot probe appears either at the location of the emotional stimulus (congruent condition) or the neutral stimulus (incongruent condition). The allocation of attention is measured by the time needed to respond to the dot probe. If participants automatically allocate attention to emotional stimuli, it is reasoned that they will be quicker to respond to the dot probe on congruent than incongruent trials. Although the paradigm is primarily used to understand attentional bias in emotional disorders, (e.g. anxious individuals were found to respond faster to congruent trials than to incongruent trials, Mogg & Bradley, 1998) there is evidence to suggest that this bias is also present in typical individuals. For example, Lipp and Derakshan (2005) found that probes that replaced fear-relevant stimuli (pictures of snakes and spiders) were identified faster than probes that replaced the non-fear-relevant stimuli (pictures of mushrooms and flowers), indicating an attentional bias. Thus, several lines of evidence show that emotional stimuli can capture our attention implicitly, outside of awareness.

A derivation of the original go/no-go paradigm, the emotional go/no-go task is also used to study the effects of emotion of cognitive performance. Participants are asked to either respond (Go trials) or withhold response (No Go trials) to different affective stimuli. Because Go trials are more common, the task is able to measure one's ability to inhibit a prepotent response under different emotional conditions. In a sample of 85 university students, Schulz et al. (2007) found significantly faster responses to happy than sad faces on Go trials, consistent with research demonstrating that healthy adults recognise facial expressions of positive emotions (e.g. happy) faster than expressions of neutral or negative emotions (e.g. sad, angry, and disgusted) (Grimshaw, Bulman-Fleming, & Ngo, 2004; Leppänen & Hietanen, 2004). However, it is not possible to tease apart whether faster reaction times were due to faster recognition, or a facilitation for happy caused by approach biases compared to avoidance biases for sad (Adams & Kleck, 2003). With a similar pattern of results, Hare, Tottenham, Davidson, Glover and Casey (2005) found that participants were slower to respond when Go targets were fearful faces, relative to neutral and happy Go trials. Additionally, this delay in response time was positively correlated with amygdala activity. Therefore the findings showed that negative expressions were able to disproportionately distract participants (or elicit an avoidance bias); and moreover that amygdala response was functionally relevant in this delay.

Emotion regulation appears to be an ongoing and iterative process that involves the interplay of several specific networks of brain regions – from the detection of biases to identifying the way in which biases may be regulated.

Perhaps the most well-used task to study cognitive conflict is the Stroop task (Stroop, 1935) in which participants are required to name the colour of ink in which an item is printed, while attempting to ignore the item itself. Research has continuously found that it takes participants longer to name the colours when the base items are antagonistic colour names than when they are rows of meaningless stimuli. Moreover, several studies have shown that clinical patients are particularly slow to name the colour of a word associated with concerns regarding their clinical condition, relative to neutral control words, e.g. ‘dirty’ in obsessive compulsive disorder (Williams, Mathews, & MacLeod, 1996). To investigate heightened cognitive conflict caused by emotional stimuli, Etkin, Egner, Peraza, Kandel and Hirsch (2006) developed an emotional face version of the Stroop task. Participants were shown photographs of happy or fearful facial expressions with either the word “happy” or “fearful” superimposed. Participants were asked to identify the emotional expression of the faces while ignoring the printed words, which were either of the same emotion (congruent) or of a different emotion (incongruent) as the facial expression. Incongruent stimuli were therefore associated with response conflict arising from an emotional mismatch between task-relevant and task-irrelevant stimulus dimensions (e.g., a fearful expression with the word “happy”). Consistent with this, reaction times to incongruent trials were longer than to congruent trials. However, the slowdown in reaction times was reduced when the previous image was also incongruent, demonstrating that an emotion regulatory process was already engaged to enable participants to react faster to the conflicting emotional information on subsequent incongruent trials. Functional magnetic resonance imaging (fMRI) data additionally revealed brain regions which reflected the degree of emotional conflict. High-conflict trials were defined as those in which an incongruent trial was preceded by a congruent trial, meaning regulatory resources were required to be brought online specifically at the onset of that trial. On these trials (relative to low-conflict (congruent) trials), activity in the amygdala, dmPFC, and bilateral dlPFC was also predictive of rostral ACC (rACC) activity on the subsequent trial. In contrast, high control trials were defined as those in which an incongruent trial is preceded by another incongruent trial. On these trials, activation of the rACC was associated with a reduction in amygdala activity and enhanced task performance. Etkin et al. (2006) concluded that the rACC is involved in resolving response conflict through top-down inhibition of amygdala activity.

A potential criticism of the above study is that a non-emotional control condition was not included to control for a general semantic mismatch, thus it was unable to demonstrate that the effect was emotion specific. This was addressed in a follow-up study, where Egner, Etkin, Gale, and Hirsch (2008) had participants perform the same emotional Stroop task as well as a non-emotional variation of the task, where participants were asked to judge the gender of emotional faces while ignoring the word "male" or "female" written over them. The authors found that while dACC was activated during high conflict trials in both tasks, the rACC was activated only during conflict resolution (high control) trials in the emotional version. Connectivity analyses showed that rACC activity was associated with decreased amygdala activity only in the emotional Stroop task. Although this study did not support Etkin et al.'s (2006) findings that the amygdala detects conflicts arising from emotional stimuli, both studies did suggest that the rACC is involved in cognitive control in the presence of conflicting emotional information, through inhibition of amygdala activity. In sum, it appears that the brain both implicitly processes emotion by directing attention to the emotion; in concordance with the Attention Deployment stage of the Process Model, and down-regulates neural responses to it, even when we are not consciously aware of doing so. Chapter 3 examines the interplay between top-down cognitive control and bottom-up processing of task-irrelevant emotion in more detail.

1.4 Explicit emotion regulation

Unlike implicit emotion regulation, explicit emotion regulation strategies require conscious effort during initiation, and some level of monitoring during implementation (Gyurak, Gross, & Etkin, 2011). According to the Process Model (Gross, 1998), instigating regulation relatively early on in the emotion-generative process is thought to be more effective in modifying the course of the response than applying regulatory strategies later on. The early explicit process which has received the most empirical attention is cognitive reappraisal (see *Figure 1.1a*), i.e. reinterpreting an emotional situation in a more positive (or indeed negative) light (Gross, 2002). In contrast, expressive suppression is a response-focused explicit regulatory process that occurs once an emotional response has been generated, and which prevents emotional responses from being overtly expressed (Gross & Thompson, 2007).

Most studies investigating explicit emotion regulation experimentally have used very similar paradigms (e.g. Gross & Levenson, 1993; McRae et al., 2010; Ochsner, Bunge, Gross, & Gabrieli, 2002). Typically, participants are asked to process affective stimuli (usually pictures, videos or written scenarios) under two conditions; one in which they are instructed to react naturally when viewing the stimuli (reactivity), and another in which they are instructed to regulate their emotions using a previously specified strategy (regulation). Performance on the task is indexed by contrasting emotional responding (e.g. self-reported valence ratings) in the reactivity and regulation trials, with a greater difference in emotional responding indicating more effective emotion regulation.

During explicit emotion regulation tasks, researchers have instructed participants to effortfully regulate their emotions at various points in the emotion generative timeline as outlined in the Process Model (Gross, 1998). Most of these studies have focussed on reappraisal, which involves effortful and conscious attempts to change the interpretation of an emotional stimulus or situation (e.g. an image of a woman crying can be reappraised by thinking that she is crying tears of joy, and fits within the Appraisal/Cognitive Change stage of the Process Model; Etkin, Egner, & Kalisch, 2011). Reappraisal targets the early stages of the emotion generation sequence, whereas expressive suppression, which is an explicit strategy involving inhibiting emotional expressions (e.g., facial expressions, verbal utterances, gestures) usually takes place after emotional responses have been generated, in the final stages of the sequence. One of the first studies to investigate the efficacy of reappraisal was by Gross (1998). Participants were instructed to either “think about what you are seeing in such a way that you don't feel anything at all" (reappraisal), suppress any expression of emotion (expressive suppression), or passively watch (control) disgust-eliciting film clips. Reappraisal led to reductions in both subjective and behavioural (such as facial expressions and verbal utterances) signs of disgust, with no signs of increases in physiological responding. Suppression, by contrast, although effective at diminishing expressive behaviour, had no impact on subjective ratings of disgust and led to increases in multiple measures of sympathetic nervous system activation (finger pulse amplitude, finger temperature, and skin conductance responses). Therefore interjecting regulation relatively early on in the emotion-generative process seems to be most effective in altering the course of the emotional response. Using reappraisal to regulate emotions in everyday life has also been associated with healthier patterns of affect, social functioning, and well-being than using expressive suppression (Cutuli, 2014).

Several other explicit emotion regulation strategies have also been investigated. For example McRae et al. (2010) looked at the behavioural and neural effects of using distraction as an emotion regulation strategy. Participants were presented with photos taken from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2008) preceded by a 6-letter string (distraction condition), which they had to keep in mind during the picture presentation and were told that they would be probed for memory directly after the presentation of each picture. There was also a reappraisal condition in which participants were instructed to re-interpret the situation depicted in the picture in a way that made them feel less negative about it. Both types of emotion regulation were successful in reducing negative affect relative to the passive looking condition, however reappraisal led to a significantly greater reduction in negative affect than distraction. Additionally in a different study, reappraisal but not distraction was found to have long-lasting effects (7 days after experimental manipulations), with reappraisal participants experiencing fewer recurring thoughts compared to the distraction group (Kross & Ayduk, 2008). This may be because reappraisal (but not distraction) requires a change in how the affective meaning of the stimulus is represented, which is perhaps more adaptive in the long term than simply reducing stimulus processing through distraction. However, it is worth noting that reappraisal may not always be the most appropriate strategy. Recent evidence suggests that the success of reappraisal is specific to moderate emotional intensity, whereas distraction is better in high emotional-intensity situations (Shafir, Thiruchselvam, Suri, Gross, & Sheppes, 2016). Distraction can attenuate intense emotional responses early on in the regulatory process before it escalates (Shafir, Schwartz, Blechert, & Sheppes, 2015; Sheppes & Gross, 2011). In contrast, reappraisal is better suited to low-to-moderate emotional-intensity situations as it is effective at attenuating mild emotional reactions, while also altering how emotional situations are perceived (Denny, Inhoff, Zerubavel, Davachi, & Ochsner, 2015). Therefore the ability to effectively use reappraisal also involves deciding if, or when, it is appropriate to deploy it, which is in line with the Extended Process Model (Sheppes et al., 2015).

In the first study to investigate the neural bases of reappraisal, Ochsner and colleagues (2002) instructed participants to reappraise negative emotion-eliciting photos to modify their emotional response. It was found that, relative to simply attending to the negative photos, reappraisal successfully diminished subjective negative affect. Effective reappraisal was also associated with increased activation in lateral and medial PFC, and decreased activation in amygdala and medial orbitofrontal cortex (mOFC). Furthermore, the magnitude of vlPFC activation during reappraisal was inversely correlated with activation in the amygdala and mOFC. Taken together, these findings suggest that engagement of cognitive control-related areas dampens activity associated with emotional reactivity.

An influential study by Wager, Davidson, Hughes, Lindquist, & Ochsner (2008) investigated whether subcortical regions mediate the relationship between key PFC regions and reappraisal success. Using pathway-mapping analysis, the authors identified two separable pathways linking prefrontal activation with reductions in self-reported negative emotion during reappraisal. One path was through the nucleus accumbens, which predicted greater reappraisal success (i.e., less negative emotion), and the other was through the amygdala, which predicted reduced reappraisal success. These results demonstrated that the vlPFC is involved in both the generation and regulation of emotion through different subcortical pathways, suggesting a general role for this region in appraisal processes.

A related study by Kim and Hamann (2007) looked at whether the same neural circuitry used to reappraise pictures evoking negative emotions would be engaged in reappraising pictures evoking positive emotions. They also asked participants to either increase (up-regulate) or decrease (down-regulate) the intensity of their positive and negative emotional responses. Although there were small differences, the overall pattern of results revealed generally shared activations in prefrontal regions (dmPFC, left lateral PFC, left OFC, ACC) when participants engaged in both up- and down-regulation for both negative and positive pictures. These findings support the notion that reappraisal engages the same processes regardless of emotional valence or regulatory goal.

The studies discussed above all used instructed reappraisal in an experimental setting. However, one recent study looked at the link between reappraisal use in everyday life and neural responses to facial expressions during an incidental face-matching task (Drabant, McRae, Manuck, Hariri, & Gross, 2009). Participants who reported using reappraisal as an emotion regulation strategy in everyday life showed decreased amygdala activation and greater activity in prefrontal and parietal regions in response to viewing negative facial expressions. Thus, the findings suggest a link between explicit emotion regulation strategy use in everyday life, and basic emotional responses to affective stimuli in the lab, in the absence of explicit instructions to regulate these. More research is needed regarding the neural bases of habitual reappraisal, however several behavioural studies have established a link between reappraisal performance in the lab, the use of reappraisal in everyday life, and psychological wellbeing (e.g. Cutuli, 2014; Gross & John, 2003; Haga, Kraft, & Corby, 2009; McRae, Jacobs, Ray, John, & Gross, 2012). While causality is unclear, data nonetheless suggest the importance of habitual reappraisal use in good mental health.

While a wealth of research has examined the behavioural, physiological and neural effects of reappraisal, fewer studies have explored strategies *within* reappraisal. One strategy of particular interest is distancing, which involves mentally changing the interpretation of an emotional event by increasing or decreasing one's psychological distance from it (Ochsner et al., 2012). This can be accomplished in multiple ways. For instance, in line with Construal Level Theory (Trope & Liberman, 2003; 2010), psychological distance can be changed by varying the perceived temporal or physical closeness of an emotional situation, or instead by viewing it from the perspective of an impartial observer. A number of studies have shown that distancing is adaptive in reducing the intensity of negative affect and blood pressure responses. For example, Ayduk and Kross (2008) instructed participants to recall an experience when they were angry and then assigned them to either the self-immersed condition in which participants had to relive the situation, or the self-distanced condition in which they were told to "Take a few steps back…Watch the conflict unfold as if it were happening all over again to the distant you". Participants in the self-distanced group displayed significantly lower levels of blood pressure reactivity relative to baseline compared to the self-immersed group, both during the experiment *and* the recovery period after the experiment was over. The findings suggest that the beneficial effect of distancing is not limited to the brief amount of time during which participants are implementing the strategy; rather it has additional longer-term implications.

In a similar vein, Denny and Ochsner (2014) trained separate groups of participants in distancing and reinterpretation over a two-week period, using the standard reappraisal paradigm with negative photos as defined above. The distancing group were given an instruction similar to that given in the Ayduk and Kross (2008) study as well as "imagine that the pictured events happened far away or a long time ago". Results showed that both distancing and reinterpretation training resulted in reductions over a two-week period in self-reported negative affect. Additionally, participants who used distancing also showed a longitudinal decrease in negative affect on baseline trials on which no strategy was used. This suggested that the effects of distancing training may extend beyond trials on which participants were explicitly instructed to regulate, in effect, "spilling over" to baseline trials where negative affect was also reduced. Only the distancing group showed such a reduction on baseline trials over and above the reduction seen in the no-regulation control group, suggesting that effects were not attributable to habituation.

The neural basis of distancing has also been explored. Koenigsberg et al. (2010) found that taking a detached and distant observer perspective when viewing photos of negative social scenes reduced self-reported negative affect and amygdala activity, while engaging the dACC, medial prefrontal cortex (mPFC), lateral prefrontal cortex, precuneus, posterior cingulate cortex, intraparietal sulci, and middle/superior temporal gyrus. Importantly these brain networks have been implicated in cognitive control, social perception and perspective taking (Koenigsberg et al., 2010). Similarly, using the same instruction, Dörfel et al. (2014) found activity in regions implicated in cognitive control such as the right dlPFC, right superior frontal cortex and bilateral inferior parietal cortex during distancing. Taken together the findings from the distancing literature suggest that it is an effective emotion regulation strategy at a behavioural, physiological and neural level, and importantly the adaptive effects seem to last beyond the experiment.

Despite the clear effectiveness of distancing as an emotion regulation strategy, very few studies have moved beyond the umbrella term of distancing. Denny and Ochsner (2014) identified three distancing sub-strategies: thinking of oneself as an objective impartial observer (e.g. "I don't know any of the people involved"), using spatial distancing (e.g. "it is happening far away"), and using temporal distancing (e.g. "it happened a long time ago"). Furthermore, temporal distancing can also be operationalised as thinking about how an emotion-inducing event is likely to affect you in the future (Bruehlman-Senecal & Ayduk, 2015; e.g. “will this matter in 5 years time?”). However, previous studies have not directly compared the efficacy of these three types of distancing, or looked at whether specific strategies may be easier to implement than others. This is an important research gap, which will be addressed in Chapters 4-6 of the thesis.

The Process Model postulates that individuals have a host of emotion regulation strategies in their repertoires, however it could be argued that most empirical studies have oversimplified this model by assuming that individuals use only one strategy during the regulatory process. Aldao and Nolen-Hoeksema (2013) aimed to address this issue by examining the extent to which individuals engage in spontaneous regulation and whether this type of regulation embodies one strategy or multiple emotion regulation strategies. Online participants viewed disgust-eliciting film clips and were asked retrospectively the extent to which they used a series of emotion regulation strategies to manage their affect. The findings showed that 87% of the participants spontaneously engaged in some form of regulatory strategy, with acceptance (i.e. allowing or accepting current feelings) being the most popular strategy, followed by reappraisal, suppression and distraction. Of these participants, 65% reported using two or more regulation strategies over the course of the film clip, suggesting that most people tend to use more than one strategy. However the forced-choice strategy option utilised by this study is not fully representative of the dynamic process of emotion regulation. Chapter 4 of this thesis aims to explore this further by investigating the ease with which instructed strategies are implemented and which strategies, if unable to implement the instructed one, people use instead.

Explicit and implicit forms of emotion regulation are often framed as separate processes along a continuum of regulation. However evidence increasingly suggests that such a distinction may be too simplistic. Some researchers believe that the boundaries between explicit and implicit emotion regulation are porous, for example Gyurak et al. (2011) suggested that implicit emotion regulation might sometimes stem from the habitual use of specific explicit strategies. For example, explicitly reminding oneself that an angry colleague had a bad day may over time lead to the same reappraisal process occurring implicitly, without awareness. The habitual use of reappraisal to down-regulate emotions has been shown to be beneficial both behaviourally and in terms of physiological responding.

However, sometimes for certain individuals, reappraisal and indeed several other strategies can be ineffective at down-regulating emotions. Therefore investigating individual differences in emotion regulation is important to understand why regulatory processes can sometimes fail. The following section discusses the role of individual differences in emotion regulation, particularly the individual differences that will be examined throughout this thesis.

1.5 A role for individual differences in emotion regulation

Individual differences play a significant role in how emotion is regulated. There are several points in the emotion regulation process that vary in efficacy as a result of certain individual differences. For example, taking Sheppes et al.'s (2015) Extended Process Model, during the Identification stage perception of the emotion can either be over-represented or underrepresented. Overrepresentation is often seen in attentional disengagement biases in anxiety disorders, specifically the delayed disengagement from threat (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). This has been associated with limited ability to control attention and consequently overly representing threatening information. Overrepresentation is even apparent in more subtle individual differences. For example, young individuals at increased familial risk of depression, but with no personal history of depression, exhibited reduced responses in the left dlPFC when processing fearful faces, demonstrating abnormalities in the neural regulation of emotion (Mannie, Taylor, Harmer, Cowen, & Norbury, 2011). In contrast, underrepresentation of emotion can be seen in alexithymia, which is characterised by difficulty in identifying emotions, which can result in under-attending current emotional states (Sheppes et al., 2015). As well as the identification of emotions, individual differences can also impact the Selection stage of the regulatory process. For example, individuals with autism tend to be impaired in activating cognitive change-type emotion regulation strategies as they often involve adopting an alternative viewpoint and perspective taking, which are impaired in autism spectrum disorders (Gross, 2014). Finally, the Implementation stage is also affected by certain individual differences. For example, research has found that recalling happy memories to regulate sad mood is impaired in depressed individuals (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007). The same two studies also found that distraction via neutral thoughts was an equally effective strategy for depressed individuals and healthy controls. Therefore individual differences are extremely variable in the impact they have on the implementation of emotion regulation strategies.

I would argue that the role of individual differences needs to be taken into account more than is currently the case, given the varying ways they can influence regulatory processes. Consequently the current thesis focuses on three key modulating factors that are thought to influence emotion regulation, namely aggression, age (specifically adolescence) and awareness of bodily states (interoception). The following sections discuss each of these factors in relation to emotion regulation in detail, and highlight research gaps that will be addressed in the current thesis.

1.5.1 Aggression

The term *aggression* is typically defined as behaviour directed towards another individual where the immediate intention is to cause harm. The perpetrator must believe that they will cause harm and that the target is motivated to avoid the behaviour (Anderson & Bushman, 2002). Motives for aggression have traditionally been divided into two: reactive and proactive. Reactive aggression generally refers to aggression that occurs as an angry response to a perceived provocation or threat (e.g., Berkowitz, 1993), whereas proactive aggression is a relatively non-emotional display of aggression that is unprovoked and is used for instrumental gain or dominance over others (Dodge &

Coie, 1987). Reactive aggression is thought to be associated with high affective-physiological arousal and minimal cognitive processing (Chase, O'Leary, & Heyman, 2001). In contrast, proactive aggression entails forethought and planning, is associated with minimal autonomic arousal, and is often committed by those high in psychopathic traits (Blair, 2003). Earlier studies have shown that criminals identified as committing instrumental (proactive) offences scored higher on psychopathy measures compared to those with a history of reactive violence (Cornell et al., 1996; Dempster et al., 1996). Psychopathy will be discussed in more detail in section 1.5.1.2. Many people engage in both types of aggression, leading to the view of reactive and proactive aggression as (often correlating) dimensions rather than distinct categories (Poulin & Boivin, 2000). The following sections will summarise the literature on reactive aggression and the different facets of psychopathic traits, which consist of reactive and proactive forms of aggression, and their associations with emotional reactivity and regulation.

1.5.1.1 Reactive aggression

Studies investigating the effects of aggression on implicit emotion regulation have predominantly measured 'trait anger', which has been found to be a reliable predictor of reactive aggression (Bettencourt, Talley, Benjamin, & Valentine, 2006) and has strong conceptual overlaps with reactive aggression (Wilkowski & Robinson, 2010). Several studies have suggested that individuals high in trait anger have difficulty disengaging attention from hostile stimuli and thus are poor at implicitly regulating their emotions. For example, using a variant of the emotional Stroop task, individuals higher in trait anger are slower at colour-naming when the stimulus involves angry facial expressions (van Honk, Tuiten, de Haan, vann de Hout, & Stam, 2001). This attentional bias has also been found for words relating to aggression, demonstrating specificity for aggression-related stimuli. Smith and Waterman (2005) found that verbal aggression predicted colour-naming bias for indirect aggression words (e.g., gossip, bitch), and that anger predicted bias for direct aggression words (e.g., slap, punch). Self-reported use of physical aggression, a key component of reactive aggression, was the best predictor for both sets of words (Smith & Waterman, 2005). Criminal convictions for violent offending (Smith & Waterman, 2003) and previous self-reported aggressive experience (Smith & Waterman, 2004) have also significantly predicted attentional biases to stimuli that are either threatening or aggressively themed. This is further supported by studies using spatial cueing tasks, for example Wilkowski, Robinson and Meier (2006) found that individuals with greater tendencies toward anger were slower to disengage attention from hostile words (e.g., shoot, hit, stab, kill, kick). A problem with using aggressive words, however, is that participants can attribute either positive or negative valence to the words. For example, the word 'hit' can capture the attention of a sadist because they gain pleasure from the act rather than being threatened by it. Consequently it is difficult to identify the valence of this attentional capture. Nonetheless, the findings of these studies suggest that individuals high in reactive forms of aggression have difficulty disengaging attention from anger-related stimuli, suggesting a reduced ability to regulate anger-specific implicit emotional responses and biases.

Neurally, individuals characterised by excessive bursts of anger and reactive aggression demonstrated exaggerated amygdala reactivity and diminished OFC activation to faces expressing anger relative to non-aggressive control participants (Coccaro, McCloskey, Fitzgerald & Phan, 2007). Additionally Coccaro et al. (2007) found that while control participants showed an inverse relation between amygdala and OFC response to angry faces, this association was not apparent in reactively aggressive participants. These findings suggest that dysfunction in frontal-limbic networks are implicated in the poor emotion regulation abilities of those characterised by aggression. Human and animal studies indicate that the amygdala is part of the neural circuitry that modulates reactive aggressive behaviour (Blair, 2004). For example animal models reveal that electrical stimulation of the medial amygdala can potentiate reactive aggression (Siegel, Bhatt, Bhatt, & Zalcman, 2007). Other studies have also implicated relative amygdala hyper-activity in reactive aggression but not proactive forms of aggression (Sebastian et al., 2014; Viding et al., 2012; Blair, 2010). Proactive forms of aggression, such as those commonly exhibited in individuals high in psychopathic traits, will be discussed in detail in section 1.5.1.2.

Surprisingly, research exploring the effects of reactive aggression on explicit forms of emotion regulation is scarce. In older child and adolescent studies (aged 10 to 17) reactive aggression has been associated with low frustration tolerance and poorly regulated emotion and anger to perceived provocation (Marsee & Frick, 2007; Vitaro, Brendgen, & Tremblay, 2002). Using self-report questionnaires, Sullivan, Helms, Kliewer and Goodman (2010) found that 13-year olds' difficulty regulating anger was associated with increased physical aggression. Moreover in a longitudinal study, it was found that reactive aggression in childhood and early adolescence (aged 9 to 12) was uniquely associated with negative emotionality, specifically anxiety, in adulthood (Fite, Raine, Stouthamer-Loeber, Loeber, & Pardini, 2010). In contrast, proactive aggression was uniquely associated with measures of adult psychopathic features and antisocial behaviour in adulthood. Similarly other longitudinal studies have found that emotion dysregulation in childhood and adolescence is predictive of later aggressive behaviour (Roll, Koglin, & Petermann, 2012). These longitudinal studies provide useful evidence concerning the causal and potentially bidirectional relationships between aggression and emotion regulation.

In adult samples, questionnaire studies have found that less adaptive emotion regulation strategies, such as blaming others, rumination and catastrophising are positively associated with trait anger, anger arousal and anger-eliciting situations (Besharat, Nia, & Farahani, 2013; Martin & Dahlen, 2005). Rumination in particular has been found to increase the internal experience of anger (Bushman, 2002) and aggression (Borders, Earleywine, & Jajodia, 2010). Relatedly, in a recent study by Roberton, Daffern and Bucks (2014) maladaptive emotion regulation, which was operationalised as a lack of emotional awareness and difficulty refraining from impulsive reactions, significantly predicted lifetime history of violence in an offender sample. Some studies have also looked at the role of emotion regulation in more specific types of aggression. For example, Gratz and Roemer (2004) found that frequency of intimate partner abuse was positively correlated with difficulties inhibiting impulsive behaviours and engaging in goal-directed behaviours when distressed, as well as limited access to emotion regulation strategies in a sample of undergraduate students. Parallel effects were also found in a sample of violent offenders attending intervention programs; those who reported more difficulties with emotion regulation had more frequent perpetration of abusive behaviour towards their partner (Tager, Good, & Brammer, 2010). Overall these findings suggest that those characterised by reactive aggressive behaviours tend to have difficulty regulating their emotions using explicit strategies, or use maladaptive strategies, such as rumination.

Studies using experimental tasks have also found evidence for poor emotion regulation in those high in reactive aggression. For example, with an undergraduate sample, Cohn, Jakupcak, Seibert, Hildebrandt and Zeichner (2010) used the Response Choice Aggression Paradigm (Zeichner, Frey, Parrott, & Butryn, 1999), a competitive reaction time task where electric shocks are received from and administered to a fictitious opponent. They found that self-reported emotion dysregulation, particularly low emotional awareness and inability to tolerate emotional experiences, was associated with reactive aggression, as measured by the average intensity of shocks delivered.

There have also been studies experimentally manipulating aggression using anger provocation tasks. For example, Gerin, Davidson, Christenfeld, Goyal and Schwartz (2006) found that self-reported ruminative tendencies predicted delayed recovery from an anger induction (recalling an anger-provoking event), indicated by prolonged levels of cardiovascular (blood pressure and heart rate) arousal following the induction. These results suggest that tendencies to use maladaptive emotion regulation strategies can predict objective measures of prolonged tendencies toward anger and reactive aggression. A few studies have also investigated more specific adaptive and maladaptive emotion regulation strategies in relation to aggression. Mauss, Cook, Cheng and Gross (2007) used a lab-based anger-provocation task in which participants received critical and negative evaluation during a difficult counting task. They found that participants who reported using reappraisal more often in everyday life experienced significantly less anger and negative emotions, and demonstrated more adaptive cardiovascular responses in comparison to low reappraisers. Similarly, Memedovic, Grisham, Denson and Moulds (2010) conducted a lab-based provocation task in which participants were insulted by a fictitious participant and found that reappraisal use was associated with reduced self-reported anger and blood pressure, even when controlling for negative emotionality (i.e. depression, anxiety and stress), whereas suppression use was not. Therefore these studies demonstrate that those who use more adaptive emotion regulation strategies in day-to-day life, such as reappraisal, are more adept at down-regulating and controlling their anger, at subjective and objective levels.

The studies mentioned above, however, assessed reappraisal using questionnaire measures. In the first study to examine the differential effects of instructed reappraisal on anger, Szasz, Szentagotai and Hofmann (2011) instructed participants to recall a recent anger-provoking situation and directed them to use reappraisal, emotional suppression or acceptance in response to emotions elicited by the recollection. They found that participants instructed to use reappraisal were more effective at reducing subjective anger relative to participants in the suppression and acceptance conditions. Additionally, those in the reappraisal condition persisted longer with a computerised frustration-inducing task than those in the remaining two conditions, suggesting that they were better able at regulating their frustration. Likewise, using a similar anger-provoking method, Denson, Moulds and Grisham (2012) found that while instructed rumination maintained anger, reappraisal and distraction were both effective at significantly reducing self-reported anger. The authors concluded that reappraisal facilitates adaptive processing of anger-inducing recollections, whilst distraction facilitates rapid reductions in anger experience. Taken together these findings suggest that instructed reappraisal is effective at regulating anger. However, a limitation of these studies is that they average across individual differences, rather than explicitly taking them into account. For example, neither study measured participants' levels of reactive aggression to see whether this would have an influence on: a) how likely they are to be provoked, and b) how effective they are at implementing the strategy.

Germain and Kangas (2015) employed the same anger-provoking recollection task as Szasz et al. (2011) and Denson et al. (2012), but only examined participants scoring high on trait anger. Unexpectedly both reappraisal and suppression reduced self-reported anger and systolic blood pressure, while participants in the acceptance group did not experience such reductions. While the findings suggest that reappraisal and suppression are effective strategies for down-regulating the affective and physiological consequences of anger for individuals with elevated levels of trait anger in the short-term, a low trait anger comparison group was not included in the study. Consequently it is not possible to examine whether those high in trait anger are more or less effective at implementing these strategies relative to those low in trait anger.

So far the studies discussed in this section have demonstrated a correlation between reactive aggression and both implicit and explicit emotion regulation. There is also some evidence of causality in both directions, with bidirectional relationships being reported where high levels of reactive aggression cause poor emotion regulation abilities, and poor emotion regulation causes reactive aggressive behaviour (e.g. Besharat et al., 2013; Cohn et al., 2010; Gerin et al., 2006; Robertson et al., 2014; Roll et al., 2012). Given the lack of research on whether the efficacy of instructed reappraisal varies with levels of reactive aggression, Chapters 4 – 6 of the present thesis aim to address this by using experimental tasks to assess different forms of reappraisal and whether their efficacy varies with individual differences in aggression across the full continuum seen in the general population. As well as reactive aggression, there is a growing literature suggesting that proactive forms of aggression, such as psychopathic traits, also influence emotion regulation abilities. The following section summarises some of the research published on this subtype of aggression.

1.5.1.2 Psychopathic traits

Psychopathy is typically categorised into two separate facets involving affective-interpersonal and behavioural components (Frick, O'Brien, Wootton, & McBurnett, 1994; Hare, 2003; Harpur, Hare, & Hakstian, 1989). The affective-interpersonal dimension of psychopathy includes traits such as shallow affect, deceptiveness, lack of guilt and empathy, whereas the lifestyle-antisocial facet includes a predisposition towards antisocial behaviour, impulsivity, irresponsibility and criminal versatility (Hare, 2003; Hare & Neumann, 2008). There is evidence to suggest that the two dimensions of psychopathy are differentially related to emotional reactivity. The affective-interpersonal dimension has been found to be negatively correlated with negative emotional reactivity; individuals high on this dimension appear to experience negative emotions as less aversive than those scoring low on this dimension. On the other hand, the lifestyle-antisocial dimension has been found to be positively associated with negative emotional reactivity; similar to reactive aggression, those high in this dimension are particularly sensitive to negative emotions and experience them as more aversive than others with lower reactivity (Hicks & Patrick, 2006).

Neuroimaging work has contributed to our understanding of emotional deficits associated with psychopathy. Amygdala reactivity has been found to be reduced in individuals with psychopathy during a range of affective tasks, such as aversive conditioning tasks (Birbaumer et al., 2005; Veit et al., 2002) and during emotional memory tasks (Kiehl et al., 2001). Adults with psychopathy have also been found to show poor performance in recognition of and automatic responding to fearful and sad facial and vocal expressions and in tasks that require reversal learning (Blair et al., 2002; Blair et al., 2004; Blair, Colledge, & Mitchell, 2001; Blair, Monson, & Frederickson, 2001). Emotion recognition is thought to involve the amygdala and reversal learning is thought to involve the ventrolateral/ orbitofrontal cortex, suggesting that a network including amygdala and ventrolateral/ orbitofrontal cortex is compromised in psychopathy (Blair, Mitchell, & Blair, 2005). Moreover, studies have shown that psychopaths, compared to non-psychopaths, show increased lateral and superior prefrontal activity (Gordon, Baird, & End, 2004; Kiehl et al., 2001; Müller et al., 2003) and diminished limbic activity (Birbaumer et al., 2005; Gordon et al., 2004; Kiehl et al., 2001) to emotional stimuli, including unpleasant words or facial expressions, suggesting blunted reactivity and/or increased emotional control under certain conditions.

To explain these differences between psychopaths and non-psychopaths, two theoretical accounts have been posited. One account suggests that psychopathy can be explained in terms of a general information processing deficit (Hiatt & Newman, 2006; Newman & Lorenz, 2003), whereas the other postulates a specific emotional deficit (Blair & Mitchell, 2009; Blair et al., 2005; Frick & Viding, 2009; Kiehl, 2006; Lykken, 1995; Patrick, 1994). According to the Response Modulation Theory (Newman & Lorenz, 2003), individuals high in psychopathic traits have difficulty shifting attention from goal-relevant information in order to monitor and potentially use other important information. Specifically, they have a deficit in shifting attention to salient, bottom-up cues, especially when the cues are not relevant to the present task. While this model has been influential in the field, several experimental findings have failed to support its theory. For example, studies using Stroop paradigms have shown that individuals with psychopathy seem to be sensitive to task irrelevant information (Blair et al., 2006; Dvorak-Bertsch, Curtin, Rubinstein, & Newman, 2007; Hiatt, Schmitt, & Newman, 2004). Further, one of the main limitations of the Response Modulation theory is that it does not account for some of the specific affective processing deficits commonly seen in psychopathy, such as a difficulty processing some emotions (e.g. fear) but not others.

Indeed, in one of the first studies to investigate expression recognition in adult psychopathic individuals, Blair et al. (2004) found that relative to a comparison group, the psychopathic group showed greater impairment in their expression recognition scores for fearful expressions. However, there were no differences in the recognition of happy, surprised, disgusted, angry or sad expressions suggesting that psychopathic individuals are impaired in the processing of fear-related stimuli. The strongest evidence for this fear deficit comes from studies that assess emotion-modulated startle using the picture-viewing paradigm. While viewing unpleasant pictures, non-psychopathic individuals display startle potentiation to noise probes and, in contrast, startle inhibition while viewing pleasant pictures. However, the startle potentiation to unpleasant pictures appears to be absent or reduced in psychopathic participants (Levenston, Patrick, Bradley, & Lang, 2000; Patrick, Bradley, & Lang, 1993; Patrick, 1994; Veit et al., 2013). This effect is particularly evident in individuals high on the affective-interpersonal dimension of psychopathy (Patrick, 1994; Vaidyanathan, Hall, Patrick, & Bernat, 2011). Such findings are generally interpreted as evidence that psychopathic individuals have a fundamental fear deficit that undermines their reaction to threatening or unpleasant images in an experimental context (Lykken, 1995; Patrick, 1994) as well as their sensitivity to the affect of other individuals, yielding a callous and aggressive interpersonal style (Patrick, 2007).

As well as individual differences in psychopathic traits being associated with differences in the processing of emotional stimuli, there is also some evidence suggesting that those high in psychopathic traits tend to perform better at implicit emotion regulation tasks, often showing reduced automatic orienting of attention to task-irrelevant stimuli. In one of the few studies to date, Mitchell, Richell, Leonard and Blair (2006) presented adult participants with a very rapid stream of images among which was a target image that had to be responded to. The authors found that while presenting an emotional image either before or after the target image interfered with performance in non-psychopathic individuals, those with psychopathy were unaffected. In an event-related potential (ERP) study, Verona, Sprague, and Sadeh (2012) used a Go/No-Go task consisting of affective words and found reduced reactivity in psychopathic offenders to negative words, independent of whether a response was required (Go trials), or a response needed to be inhibited (NoGo trials), relative to criminals with antisocial personality disorder (ASPD) and to a criminal control group (i.e. without psychopathy or ASPD). In contrast, the ASPD group showed greater processing of negative emotional versus neutral words regardless of trial type. These findings suggest that psychopathic individuals are less sensitive to emotional contexts, enabling them to ignore emotional distractors when performing inhibitory control tasks. On the other hand, individuals characterised by antisocial and more reactive forms of aggression are unable to suppress negative emotional processing and are therefore poorer at implicitly regulating their emotional reactivity (e.g. van Honk et al., 2001; Verona et al., 2012; Wilkowski et al., 2006).

Research has shown that psychopathic traits occur on a continuum, are continuously distributed throughout the population (Paulhus, Neumann, & Hare, in press), and that emotional processing varies with levels of these traits (e.g. Seara-Cardoso, Neumann, Roiser, McCrory, & Viding, 2012). However, few studies have investigated whether bottom-up attentional emotional processing varies continuously with these traits in an adult community sample. One study found electroencephalography (EEG) evidence showing decreased emotional capture in those with high levels of psychopathic traits relative to those with low psychopathic traits, however no behavioural differences were found (Carolan, Jaspers-Fayer, Asmaro, Douglas, & Liotti, 2014; see section 2.1 for more detail). Thus it is unclear whether behavioural effects reported with individuals sampled from the extreme end of the continuum extend continuously throughout the population. Chapter 2 aims to address this by looking at whether the ability to implicitly regulate bottom-up attentional processing of emotion varies with psychopathic traits in a general non-pathological sample.

Very few studies have investigated individual differences in psychopathic traits in the general population in relation to explicit emotion regulation. In one neuroimaging study, Harenski, Kim and Hamann (2009) looked at regional brain activation, both during passive viewing of unpleasant pictures and during active down-regulation of emotional responses to unpleasant pictures. They found that individuals who scored high in the affective-interpersonal dimension of psychopathy showed reduced amygdala activation during passive viewing of unpleasant pictures relative to those low in psychopathy. During emotion regulation, there was a positive correlation between total and affective-interpersonal psychopathic traits and vlPFC activity, indicating that psychopathic traits are associated with increased prefrontal activity during emotion regulation. One interpretation is that individuals higher in psychopathic traits are more easily able to regulate emotional responses to unpleasant stimuli, relative to those lower in psychopathic traits, possibly because their initial emotional response is already reduced.

A critique of many of the studies in this section is that they rarely account for other individual differences that are often highly correlated with both reactive and proactive aggression, one of which is anxiety (Ali, Amorim, & Chamorro-Premuzic, 2009). Similar to aggression, anxiety is also characterised by heightened emotional reactivity and difficulty disengaging from threatening cues (Fox, 2002; Mennin, Heimberg, Turk, & Fresco, 2005), consequently it is important to take anxiety into account when investigating the relationship between aggression and emotion regulation.

1.5.1.3 A note on aggression and anxiety

Although this thesis is mainly concerned with how the different subtypes of aggression modulate emotional reactivity and regulation, evidence suggests that there are underlying similarities in the behavioural manifestations and the neural underpinnings of anxiety and (particularly reactive) aggression. Like reactive aggression and antisocial behaviour, anxiety is also characterised by high emotional reactivity (Richards, Benson, Donnelly, & Hadwin, 2014) and several previous studies have highlighted that failures in the ability to down-regulate negative emotions are the core substrate of anxiety disorders (Cloitre, Koenen, Cohen, & Han, 2002; Mennin et al., 2005). Thus, it is important to try to establish whether findings relating aggression and poor emotion regulation reflect unique mechanisms specific to aggression, or shared substrates between aggression and anxiety.

Research has considered that trait anxiety may moderate the relationship between aggression and threat-related amygdala reactivity. Using a face-processing task displaying angry and fearful faces, Carré, Fisher, Manuck and Hariri (2012) found that trait anger was positively correlated with bilateral dorsal amygdala reactivity to angry facial expressions, but only among men with high trait anxiety. These findings add to the growing body of evidence indicating that variability in aggression and anxiety in non-clinical samples contribute to individual differences in threat-related amygdala reactivity.

In terms of psychopathy, two variants characterised by anxiety have been posited. Compared to "primary" psychopaths, "secondary" psychopaths have been characterised as being more anxious, fearful, impulsive, and with more reactive anger and aggression (Skeem, Polaschek, Patrick, & Lilienfeld, 2011). Individuals with psychopathic traits who are high and low on measures of anxiety seem to show differences in their emotional and cognitive processing. For example, studies have shown that only low-anxious (primary) psychopaths show deficits in passive avoidance learning (Arnett, Smith, & Newman, 1997; Newman & Schmitt, 1998), modulation of responses to emotional and neutral stimuli (Hiatt, Lorenz, & Newman, 2002; Lorenz & Newman, 2002), and fear-potentiated startle response (Sutton, Vitale, & Newman, 2002). High-anxious (secondary) psychopaths do not show these etiological markers. Using a picture version of the dot-probe task, Kimonis, Frick, Cauffman, Goldweber and Skeem (2012) found that adolescent offenders who were characterised as primary low-anxious psychopaths were not attentionally engaged by stimuli depicting distress in others, whereas those characterised as high-anxious psychopaths were more attentive to stimuli depicting distressing emotional content.

Given that several aspects of aggression and anxiety are related to each other, anxiety will also assessed alongside aggression across the implicit and explicit emotion regulation experiments in the thesis, and will be used as a control variable where appropriate.

Aggression and emotion regulation are the key themes running throughout the current thesis. However, in Chapters 4 and 5 respectively, two important modulators of both emotion regulation ability and aggression will also be investigated, namely interoceptive awareness and age, specifically adolescence. These will be introduced in the following sections.

1.5.2 Interoceptive awareness

Theories of emotion suggest that a prerequisite of successful emotion regulation is the awareness of one's emotional state (Craig, 2004; Damasio, 1994; James, 1884). According to Damasio (1999), conscious awareness of emotion is related to upgrades in the self-representational maps emerging from the feedback of bodily states. In line with this, Barrett's Constructed Theory of Emotion suggests that the brain uses bodily feedback to categorise and predict instances of emotion (Barrett, 2017). Interoception has been defined as "sense of the physiological condition of the entire body" (Craig, 2002, p.655), and it has been suggested that individual differences in emotional awareness are related to differences in the capacity for interoceptive feelings (Craig, 2004, 2009). Indeed, in a student sample, interoceptive awareness was found to be inversely associated with alexithymia, which is characterised by impairments in emotional awareness (Herbert, Herbert, & Pollatos, 2011). This awareness of one's internal bodily signals has been postulated by Füstös, Gramann, Herbert and Pollatos (2013) and others (e.g. Craig, 2004; Damasio, 1994), to facilitate the regulation of emotional responses as the ability to detect bodily responses more accurately may in turn aid in the discrimination of emotional states and therefore aid the deployment of appropriate strategies to regulate these emotional states.

Indeed there are several studies demonstrating that those higher in emotional awareness are better able to regulate their emotions in an adaptive manner. For example, Gohm and Clore (2002) found that greater emotional clarity (i.e. identifying and distinguishing specific emotions) was associated with adaptive forms of emotion regulation, such as positive reinterpretation, which involves construing a stressor in positive terms, and active coping (i.e. actively trying to remove or avoid the stressor or to ameliorate its effects). Additionally in an experimental study, individuals high in emotional clarity were better able at implicitly down-regulating the influence of aggressive word primes (Wilkowski & Robinson, 2008). This suggests that those with higher awareness of their emotions may be more capable at detecting when early precursors to negative emotions, such as anger, start to escalate into more extreme forms of emotion, and consequently initiate emotion regulation operations at an early stage before strong emotional arousal is elicited. Further to this, emotional awareness has been found to be associated with attenuated arousal at the neural level. Herwig, Kaffenberger, Jäncke and Brühl (2010) found that when participants were asked to be aware of their current emotions and bodily feelings, amygdala activity significantly decreased in comparison to awaiting a photo (neutral condition) or thinking about personal goals. Therefore making oneself aware about one's own emotions can attenuate emotional arousal as it may lead to an inner distancing from the affective feelings in question.

These studies demonstrate that emotional awareness is positively associated with adaptive emotion regulation and a reduction of emotional arousal. However, in these studies emotional awareness was measured explicitly, either by using subjective questionnaires or asking participants to be aware of their current emotions. Given that it has been predicted that individual differences in emotional awareness are directly related to differences in the capacity for interoceptive feelings (Craig, 2004, 2009), interoceptive awareness may provide a less subjective and more direct predictor of emotional awareness. The most commonly used method to assess interoceptive awareness is the ability to perceive one’s heartbeats accurately (Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004; Dunn, Dalgleish, Ogilvie, & Lawrence, 2007). This ability is quantified by using heartbeat perception tasks (Schandry, 1981; Tsakiris, Tajadura-Jiménez, & Costantini, 2011), in which participants are instructed to perceive their own heartbeats without feeling for their pulse (see section 1.6.1 for more detail). Using this heartbeat perception task, Werner, Kerschreiter, Kindermann and Duschek (2013) investigated whether interoceptive awareness moderates the effects of social exclusion, which reliably induces a range of negative affective responses (e.g. Williams, Cheung, & Choi, 2000). In their study participants took part in a discussion round, and then after a certain time were excluded from the discussion. Participants with high interoceptive awareness (i.e. those who were more accurate in counting their heartbeats) indicated a smaller increase of negative affect and perceived rejection when comparing an inclusion phase with a subsequent exclusion phase than did participants with low interoceptive awareness. Werner et al. (2013) suggested that physiological signals are more easily accessible for individuals high in interceptive awareness and therefore they are better able to regulate negative affect in stressful situations by using this somatic information for self-regulation. However, this causal hypothesis cannot be conclusively confirmed as the study was correlational.

In an EEG study, Füstös et al. (2013) used a more explicit emotion regulation task in which participants were presented with negative pictures. They found that interoceptive awareness, measured using the heartbeat perception task as mentioned above, was positively correlated with the down-regulation of subjective negative affect when using reappraisal. This was accompanied by a reduction of electrophysiological responses (P3 and slow-wave amplitudes), with the difference in potentials between the reappraisal and no regulation conditions being positively correlated with interoceptive awareness. The findings of Füstös et al. (2013) show that a more accurate perception of interoceptive signals associated with emotional reactions to affective stimuli seems to facilitate effective emotion regulation, both behaviourally and physiologically.

Taken together, these findings suggest that interoceptive awareness is associated with emotion regulation abilities. However, as discussed above (see section 1.4) and throughout the thesis, there are a whole host of different types of emotion regulation strategies and it is unknown whether interoceptive awareness is equally important for all types of emotion regulation. In Chapter 4 evidence is presented suggesting that interoceptive awareness may be more strongly related to certain sub-strategies within the broad definition of reappraisal than others.

Finally, a key modulating factor that has been investigated in relation to emotion regulation over the past couple of decades is age, particularly development over the period of adolescence. Adolescence is often characterised by heightened emotional reactivity and is also a time of increasing vulnerability to internalising and externalising psychopathologies associated with poor emotion regulation, including depression, anxiety and antisocial behavior (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015). It is therefore of particular interest to understand how emotion regulation develops over this time, and whether age and aggression may interact to influence emotion regulation success.

1.5.3 Adolescence

There is a growing literature to suggest that the structural and functional development of brain regions subserving emotion regulation is relatively protracted over the lifespan (Paus, Keshavan, & Giedd, 2008), and thus it is crucial to examine how emotion regulation abilities may consequently develop and change with age. The period of adolescence is of particular interest and will be the focus of Chapter 5 for several reasons. Adolescence begins at the onset of puberty, roughly spanning the ages of 10 to 19 (Sawyer et al., 2012) and is characterised by an increasing incidence of internalising and externalising symptoms and emotional volatility (Lee et al., 2014; Paus et al., 2008; Spear, 2000). Developmentally, this period is associated with significant biological and physical changes, a growing need for independence, academic and employment pressures and fluctuating social relationships (Casey, Duhoux, & Cohen, 2010). These challenges are often accompanied by increased emotional reactivity and stress. Cognitively, high-level executive and social processes needed for emotion regulation, including working memory, inhibitory control, abstract thought, decision making and perspective taking, all undergo development during adolescence (e.g. Blakemore & Robbins, 2012; Dumontheil, 2014; Sebastian, Viding, Williams, & Blakemore, 2010; Somerville & Casey, 2010). Development of these cognitive processes appears to be underpinned by structural and functional development at the neural level, particularly in the protracted development of parts of prefrontal cortex and the remodelling of connections between prefrontal and limbic regions.

Adolescence emerges as a critical phase of reorganisation of regulatory systems and neural development in brain regions underpinning emotional processing. Grey matter volume gradually declines during adolescence (Giedd et al., 1999), particularly the PFC (Shaw et al., 2008). Subcortical emotion-processing structures, such as the amygdala, however, have been found to substantially increase in volume between the ages of 7.5 and 18.5 years (Schumann et al., 2004). One prominent set of theories posits a ‘developmental mismatch’, such that during adolescence the development of prefrontal regions lags behind that of the limbic structures such as the amygdala and ventral striatum, (e.g. Casey, Jones, & Hare, 2008; Nelson, Leibenluft, McClure, & Pine, 2005). At the same time, connectivity between brain regions involved in emotion regulation is still developing (Gee et al., 2013). As a result, during the time lag in functional maturity between prefrontal and limbic regions, adolescents are less effective at regulating their own emotions.

Behavioural and neuroimaging studies have supported this notion with implicit emotion processing showing differences across development, particularly during adolescence. For example a recent behavioural study showed that younger adolescents (aged 11-12 years), but not older adolescents (aged 17-18 years) exhibit more difficulties with attentional disengagement in the presence of emotional faces on a go/no-go task indicated by longer reactions times (Cohen Kadosh, Heathcote, & Lau, 2014). Also using a go/no-go task, Hare et al. (2008) found that children (aged 7–12) and adolescents (aged 13–18) were slower than adults when responding to fearful target (‘go’) faces, implying that they were less efficient at overriding affective interference compared with adults, particularly when asked to override what might be considered a prepotent response to avoid (as opposed to approach) fearful faces. Neurally, adolescents showed exaggerated amygdala activity relative to both children and adults across target and non-target expressions (although this exaggerated response habituated with repeated exposure to the stimuli), providing evidence of a non-linear developmental trajectory of amygdala response, possibly in line with 'developmental mismatch' accounts.

Despite the abundance of implicit emotion regulation studies across adolescence (see Ahmed et al., 2015, for a review) there have been relatively fewer studies on explicit forms of emotion regulation. In a longitudinal study of 1128 adolescents, Gullone, Hughes, King and Tonge (2010) found that self-reported suppression use decreases between the ages of 9 and 15. Suppression is generally considered a maladaptive strategy, with reliance on this strategy associated with reduced ability to repair negative moods and decreased experience of positive affect (Gross & John, 2003). Therefore, this reduction in use in this age range makes theoretical sense, as individuals gain the experience and underlying executive and social skills to develop alternative strategies (John & Gross, 2004). By the same logic, we would predict that use of the more adaptive reappraisal strategy would increase over this time; however, evidence to date has been mixed. Contrary to predictions, Gullone et al. (2010) found an overall decrease in the self-reported use of this strategy in everyday life between the ages of 9 and 15. However, results using a lab-based reappraisal paradigm suggest development in the ability to successfully use reappraisal, at least when instructed to do so (Silvers et al., 2012). Participants aged 10–23 were instructed to 'look' at negative and neutral pictures and give their natural response, or 'decrease' negative pictures, i.e. use a reappraisal strategy (in this case distancing) as trained prior to the experiment. Regulation success was defined as percentage decrease in self-reported negative affect on 'decrease' trials relative to 'look' trials for negative stimuli, and was found to improve with age, following both linear and quadratic trends (Silvers et al., 2012). It is worth noting significant methodological differences between these two studies that could explain the discrepant findings, including different age ranges, sample sizes and operationalisations of reappraisal (frequency vs. success). Studies that combine self-reported and experimental measures of reappraisal use and success across the adolescent age range are therefore needed. While there is research on adults investigating this, there are still many confounds involved, such as the different methods used and the timescales in which frequency and success are measured.

Neuroimaging studies of reappraisal efficacy also suggest development may be protracted. In a study by McRae et al. (2012) participants aged 10–22 years completed a reappraisal task similar to that reported by Silvers et al. (2012), whilst undergoing fMRI. A linear increase in cognitive reappraisal ability was found with age (in line with Silvers et al., 2012) and this was accompanied by a concomitant age-related increase in left vlPFC. As discussed above, this brain region has been implicated in cognitive control processes in both emotional and non-emotional contexts, and is also associated with cognitive reappraisal in adults (Ochsner & Gross, 2005; Ochsner & Gross, 2008). When participants were not specifically asked to reappraise (i.e. during an unregulated emotional response) adolescents (aged 14–17 years) showed less activation in brain areas associated with social cognition, such as medial prefrontal, posterior cingulate and temporal regions than did either children (aged 10–13 years) or emerging adults (aged 18–22 years). However, these regions were activated to a greater extent during reappraisal (i.e. a regulated emotional response) in adolescents compared to the other age groups. The authors interpreted this as suggesting that adolescents may not automatically engage in these social cognitive processes during unregulated responding, but are able to do so when specifically instructed.

As is the case for adult emotion regulation research, the majority of explicit emotion regulation studies in adolescents have focused on general strategies, such as reappraisal. In Chapter 5, I investigate the development of explicit emotion regulation in adolescence using a more specific strategy with both behavioural and physiological methods.

So far this chapter has discussed the models used to delineate the processes involved in emotion regulation and the underlying neural mechanisms of these processes, as well implicit and explicit forms of emotion regulation. Furthermore, modulating factors, namely, aggression, interoceptive awareness and age, have been discussed in relation to emotional reactivity and regulation. The next section describes some of the methodological approaches used throughout the thesis. Predominantly, standard quantitative behavioural psychological measures will be used, such as reaction time, error rates, questionnaires and Likert responses in both adults and adolescents. However, the more specialist techniques used will be discussed in more detail below, specifically interoceptive awareness, skin conductance and fMRI brain imaging.

1.6 Methods used in the thesis

While detailed methods are reported in each experimental chapter, there are a number of wider methodological issues concerning specialist techniques used in this thesis which will be discussed here.

1.6.1 Interoceptive awareness

The experimental study presented in Chapter 4 uses a variant on a classic behavioural reappraisal paradigm (e.g. Gross & Levenson, 1993; McRae et al., 2010; Ochsner et al., 2002) but also explores how interoceptive awareness influences emotion regulation abilities. As mentioned in section 1.5.2, interoceptive awareness is often measured using heartbeat tracking tasks in which participants are asked to silently count, and later report, the number of heartbeats they feel within a given time interval (e.g., Schandry, 1981). Participants' subjective reports are then are compared to their actual cardiac measurements to determine perception accuracy (see below for more details). This procedure is a widely-used method to assess interoceptive awareness (e.g., Herbert & Pollatos, 2014; Ferri, Ardizzi, Ambrosecchia, & Gallese, 2013; Füstös et al., 2013; Koch & Pollatos, 2014; Michal et al., 2014; Penton, Thierry, & Davis, 2014; Pollatos et al., 2008; Pollatos, Füstös, & Critchley, 2012; Schaefer, Egloff, Gerlach, & Witthöft, 2014) and has high test-retest reliability (Mussgay, Klinkenberg, & Rüddel, 1999), therefore it is often considered to be stable trait variable (Cameron, 2001).

However this task has faced some criticism, with some suggesting that the number of heartbeats counted may be based on the *rate* at which individuals believe their hearts to be beating, rather than on the real-time processing of heartbeat sensations (Brener, Knapp, & Ring, 1995; Ring & Brener, 1996). Heartbeat tracking accuracy may also be influenced by individuals' expectancies pertaining to how activities such as exercise can influence their heart rate (Ring, Brener, Knapp, & Mailloux, 2015). Thus, it has been argued that heartbeat tracking tasks may not be very sensitive in differentiating between individuals who are more accurate at perceiving heartbeat sensations and individuals who simply have accurate beliefs about their heart rate (Brener et al., 1995).

It should be taken into account, however, that these criticisms are predominantly based on studies investigating the effects of heart rate feedback on heartbeat tracking accuracy. Heart rate feedback can influence heartbeat tracking accuracy by priming participants to count their heartbeats at a specific temporal frequency. If participants are given false feedback, they will update the temporal frequency with which they count their heartbeats at (i.e. slower or faster counting), leading to low heartbeat tracking accuracy. In contrast, if participants are given correct feedback, they are able to correctly update temporal frequency to closely match their heart rate and therefore show increased heartbeat tracking accuracy as the task progresses (as was observed in the above studies). As the aim of Chapter 4 is to assess how accurately participants perceive their own heartbeats, it is important that participants are not provided with feedback about their performance during the task so that they cannot update the temporal frequency they count at.

As mentioned briefly above and in section 1.5.2, interoceptive awareness is measured using the Mental Tracking Method (Schandry, 1981), which is a standard method and has high test–retest reliability of 81% (Mussgay et al., 1999). This method is used in Chapter 4 using the POLAR RS800CX heart rate monitor (Polar Electro Oy, Kempele, Finland; sampling rate of 1000 Hz) to monitor actual (as opposed to estimated) heart rate. Signals are analysed by the Polar ProTrainer

5 software (version 5.40.172). The POLAR heart rate monitor has excellent construct validity and instrument reliability, measuring heart rate data on par with electrocardiogram recorded data (e.g., Kingsley, Lewis, & Marson, 2005; Nunan et al., 2008; Quintana, Heathers, & Kemp, 2012; Weippert et al., 2010). During the task, participants are instructed to place their wrists on the H3 POLAR heart rate sensor that is attached to the table in front of them and mentally count their heartbeats when they hear an audio tone signalling the start of the trial until they receive an identical tone signalling the end of the trial. The experiment in Chapter 4 consisted of three trials of different time intervals; 25s, 45s and 60s, separated by 10s resting periods, presented in the same order across participants. Following each interval, participants are asked to verbally report the number of counted heartbeats. Throughout the heartbeat task, participants' true heart rate is monitored with the sensor under their wrists. During the task, participants are not allowed to take their pulse or use any other strategy, and no information regarding the length of the individual time intervals or feedback regarding performance is given. Interoceptive awareness score is calculated as the difference between recorded heartbeats and counted heartbeats for each interval, which is then averaged (see section 4.2.3 for the equation used).

1.6.2 Skin conductance

Chapter 5 investigates the development of an explicit emotion regulation strategy across adolescence whilst measuring skin conductance. Skin conductance is a measure of electrodermal activity and a well-known method in the field of psychophysiology. When exposed to certain types of events or stimuli, the automatic nervous system signals sweat glands in the skin to produce sweat. This increase in sweat changes the skin's moisture content, which ultimately affects how electrically conductive the skin is. This change in conductivity can be measured by applying a small electric current through the skin (Boucsein, 2012). Events or stimuli that are novel, intense or significant in nature typically elicit a sharp increase in skin conductivity (Picard & Scheirer, 2001). Importantly, individuals are normally incapable of controlling their levels of skin conductance, therefore changes in conductance are likely to arise from unconscious processes in the brain and body (Gale, 1988). Furthermore skin conductance is not affected by the normal, at-rest functions of the body, thus it is one of the most valuable indicators of arousal within the autonomic nervous system (Braithwaite, Watson, Robert, & Mickey, 2013) and has been found to be a good index of emotional arousal (e.g., Bradley, Miccoli, Escrig, & Lang, 2008; Lang, Greenwald, Bradley, & Hamm, 1993). Several explicit emotion regulation studies have demonstrated reduced skin conductance response patterns during regulation relative to control conditions (e.g., Feeser, Prehn, Kazzer, Mungee, & Bajbouj, 2014; Matejka et al., 2013; Urry, van Reekum, Johnstone, & Davidson, 2009), making it a good accompaniment to ratings of subjective affect.

There are a variety of ways in which skin conductance during experimental conditions of interest is quantified. Firstly a latency onset window needs to be defined to locate skin conductance responses (SCRs) that are viewed as being elicited directly from the stimuli of interest. A typical criterion is that the onset of an SCR has to be between 1 and 4 seconds after stimulus onset (Boucsein et al., 2012). One method of quantification is to use the frequency of discrete SCR peaks elicited within the latency period; however this can limit the analysis as SCRs of any 'size' are given equal weight in the analysis regardless of their amplitude (Bach, Friston, & Dolan, 2010). For instance, an individual with several SCR responses low in amplitude would be classed as having the same levels of skin conductance as an individual with the same number of SCR responses all high in amplitude. One way of attributing greater weight to 'larger' SCRs is by measuring amplitude instead of frequency. Using peak amplitude is perhaps the most commonly employed method and this is quantified by computing the difference between skin conductivity before the SCR onset and the skin conductivity at the peak of the SCR (Boucsein, 2012). As peak amplitude is the most widely used indicator of skin conductance (Figner & Murphy, 2011), and is also more commonly used in the emotion regulation literature (Feeser et al., 2014; Kinner et al., 2017; Matejka et al., 2013; Urry et al., 2009), Chapter 5 of the current thesis employs this measure.

1.6.3 fMRI

Finally, Chapter 6 utilises functional magnetic resonance imaging (fMRI). fMRI is a non-invasive tool that has the capacity to demonstrate the entire network of brain areas engaged during a particular task (Logothetis, 2008). It records on a spatial resolution in the region of 1 to 6 millimeters, higher than any other non-invasive technique available for use with humans, and has a temporal resolution on the order of a few seconds. fMRI works by detecting changes in blood oxygenation and flow (the blood oxygen level dependent (BOLD) signal), and relies on the fact that cerebral blood flow and neuronal activation are coupled. When a brain region becomes more active, it requires more oxygen and as a result more oxygenated blood flows towards the active region. Therefore brain regions involved in certain cognitive functions can be inferred, as they are assumed to require the greatest increase in oxygen levels during task performance, relative to an appropriate control condition (see Huettel, Song, & McCarthy, 2014, for a comprehensive overview of fMRI).

Conducting an fMRI study involves several key stages, each of which requires careful consideration. The first stage is designing the experimental paradigm. Conditions must be well matched in terms of psychological processes. For example, previous emotion regulation studies tend to contrast the reappraisal condition with a no-regulation condition (e.g. McRae et al., 2012; Ochsner et al., 2002), however this does not control for the wealth of cognitive processes involved in reappraisal (e.g. selective attention, working memory, inhibitory control and updating goals; Ochsner et al., 2012). Ideally the task should be designed so that there is only one well-defined difference between the two conditions that are being compared, which will only ‘activate’ those brain regions responsible for the process of interest. Another key consideration is that regressors should be orthogonal (uncorrelated). If events of interest occur in close proximity, the corresponding regressors in the general linear model (GLM) will be highly correlated. If they are correlated, the variance attributable to an individual regressor may be confounded with another regressor. This may lead to misinterpretations of activations in certain brain areas and a loss of statistical power (Poldrack, Mumford, & Nichols, 2011).

Once the experimental design has been finalised, data must be collected. This entails selecting an appropriate sequence that is optimised to prevent dropout (i.e. signal loss and distortion caused by non-uniformities in the static magnetic field) in regions of interest. For emotion perception and regulation studies, regions of interest such as the amygdala and orbitofrontal cortex can be susceptible to dropout. Guidelines such as those provided by Weiskopf, Hutton, Josephs and Deichmann (2006), can be followed to maximise the BOLD sensitivity of these areas. This includes choosing an appropriate slice tilt and phase-encoding polarity, helping to reduce BOLD sensitivity loss due to susceptibility-induced gradients in the phase-encoding direction.

When the data has been collected it must then be analysed. The first stage of fMRI data analysis is the pre-processing of the data. During pre-processing, several image and signal processing techniques are applied to the raw MRI data to align and warp the data to a standard space so that data are comparable a) across time within an individual, and b) across individuals. Participant head movement during the experiment is a key problem, with even the slightest movement changing pixel intensity at the edges of the brain. Therefore the first step of pre-processing is usually realignment, which involves aligning all images with the first image so that scans from each participant are aligned (Huettel et al., 2014). In addition to spatial realignment, temporal realignment is often required as well. Functional MRI volumes are normally acquired one slice at a time with the timing of the slice acquisition evenly spread over the repetition time (TR), which is usually a few seconds. In effect, there is a slight time difference between acquisition of the first and the last slice in the volume. Analysis of fMRI data assumes all slices are acquired at the same time, therefore without correction, the relative timing of the stimulus and response will not be matched and consequently the statistical model which is used to describe the data will fit with less than optimal accuracy. To compensate for the difference in acquisition time between slices in a volume, slice timing correction is often applied during the pre-processing stage. Slice timing correction temporally adjusts the voxel time series so that a common reference timing (often the first slice) exists for all voxels. During this step, the time-series of each voxel in a slice is shifted slightly forward or backward in time to temporally align data (Sladky et al., 2011). Another important issue for fMRI analysis is that across participants, brains differ in size and shape. Therefore spatial normalisation is a crucial step during pre-processing in order to perform group level analysis. Normalisation is typically performed by warping each brain to a standard template. As a result, one location in one participant’s brain scan corresponds to the same location in another participant's brain scan. As a final pre-processing step, the fMRI data are spatially smoothed. This involves averaging data points with neighbouring data points. The approach of spatial smoothing is commonly used in fMRI studies as it may improve inter-participant registration and overcome potential limitations in the spatial normalisation step by blurring any remaining anatomical differences. Smoothing also decreases random noise in individual voxels and increases the signal-to-noise ratio within the region (Lindquist & Wager, 2008). The mentioned pre-processing steps are essential in making the statistical analysis of the fMRI data valid and improving the power of the subsequent analyses. There are many possible variations in terms of the pre-processing pipeline, but to maximise chances of replicability, a very standard pipeline will be used in Chapter 6 of the thesis.

Statistical inference is the final stage in analysing an fMRI study. Chapter 6 utilises the subtraction method, which involves subtracting the recorded neural response of one condition (e.g. control) from the other (e.g. experimental). Accordingly, this method relies on identifying conditions that are in minimal contrast with one another, where the minimal contrast corresponds to the cognitive process of interest. While the subtraction method is the most commonly used form of analysis, it is not without criticism. Fundamental to this method is the assumption of ‘pure insertion’ – the idea that a cognitive process can be added to a preexisting set of cognitive processes without any effect on them (Donders, 1969). For example, according to this assumption, when subtracting the activation associated with looking at a neutral face from looking at a fearful face, the activation that is isolated is purely activation associated with processing fear. Even if it were the case that cognitive processes can be added without affecting preexisting processes, pure insertion assumes that there are no interactions among the cognitive components of the task, e.g. the processing of fear and other cognitive processes, such as inhibiting a prepotent response during the cognitive task (Friston et al., 1996).

In addition to the pure insertion problem, more generally it is difficult to know whether activity in a particular region is necessary and/or sufficient for a given cognitive function (Poldrack, 2008), as fMRI data are correlational. This is particularly problematic when the specific cognitive processes involved in a task are not well known as this can lead to reverse inference (Poldrack, 2006). Reverse inference involves observing the pattern of brain activation resulting from a given task, and inferring the cognitive processes involved, e.g. “activation of the amygdala was significant, suggesting a fear response.” These deductive interpretations are often invalid, as there is rarely a one-to-one mapping between brain activation in a particular region and a cognitive process.

A common method of analysing fMRI data which somewhat circumvents these issues involves the extraction of signal from specified regions of interest (or ROIs). A combination of both ROI and whole brain analyses will be used in Chapter 6 as these have different purposes; ROI analysis can confirm specific predictions regarding the role of particular brain areas, whereas whole brain analysis is exploratory - showing activations across the entire brain. Since the whole brain consists of thousands of voxels, correction for multiple statistical comparisons becomes an issue. To account for this, familywise error correction will be applied across all analyses, as it is the most conservative type of correction with respect to Type I errors (Lieberman & Cunningham, 2009).

As it is a correlational method, fMRI alone can never address the causal role of a particular brain region in a particular task. However, despite this and the issues raised above, fMRI is one of the few techniques that provides information about the broad networks of brain regions involved in a task. fMRI can be used to arbitrate between competing hypotheses at the behavioural level. For example, it could help determine whether aggressive behaviour is driven by increased response in limbic regions, decreased response in cognitive control regions associated with regulation, poor connectivity, or a combination of these. The current thesis will use fMRI to investigate which neural systems underlie temporal distancing, an emotion regulation strategy that has yet to be examined using neuroimaging; and introduces a more stringent control condition than is typically used in fMRI studies of reappraisal.

1.7 Summary and the current thesis

As demonstrated in this chapter, the past two decades have seen exciting new developments in the field of emotion regulation. The research described so far has given an overview of the current state of the literature on implicit and explicit emotion regulation, as well as key individual differences that are believed to influence these regulatory processes. The present thesis first examines implicit emotion regulation processes followed by explicit emotion regulation; in line with the framework provided by the Process Model (Gross, 1998), and explores how their function and efficacy are modulated by several factors including specific task demands, aggression, interoceptive ability, and age across the transition from adolescence to adulthood.

Chapter 2 employs a paradigm in which emotion is task-irrelevant in order to explore how attention is implicitly captured by emotional faces. While the extent of 'emotional capture' has been found to vary with psychopathic traits in antisocial samples, this chapter aims to address whether this variation extends throughout the continuum of psychopathic traits in a community sample. Using a similar paradigm where emotion is still task-irrelevant, Chapter 3 explores whether emotional capture effects vary with the level of cognitive load involved in the task, in order to better understand the conditions under which emotion can, and cannot, implicitly capture attention. Four behavioural experiments are conducted in order to investigate the task conditions under which load-dependent effects hold.

Chapters 4-6 investigate explicit emotion regulation strategies using adapted versions of paradigms commonly used in the explicit emotion regulation literature, extending them by utilising more relatable stimuli such as commonly occurring ‘everyday’ scenarios, and investigating more clearly delineated emotion regulation strategies than in previous studies. Chapter 4 examines the efficacy and ease of use of three distancing sub-strategies within the broad family of reappraisal processes, as discussed in section 1.4. This study also investigates whether aggression and interoceptive awareness influence the ability to use distancing to regulate emotion effectively. Chapter 5 focuses on the efficacy of one of these strategies, namely temporal distancing (e.g. ‘this too shall pass’), using a novel experimental task across the transition from adolescence to adulthood. This chapter will also investigate whether the ability to use this strategy is influenced by aggression and/or an interaction between aggression and age, since adolescence is associated with an increase in externalising behaviours such as reactive aggression (Moffitt, 1993). In the final experimental chapter (Chapter 6), an fMRI-adapted version of the task used in Chapter 5 is employed to investigate in healthy adult participants, for the first time, the neural processes underpinning temporal distancing and whether these processes are modulated by aggression.

Chapter 2: Emotional capture by fearful expressions varies with psychopathic traits

2.1 Introduction

As discussed in Chapter 1 section 1.3, there is now a large body of research showing that threat-related stimuli have a tendency to attract visual attention (e.g. Cisler, Bacon, & Williams, 2009). Recent work has shown that attentional capture by emotion (‘emotional capture’) occurs in response to task-irrelevant facial expressions (see Carretié, 2014 for a review), and occurs irrespective of whether emotion is presented in a target location or as a peripheral distractor (Hodsoll, Viding, & Lavie, 2011). Thus, emotional capture occurs both when attention is allocated endogenously during search, and when attention is automatically reoriented by an emotional distractor.

Individuals high in psychopathic traits show atypical processing of affective stimuli. Psychopathy is typically conceptualised as comprising two correlated but separable facets: affective-interpersonal traits include shallow affect, deceptiveness, low guilt and empathy; while lifestyle-antisocial traits include antisocial, impulsive and irresponsible behaviour (Blair & Viding, 2008; Hare, 2003). High levels of affective-interpersonal psychopathic traits have been repeatedly associated with fearlessness and diminished reactivity to others’ emotions; particularly fear (Blair, 2015, see section 1.5.1.2). Thus individuals high in these traits are often characterised as having a fundamental fear deficit (Blair et al., 2004; Veit et al., 2013). An alternative line of enquiry suggests that these individuals are characterised by a more general information processing deficit. According to the Response Modulation Theory (Newman & Lorenz, 2003), individuals high in psychopathic traits have difficulty shifting attention from goal-relevant information in order to monitor and potentially use other important information. More recently, affective and attention-based theories of psychopathy have been integrated in the Impaired Integration Model (Hamilton, Hiatt-Racer, & Newman, 2015), which proposes that abnormalities in neural connectivity lead to difficulties in binding different stimulus features into a unified percept. As a consequence, fewer attentional resources are available to be 'captured' by complex, peripheral or less relevant stimuli.

According to this formulation, psychopathic traits should be associated with emotion-specific deficits if emotional stimuli are multidimensional or secondary to the current attentional focus (Hamilton et al., 2015). Recent work is in line with this account. For example, a study in adolescents with high levels of callous-unemotional traits (similar to adult affective-interpersonal traits) demonstrated reduced emotional capture in this group by task-irrelevant emotional expressions, regardless of whether the emotion appeared as target or distractor (Hodsoll, Lavie, & Viding, 2014). This suggests a deficit in automatic or 'bottom-up' allocation of attention to emotion in a sample at the extreme end of the antisocial/callous-unemotional continuum, regardless of whether the spatial focus of attention is oriented towards the affective stimulus. This is in line with several recent studies suggesting that individuals high in affective-interpersonal/callous-unemotional traits show reduced automatic orienting to emotional stimuli (e.g. Sylvers, Brennan, & Lilienfeld, 2011; Verona, Sprague, & Sadeh, 2012). For example, using a Go/No-Go task in an ERP study, Verona et al. (2012) found reduced processing of negative emotional words regardless of inhibitory control demands in psychopathic offenders compared to control offenders, who only showed suppressed negative emotional processing under conditions requiring inhibitory control (i.e., less emotional processing in No-Go vs. Go trials).

Research has shown that psychopathic traits are continuously distributed throughout the population (Paulhus et al., in press), and that emotional processing varies with levels of these traits (e.g. Seara-Cardoso et al., 2012). However, few studies have investigated whether bottom-up attentional emotional processing varies continuously with these traits in an adult community sample. Carolan et al., (2014) compared community samples selected for high and low levels of psychopathic traits using EEG during an emotional Stroop task. No behavioural differences were found between the groups, but EEG evidence was suggestive of decreased emotional capture in the group with high levels of psychopathic traits. Relatedly, Anderson and Stanford (2012) found reduced emotion-dependent effects on ERPs on an emotional picture-viewing task as a function of psychopathic traits. However, it is unclear whether behavioural (as opposed to neural) effects reported with individuals sampled from the extreme end of the continuum extend continuously throughout the population in addition to in pre-selected groups.

In contrast to affective-interpersonal traits, lifestyle-antisocial traits are associated with increased emotional reactivity to negative stimuli in both clinical (Hicks & Patrick, 2006) and general (Seara-Cardoso et al., 2012) samples. Psychopathic traits also often co-occur with trait anxiety, with anxiety levels particularly associated with antisocial behaviour dimensions of psychopathy (e.g. Ali et al., 2009). Relatedly, some researchers distinguish between 'primary' and 'secondary' psychopathy. Compared to primary psychopaths, secondary psychopaths have been characterised as more anxious, fearful, impulsive, and reactively aggressive (Ali et al., 2009). Although these high-anxious secondary subtypes show equivalent levels of affective-interpersonal traits to low-anxious primary subtypes, they show hypervigilant attentional orienting to negative emotion, while primary psychopaths show reduced orienting (e.g. Zeier & Newman, 2013). Studies investigating anxiety in isolation generally find it to be associated with a hypervigilant attentional system, including an increased tendency to orient attention towards fearful and angry expressions (Capitão, Underdown, Vile, Yang, Harmer, & Murphy, 2014; Richards et al., 2014).

Thus, both trait anxiety and lifestyle-antisocial traits are associated with hypervigilant attention and emotional hyperreactivity, while affective-interpersonal traits are associated with emotional hyporeactivity, particularly to fear (Blair et al., 2004). Several recent studies have revealed distinct, opposing contributions of affective-interpersonal and lifestyle-antisocial components to emotional reactivity within the same individuals, particularly when unique variance associated with each trait is inspected after controlling for the other. Effects have been seen both in clinical/subclinical (Hicks & Patrick, 2006;. Sebastian et al., 2012) and community (Carré, Hyde, Neumann, Viding, & Hariri, 2013; Hodsoll, unpublished thesis; Seara-Cardoso et al., 2012) samples. For example, Seara-Cardoso et al. (2012), found that unique variance associated with affective-interpersonal traits was associated with lower propensity to feel empathic concern, whereas unique variance associated with lifestyle-antisocial traits was associated with greater propensity to feel concern for the distress of others within the same individuals. Moreover, one recent study in a community sample found an interaction between these traits on a decision-making task in the presence of emotional pictures, such that reduced distraction by emotion was associated with higher affective-interpersonal traits (specifically 'fearlessness') only when participants scored low on 'carefree non-planfulness', related to impulsivity (Maes & Brazil, 2015).

We extend this literature to explore relationships between emotional capture (i.e. variation in reaction times (RTs) attributable to attention capture by emotional stimuli) and affective-interpersonal, lifestyle-antisocial and anxious traits in an adult community sample. Based on previous research we predicted that affective-interpersonal traits would be negatively associated with emotional capture (across distractors and targets). Given previous work suggesting reduced automatic orienting of attention to emotion, particularly fear, in individuals high in affective-interpersonal psychopathic traits (Sylvers et al., 2011), we predicted that effects would be strongest in the presence of fearful faces. We additionally predicted that lifestyle-antisocial and anxious traits would be independently and positively associated with emotional capture. In line with recent preliminary evidence suggesting an interaction between psychopathic traits in their effects on emotional distraction (Maes & Brazil, 2015), we also predicted that affective-interpersonal traits would only be associated with emotional capture where lifestyle-antisocial traits and/or anxiety are low.

2.2 Method

2.2.1 Participants

Eighty-five university students (33 males) aged 18-35 (M=20.86, SD=3.05) were recruited from Royal Holloway University of London, and received course-credit or £3 for participation. The study was approved by the departmental ethics committee and there were no exclusion criteria. A power analysis indicated that 82 participants were needed to have 80% power for detecting an effect size of .30 (based on the average effect size attained by Hodsoll et al., 2014) when employing the traditional α=.05 criterion of statistical significance.

2.2.2 Stimuli and procedure

Task procedures and design followed Hodsoll et al. (2011). The experiment was conducted using a 15-inch Windows laptop. Viewing distance (60cm) was maintained with a chin-rest; this was to ensure that emotion captured attention without participants needing to make exploratory saccades. Stimuli consisted of 12 grey-scale faces of six (three female, three male) identities from the NimStim (http://www.macbrain.org/resources.htm). Each face measured 2.1cm by 1.7cm. Faces were presented on a black background in a virtual triangle with the centre of each image placed at 1.3cm from the central fixation cross. Fixation was presented for 500ms followed by the search displays, presented until the participant responded or for up to 3 seconds.

On each trial participants saw three faces, and searched for one target face among two distractors (see *Figure 2.1*). The target was either male amongst female distractors or vice versa: target gender was randomly allocated across participants. Participants indicated with a key press whether the target tilted (15°) to the left or right. Error feedback was given by a short tone. Participants completed three blocks (angry, fearful and happy, with order counterbalanced across participants) of 96 trials, preceded by 24 practice trials. Within each block, an emotional face was present on 72 trials. Of these, 24 contained an emotional target and 48 contained an emotional distractor. The remaining 24 trials consisted of all-neutral faces. Trial order, location of specific identities, and stimulus orientation were randomised. Facial identities were also randomised, with the constraint that target faces did not repeat on two successive trials. The task was presented using Delosis Psytools (http://www.delosis.com) and was on average 8 minutes long (time varied due to the self-paced nature of the task). Reaction times (RTs) and error rates were measured; RTs 2.5 standard deviations above and below each participant's mean were removed.

All-Neutral Fearful Distractor Fearful Target

Figure 2.1. Example displays for all-neutral, fearful distractor, and fearful target conditions (not to scale). Please note that the female face in the top right corner of each of the three images was not used in the current experiment, but is included here to comply with NimStim publishing guidelines.

2.2.3 Questionnaires

2.2.3.1 Assessment of psychopathic traits

The Self-Report Psychopathy Scale-III Short Form (SRP-III-SF; Paulhus et al., in press) is a 29-item measure assessing psychopathic traits in non-incarcerated populations (Appendix 1a). The SRP-III-SF uses 29 of the 64 items from the SRP and is correlated .92 with the full version (Paulhus et al., in press). Like the Psychopathy Checklist-Revised (PCL-R), the SRP-III-SF is organised into four facets – interpersonal, affective, lifestyle, and antisocial, which are modelled into two factors; core interpersonal and affective features of psychopathy ('affective-interpersonal') and antisocial traits and impulsive lifestyle ('lifestyle-antisocial'). Items are rated on a 5-point Likert scale, with total score indicating overall levels of psychopathic personality traits. The maximum possible SRP-III-SF total score is 145. The SRP has shown evidence of good construct validity and reliability in community samples (Carré et al., 2013; Paulhus et al., in press; see Gordts, Uzieblo, Neumann, Van den Bussche, & Rossi, 2015, for a discussion on the psychometric properties of the SRP) and strongly correlates with the PCL-R (Paulhus et al., in press). In the present sample, SRP-III-SF total scores ranged between 29 and 101 (M=52.50; SD=14.03), affective-interpersonal scores ranged between 14 and 49 (M=24.78; SD=8.89), lifestyle-antisocial scores varied between 14 and 47 (M=24.02; SD=6.54), thus presenting a similar distribution to a previously reported distribution from a larger sample of adults from the general population (Seara-Cardoso et al., 2012). Cronbach's alpha for the total SRP scale was .88, comparable to that found in a larger sample (α=.84; Gordts et al., 2015). For the subscales, alpha coefficients were .86 for affective-interpersonal facet and .75 for the lifestyle-antisocial facet, demonstrating good internal consistency. For the calculation of the lifestyle-antisocial facet, the item 'I was convicted of a serious crime' was not included in the score as this was directed at offenders (Paulhus et al., in press).

2.2.3.2 Assessment of anxiety

The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used, which comprises of two subscales containing 20 items each, rated on a four-point scale (Appendix 1b). The State Anxiety scale evaluates the current state of anxiety, asking how respondents feel "right now", whereas the Trait Anxiety scale evaluates relatively stable aspects of anxiety, asking respondents how they feel '"generally". Internal consistency coefficients has been high for the scale; ranging from .86 to .95 (Spielberger et al., 1983). Analyses focused on trait anxiety as the study hypotheses concerned dispositional anxiety.

2.2.4 Data analysis

All analyses were conducted using SPSS version 21.0 (here and throughout the thesis). For the behavioural task results, mean RTs on correct trials for each participant were entered into repeated measures ANOVAs with the following factors and levels: Emotion (angry, fearful, happy) and Condition (target, distractor, all-neutral). To clarify, the ‘target’ condition comprised emotional targets among neutral distractors, the ‘distractor’ condition comprised neutral targets among emotional distractors, and the ‘all-neutral’ condition comprised neutral targets among neutral distractors. Pairwise comparisons between the conditions were also performed, with Bonferroni correction applied for the number of comparisons within each independent variable or interaction term.

We then conducted bivariate correlations between reaction time variables (mean RT differences between emotion and neutral conditions, as well as RTs for individual conditions) and psychopathic traits/anxiety, with our strongest a priori hypothesis regarding a relation between RTs to fearful stimuli and affective-interpersonal traits. Partial correlations between RTs and each SRP-III-SF factor after controlling for the other were also conducted in order to investigate the contributions of unique variance associated with each facet. To examine whether the lifestyle-antisocial traits moderated the association affective-interpersonal traits and fear-related RTs, a moderation analysis was conducted using Hayes' (2012) PROCESS macro (Model 1) for SPSS to obtain bias-corrected 95% confidence intervals. Bonferroni correction was not used for the individual difference analyses (correlations and moderation), given our strong a priori hypotheses regarding fear, and the total number of possible analyses which would render this correction over-conservative.

2.3 Results

One participant was excluded due to error rates greater than 50%. Overall error rates were low (*M*=4.98%, *SD*=4.61) and did not significantly differ across trials and conditions. Missed trials were also low (*M*=.89%, *SD*=1.88).

2.3.1 Main task

A 3x3 Condition (target, distractor, neutral) x Emotion (angry, fearful, happy) repeated-measures ANOVA on mean correct RTs (*Figure 2.2*) revealed a main effect of Condition ($F(2,168)=4.04$, $p=.019$, partial $\eta^2=.05$). RTs were significantly slower in emotional distractor trials (M=930ms, SD=189) compared with all-neutral trials (neutral trials interspersed within emotion blocks) (M=913, SD=198: $t(84)=3.01$, $p=.01$). There were no differences between emotional distractor and target trials ($p=.63$) and target and all-neutral trials ($p=.42$).

There was also a main effect of Emotion ($F(2,168)=14.37$, $p<.001$, partial $\eta^2=.15$). RTs in the happy condition (M=894, SD=186) were significantly faster than the angry (M=947, SD=196, $t(84)=5.59$, $p<.001$) and fearful (M=925, SD=205, $t(84)=2.85$, $p=.016$) conditions.

The Condition x Emotion interaction was significant ($F(4, 336)=2.87$, $p=.023$, partial η^2 =.03). Within the angry block, there was a main effect of Condition ($F(2,168)=4.97$, $p=.008$, partial $\eta^2=.06$), with pairwise comparisons showing longer RTs on angry distractor trials (M=963, SD=198) compared with all-neutral (M=935, SD=216; $t(84)=2.94$, $p=.013$) and angry target (M=942, SD=190; $t(84)=2.63$, $p=.031$) trials. RTs on angry target and all-neutral trials did not differ. There was also a main effect of Condition in the fearful block ($F(2,168)=3.56$, $p=.031$, partial $\eta^2=.04$). RTs were significantly longer on fearful target (M=936, SD=213) than all-neutral trials; (M=911, SD=214; $t(84)=2.50$, $p=.044$), but there was no significant difference between fearful distractor (M=927, SD=205) and all-neutral trials ($t(84)=1.77$, $p=.24$). Target and distractor conditions did not differ. There was no main effect of Condition for happy trials ($F(2,168)=.87$, $p=.42$, partial $\eta^2=.01$).

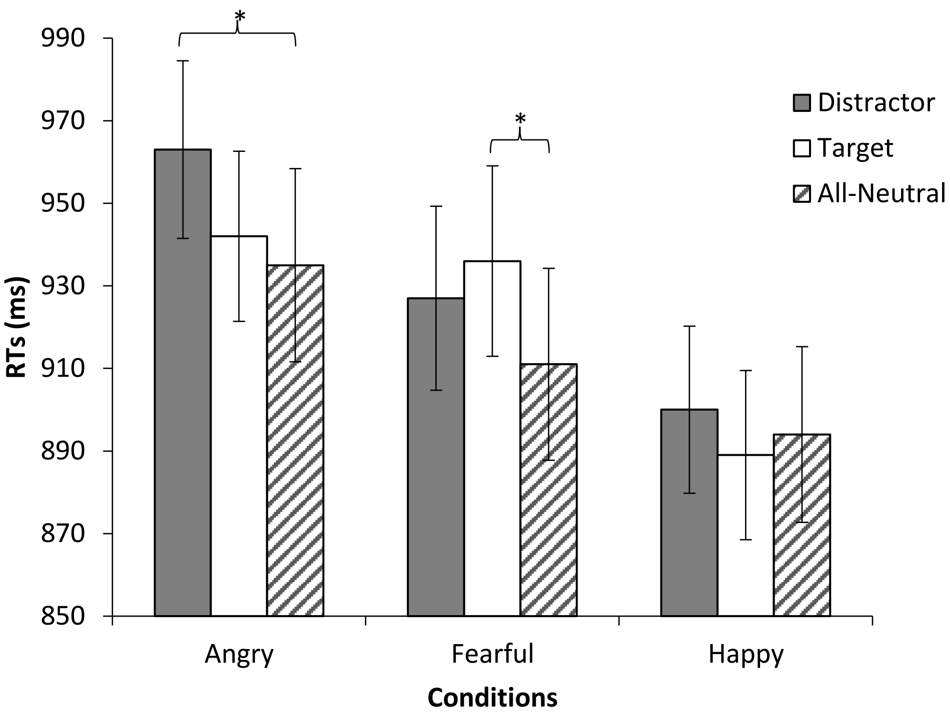


Figure 2.2. Mean reaction times (milliseconds) to correctly locate and indicate the tilt of the target (male or female) face which was either emotional (target), neutral in the presence of an emotional distractor (distractor) or neutral in the presence of other neutral faces (all-neutral) (p<.05, Bonferroni corrected). Here and throughout the thesis error bars represent the standard error of the mean of each individual condition.

2.3.2 Relationships with psychopathic traits

To investigate relationships between the task and psychopathic traits we first looked at correlations between the SRP-III-SF scores and RT differences between the emotional and all-neutral conditions, however there were no significant findings. Consequently, we explored the raw RT variables. No significant relationships were seen in in any of the angry, happy or all-neutral conditions, but we did find significant correlations for fear. There was a significant negative correlation between total SRP-III-SF score and mean RTs in the presence of fearful distractors (r(83)=-.22, p=.046). There were also significant negative correlations between affective-interpersonal traits and mean RTs to fearful target (*r*(83)=-.22, *p*=.045) and distractor (*r*(83)=-.23, *p*=.038) trials, i.e. as predicted, higher affective-interpersonal scores were associated with faster RTs, suggesting reduced interference by fearful stimuli as these traits increased.

No hypothesised positive relationships were found between lifestyle-antisocial traits and RTs during emotional conditions (across fearful, angry, happy distractors and targets, and difference RTs), nor were there significant associations between emotional capture and unique variance associated with either facet after controlling for the other. However, it was hypothesised that reactivity associated with lifestyle-antisocial traits might moderate the effect of affective-interpersonal traits; such that reduced RT interference by fearful distractors and targets with increasing affective-interpersonal traits (detailed above) would hold only when lifestyle-antisocial traits were low, i.e. when there was no competing source of emotional reactivity. Moderation analysis showed that lifestyle-antisocial scores moderated the relationship between RTs during the fearful distractor condition and affective-interpersonal traits (*b*=2.62, 95% CI [0.25, 4.99], *t*=2.30, *p*=.03; *Figure 2.3*). As predicted, the negative relationship between RTs and affective-interpersonal scores held only when lifestyle-antisocial scores were low (*b*=-19.74, 95% CI [-35.84, -3.64], *t*=-2.44, *p*=.017), and was not significant when these traits were moderate or high.

However, when lifestyle-antisocial scores were high, RTs were uniformly *fast* (regardless of affective-interpersonal score), whereas it was predicted that emotional capture in these participants would render RTs universally slow, as such traits are generally associated with high emotional reactivity which would be predicted to impair performance via interference effects. We explored whether a speed-accuracy trade-off specific to participants with high lifestyle-antisocial scores might underlie this finding, since one feature of the lifestyle-antisocial facet of psychopathy is heightened impulsivity. Participants in the top tertile for lifestyle-antisocial traits showed a negative correlation between error rates and RTs in the fearful distractor condition (*r*(40)=-.40, *p*=.008), i.e. those with faster RTs also made more errors; while there was no correlation for the lowest tertile (*r*(41)=.09, *p*=.58). These correlation coefficients were significantly different (*Z*=2.29, *p*=.022). This suggests a tendency to trade accuracy for speed in those with the highest levels of lifestyle-antisocial traits, potentially contributing to relatively fast mean RTs in this group.

No moderation was seen when RTs in the fearful target condition was the dependent variable (*p*=.12) nor when RTs for the all-neutral trials presented within the fearful block was the dependent variable (*p*=.11). Relatedly, there were no moderation effects seen in any of the conditions in the angry block (all *ps*>.10) or the happy block (all *ps*>.44).

2.3.3 Anxiety

It was predicted that anxiety would positively be associated with emotional capture. However no significant correlations were found between trait anxiety and difference RTs or RTs for individual conditions in the predicted direction. There were negative correlations between trait anxiety and RTs for happy distractor trials (*r*(83)=-.231, *p*=.033), all-neutral trials during the happy block (*r*(83)=-.218, *p*=.045) and all-neutral trials during the fearful block (*r*(83)=-.218, *p*=.045). The negative correlation with fearful distractor RTs was marginal (*r*(83)=-.211, *p*=.053). Trait anxiety was not significantly correlated with any of the angry conditions (*ps*>.069). No interactions between anxiety and psychopathic traits were found.

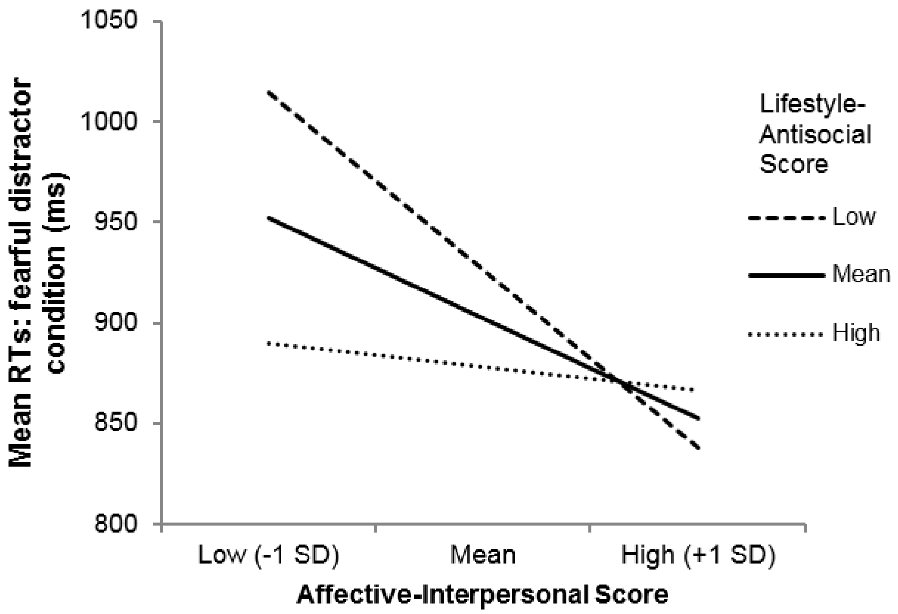


Figure 2.3. Graph showing that the relationship between mean reaction times (milliseconds) during correct trials in the fearful distractor condition and affective-interpersonal traits is moderated by levels of lifestyle-antisocial traits. The negative relationship between RTs and affective-interpersonal traits only held when lifestyle-antisocial traits were low.

2.4 Discussion

In line with predictions, emotional capture by fearful faces varied with psychopathic traits in a community sample, with a similar pattern of results to those found in an antisocial sample using the same task (Hodsoll et al., 2014). Most importantly, emotional capture by fearful stimuli (both target and distractor faces) was reduced in those with higher levels of affective-interpersonal psychopathic traits, associated at the extreme end of the continuum with low affective reactivity and empathy. Additionally, when fear was presented as a distractor, this effect held only when lifestyle-antisocial traits were low. However, hypothesised effects were not significant when using RT differences (between the emotional and all-neutral conditions), which would have been the strongest evidence in favour of predictions.

Task main effects and interactions replicated many of the effects demonstrated by Hodsoll et al. (2011). As found previously, mean RTs to angry distractors were significantly longer compared to all-neutral and angry target faces. We also found emotional capture by fearful stimuli relative to all-neutral faces, although the effect for distractor stimuli relative to neutral was at trend, and longest RTs in the fearful condition were seen in response to fearful target faces. One explanation for our findings comes from evolutionary accounts of threat processing (Öhman, Flykt, & Esteves, 2001). Compared to angry facial expressions which depict direct threat, fearful expressions indicate indirect threat; thus an adaptive action would be to rapidly shift attention away from a fearful face and into the local visual environment in order to locate the source of the threat. Consistent with this notion, it could be that RTs were longer when identifying the target face in the present study as attention was directed first to the fearful target, then elsewhere in the environment, reflecting a 'bottom-up' shift in attention, followed by a 'top-down' shift back to the target. Another possibility is that effects for fearful distractors appeared weaker because they were more strongly modulated by individual differences, discussed below. Similar to Hodsoll et al. (2011), we also found that emotional capture (specifically slower RTs) occurred only for negative stimuli; however, we did not replicate their finding of a facilitatory effect (i.e. faster RTs) for happy faces.

As predicted, the extent of emotional capture by fearful faces (both as distractors and targets) decreased with increasing affective-interpersonal traits. This supports previous studies showing reduced attention to emotional stimuli in extreme samples (e.g. Hodsoll et al., 2014; Sylvers et al., 2011; Verona et al., 2012), and extends these findings to show a continuous effect in a general sample. It further supports the notion that those high in affective-interpersonal traits have specific difficulties in fear processing (Blair et al., 2004; Veit et al., 2013), as the psychopathy findings did not extend to the angry condition, despite anger capturing attention in the task. This reflects meta-analytic findings showing that the processing of angry expressions remains intact while fear and sadness are impaired in individuals with psychopathy (Dawel, O'Kearney, McKone, &

Palermo, 2012; Marsh & Blair, 2008). The mechanism by which attention is captured by fear, perhaps through differential amygdala activation by fear (Moul, Killcross, & Dadds, 2012), may be different to that of anger and this is what varies with affective-interpersonal traits. If affective-interpersonal traits were related to a more general attention-processing deficit as suggested by the Response Modulation theory, it would have been expected that faster RTs would have been observed across all three emotions. As the findings were specific to fearful faces, it suggests that the effects are being driven by emotion processing, rather than an attentional deficit. Furthermore, the Response Modulation theory states that individuals with psychopathic traits have difficulty shifting attention to non-task relevant stimuli, however we found emotion capture by target faces as well, suggesting that emotion may be being processed to a lesser extent even when it appears in a task-relevant location.

Contrary to previous findings (e.g. Seara-Cardoso et al., 2012), the lifestyle-antisocial facet did not correlate positively with RTs in the angry and fearful conditions, and there were no associations between emotional capture and unique variance associated with either facet after controlling for the other. However, moderation analysis showed that the negative relationship between affective-interpersonal traits and RTs in the presence of fearful distractors held only when lifestyle-antisocial traits were low. This is in line with Maes and Brazil's (2015) findings of differential relationships between affective-interpersonal traits and emotional distraction depending on levels of lifestyle-antisocial traits.

One possible interpretation is that, if lifestyle-antisocial psychopathic traits are high, greater reactivity associated with antisocial behaviour counteracts diminished reactivity associated with affective-interpersonal traits (Maes & Brazil, 2015). Faster RTs in participants high in lifestyle-antisocial traits regardless of affective-interpersonal trait scores may well have resulted from a speed-accuracy trade-off (Wickelgren, 1977) specific to these participants. This may reflect greater impulsivity, which is strongly associated with lifestyle-antisocial aspects of psychopathy (Hare, 2003). This moderation effect was not found for the fearful target condition, and the only previous study to report a similar effect (Maes & Brazil, 2015) also found it in the presence of emotional distractor stimuli (emotional pictures), although no equivalent target condition was included. The specificity of this effect requires further investigation.

It is worth noting that the range of SRP-III-SF scores seen in the present study are very similar to those previously seen in seen in community samples, enabling comparisons across studies (e.g. Seara-Cardoso et al., 2012). However, while a strength of this study is that it extends findings from the clinical range to a community sample, future research could use a broader sample, including participants across the typical and atypical range of psychopathic traits.

A key limitation of the present study is that we did not see the hypothesised relationships with psychopathic traits when looking at RT difference scores (fearful - neutral), which would have represented the strongest evidence for individual differences in emotional capture. However, relationships between RTs and affective-interpersonal scores were only found in the presence of fearful distractors/targets, and not all-neutral trials presented within the same block. This suggests some specificity for diminished emotional capture by fear, as opposed to a more general speeding effect across the entire fear block in those with higher affective-interpersonal traits. The predicted moderation effect was also only seen in response to fearful distractors, and not for any other condition or emotion. Another potential limitation is that our individual difference findings would not survive multiple comparison correction across all correlations conducted. However, it is worth noting that significant results were seen only for analyses for which we had the strongest a priori hypotheses (i.e. those involving fear), and in the predicted direction.

Regarding anxiety, we predicted that trait anxiety would be associated with increased RTs, particularly in response to negative stimuli. However, this relationship was not seen, either for individual conditions or difference scores relative to neutral. For some individual conditions, anxiety was associated with faster RTs. A potential explanation is that trait anxious individuals rapidly scan the environment (Eysenck, 1992) which may result in faster performance on aspects of visual search. Given that reaction time measures as implemented in the current task cannot fully delineate the time course and components of attentional bias, this explanation is speculative. A more direct and continuous measurement of overt visual attention, such as eye tracking, may provide an important supplement to these measures, particularly in the characterisation of specific effects concerning emotional distractors vs. targets.

In sum, this study replicates the majority of the emotional capture effects observed by Hodsoll et al. (2011), and demonstrates that attentional capture by fearful faces is reduced with increasing levels of affective-interpersonal psychopathic traits in a community sample. This effect was moderated by lifestyle-antisocial traits, but not by commonly co-occurring trait anxiety. Overall, variation in emotional capture across the normative continuum of psychopathic traits appears in line with findings at the clinical end of the spectrum.

Chapter 3: Modulation of emotional capture by varying cognitive load

3.1 General Introduction

Following on from Chapter 2, which looked at implicit emotion regulation in the context of emotional capture, this study further investigates what influences the tendency for emotion to capture attention and interfere with task performance. In line with previous studies, we demonstrated that emotion can capture attention even when it is task-irrelevant, and further showed that these effects may be modulated by individual differences in aggressive traits. However, a key question is to establish whether this task-irrelevant information can be filtered out under different task conditions. In this study, four behavioural experiments are conducted in order to investigate the task conditions under which levels of cognitive load influence emotional capture effects.

According to attentional load theory (Lavie, 1995), increasing attentional load, for example by increasing the difficulty of a task, reduces the capacity for processing extraneous cues, as processing resources are occupied by the main task (Murphy, Groeger, & Greene, 2016). This concept also applies to situations in which the extraneous cue is affective in nature. For example, Erthal et al. (2005) asked participants to determine whether two peripheral bars were oriented in the same direction while ignoring unpleasant or neutral photos, which were positioned in between the bars. When the task was simple, task-irrelevant unpleasant photos slowed reaction times relative to neutral photos, however when the bar angles were changed and the task difficulty increased, there was no difference in reaction times between unpleasant and neutral photos, suggesting that the processing of affective stimuli depends on the availability of sufficient attentional resources. This finding is noteworthy as it demonstrates that emotionally salient cues do not have privileged attentional access and are susceptible to load effects, as are non-emotional stimuli.

This pattern of effects does not seem to be limited specifically to *perceptual* load tasks such as the bar orientation task above, as might be predicted by attentional load theory (Lavie, 2005), but also seems to occur when *cognitive* load (e.g. executive demands such as cognitive conflict) is manipulated. For example, in a priming study (Hart, Green, Casp, & Belger, 2010), participants had to indicate the number of items presented in congruent (i.e. the digit 4 in an array of 4) or incongruent (i.e. the digit 4 in an array of 3) arrays during a number Stroop task. They found that when task-irrelevant unpleasant photos preceded Stroop trials, processing of emotional stimuli affected cognitive control task performance only under low cognitive demand (congruent trials). When cognitive demand increased (incongruent trials), the adverse effect of emotional stimulation on cognitive function was counteracted.

This pattern of results is in line with several neuroimaging studies which have found that amygdala response to task-irrelevant emotional stimuli can be attenuated by increasing either perceptual or cognitive load via task demands (e.g. Bishop, Jenkins, & Lawrence, 2007; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Mitchell et al., 2007; see Murphy et al. 2016, for a review). For instance, when participants performed a demanding bar-orientation task in which they had to indicate whether the bars were of similar orientations (i.e., both close to horizontal or both close to vertical) or of dissimilar orientations in the presence of fearful and neutral faces, no differential amygdala activation was observed for (unattended) fearful relative to neutral trials (Pessoa et al., 2002). In contrast, when the task was less demanding (determining the sex of the emotional faces) the amygdala responded differentially to (attended) fearful faces relative to neutral. A similar effect was shown by Mitchell et al. (2007), but using a cognitive load manipulation (gender decision vs. case and syllable decision task, using letters superimposed on emotional or neutral faces). However, in both studies, the emotional stimuli (i.e. faces) were task-relevant in the attended condition but task-irrelevant in the unattended condition. Such task-related differences make the interpretation of findings less straightforward as the decision type varies among conditions (e.g. determining sex versus determining bar orientation) (Compton, 2003). Using a task where conditions were matched more similarly, Bishop et al. (2007) conducted a letter search task of low (search for an X or N among an array of only Xs and Ns) or high (search for an X or N among an array of several non-target letters) load superimposed on fearful or neutral face distractors. They found increased right amygdala activation to fearful faces on low load trials relative to high load trials, replicating the findings of Pessoa et al. (2002).

Taken together, these studies all show that as task demands increase, emotional interference effects are reduced, both behaviourally and neurally. However, in all of the studies mentioned, there have been differences between the task-relevant stimuli and emotional distractors (e.g. letters, bars and numbers as task-relevant stimuli, and faces and photos as emotional distractors). Therefore it is possible that high attentional load only decreases processing of the emotional distractor if there is some degree of separation between the target and the distractor. Under these conditions, there could be subtle differences in the perceptual processing of the emotional stimuli under low vs. high load that gives rise to the effect, as opposed to the effect being due to varying load per se.

To investigate whether reduced interference by emotion under high (vs. low) cognitive load occurs using a paradigm where perceptual inputs were matched across conditions, Sebastian, McCrory, De Brito and Viding (2017) developed a cognitive conflict task based on the Simon effect of spatial compatibility (Simon & Wolf, 1963). The Simon effect represents the very robust finding that responses where the stimulus location and the response location correspond (compatible trials, e.g. a dot appears on the left hand side of the screen and a left button-press responses is required) are generally faster than responses where the location of the stimulus and the response key do not correspond (incompatible trials). In the study participants were presented with pairs of male-female faces that were either emotional or calm in expression, and were instructed to identify the target gender (e.g. male) and indicate whether it was tilted to the left or right (see *Figure 3.1*). In compatible trials, the target face was located on the same side to which it was tilted (e.g. on the left and tilting left), and was therefore classed as low load, since location and response were the same; while on incompatible trials the target face was on the opposite side (e.g. on the right and tilting left) and thus classed as high load, since location and response were opposed. Crucially, task-relevant information (gender) and task-irrelevant emotion were co-localised to the same stimulus, and in order to identify the target's gender, the facial stimuli needed to be scanned to the same degree and in the same way on both compatible and incompatible trials. Therefore the perceptual processing of task-irrelevant emotion was matched across conditions. The findings from this task were in line with previous studies showing that there is reduced interference from emotion under high cognitive load. Specifically, response to fearful facial expressions was attenuated under high (vs. low) cognitive load conditions, as indexed by both reaction times (relatively faster under high load) and reduced right amygdala response. In contrast, fear processing under low load was associated with reaction time interference, increased amygdala response, and increased functional coupling between the amygdala and the middle frontal gyrus, a prefrontal region commonly associated with emotion regulation.

This finding suggests that the load effect seen in previous studies is not solely the result of differing perceptual inputs. However, it is still unclear what exactly is driving the effect. Even though perceptual inputs remained constant in Sebastian et al.'s study, there are still other factors that can be manipulated to better understand the conditions under which the effect is elicited. In the above study, stimulus presentation was blocked by both emotion and load. This leads to the possibility that top-down effects could be contributing to the findings, such that participants "expect" the same trial type (i.e., high or low load) to be repeated. Thus top-down control could be being imposed in a prospective manner across the whole block, with the greatest level of control implemented on high load fear blocks (leading to reduced interference).

If this is the main mechanism driving the observed effects in the above study, then we would predict that the effect would not hold if high and low load trials were intermixed. In this case, expectancies would be generated on a trial-by-trial basis, making it difficult to impose a top-down cognitive prediction or 'set' that could be applied to several trials of the same type. Instead we might predict that there would be RT interference effects on both low and high load emotional trials. Indeed, using a non-emotional visual search task, Theeuwes, Kramer and Belopolsky (2004) found that when conditions were presented in separate high and low load blocks, distractor interference was greater under low load relative to high load conditions, in line with the perceptual load theory. In contrast, when high and low load trials were intermixed within blocks this effect disappeared; participants were just as likely to show interference from the distractor in both conditions. Therefore under high load, expectancies appear to play an important role in determining the extent of processing of task-irrelevant distractors.

Given these findings, we investigated whether Sebastian et al.'s (2017) results showing reduced emotional capture under high cognitive load replicates and generalises across different experimental conditions. In Experiment 1 we used the same blocked design as Sebastian al., however in Experiments 2, 3 and 4 we randomised stimulus presentation across emotion and load conditions in different configurations to understand under which conditions emotional capture and load effects held.

A second aim of the present study was to investigate the role of individual differences, specifically sub-types of aggression, as they are associated with variation in emotional capture effects (See Chapter 1 section 1.5.1 and Chapter 2). To date there has been no research on the influence of aggression on the processing of emotion under differing cognitive load. There have been studies, however, looking at trait anxiety – an individual difference that has shown to have similar underlying neural mechanisms to reactive aggression (Coccaro et al., 2007; Davis & Whalen, 2001; See Chapter 1.5.1.3). For example, using an N-back task, Vytal, Cornwell, Arkin and Grillon (2012) found that anxiety impaired task performance (i.e. longer RTs) under low but not high cognitive load. Several other studies have found similar behavioural and neural effects (e.g. Bishop et al., 2007; Dvorak-Bertsch et al., 2007; Shackman et al., 2006). According to Bishop (2009), anxiety has a greater impact on low load conditions as cognitive resources are divided between the task and trait anxiety. The continuous low level diversion of resources (e.g. monitoring the environment for threats, Eysenck, 2013) associated with trait anxiety may lead to poor recruitment of attentional control processes required to prevent distractors from competing for further attentional resources. In contrast, during high load conditions, cognitive resources are predominantly focussed on task demands, thus reducing the impact of anxiety.

Based on the findings by Theeuwes et al. (2004), we hypothesised that task-irrelevant emotion will interfere with reaction times only during compatible trials (i.e. low load) when conditions are blocked (Experiment 1) but when conditions are inter-mixed (Experiments 2, 3 and 4) this interference will be apparent during both compatible and incompatible trials. Furthermore based on the anxiety findings above, and building on the results of Chapter 2, we predicted that when conditions are blocked (Experiment 1) high levels of reactive aggression (indexed by lifestyle-antisocial traits on the Self-Report Psychopathy Scale, and the Buss-Perry Aggression Questionnaire) would be associated with increased distraction by emotional faces only in the compatible trials, where cognitive load is low. In contrast, proactive aggression, (indexed in this study by affective-interpersonal psychopathic traits), tends to be associated with opposing levels of emotional reactivity (Blair et al., 2004; Veit et al., 2013; see Chapter 2) and therefore we predicted that affective-interpersonal traits would be associated with reduced distraction by threatening stimuli (i.e. angry and fearful faces), regardless of load. For the purposes of comparison with previous studies and as a control variable, anxiety is also measured and is predicted to have the same effects as reactive aggression. Predictions regarding aggression and anxiety for the following experiments will depend on whether the predictions for Experiment 1 are supported.

3.2 Experiment 1

3.2.1 Introduction

As discussed above, in Experiment 1 we aimed to replicate the effects of reduced emotional capture under high cognitive load found by Sebastian et al. (2017), using the same task in which individual emotion conditions of high and low cognitive load were presented in separate blocks of trials. Moreover, the role of individual differences in aggression and anxiety in relation to emotional capture were investigated as previous studies have found that such individual differences only influence task performance under low cognitive load (e.g. Vytal et al., 2012).

3.2.2 Method

3.2.2.1 Participants

Forty-two university students were recruited from Royal Holloway University of London, and received course-credit or £3 for participation. This sample size was comparable to previous similar studies investigating individual differences in anxiety (e.g. 39 participants in Vytal et al.'s study) and double that of Sebastian et al.'s original study (20 participants), partly to maximise the chance of detecting the hypothesised effect if present (Simonsohn, 2015), and partly as greater power was needed to detect potentially small individual difference effects. Six were excluded due to error and missed trial rates that were greater than 2.5 standard deviations above the group mean. Data from a final sample of 36 participants (15 males, mean age 19.92, *SD*=2.82, range=18-30) were analysed.

3.2.2.2 Stimuli

Stimuli consisted of 48 grey-scale faces of two male and two female identities each with different facial expressions depicting three emotions: fear, anger and calm. The expressions were chosen from the standardised NimStim face set (Tottenham et al., 2009). The calm faces are a distinct set in the NimStim from neutral; while perceptually similar to neutral expressions, calm expressions tend to be perceived as having a less negative valence as there is less overall muscle tension in the face. The current study used the same calm expressions (as opposed to the neutral expressions used in Chapter 2) as Sebastian et al.'s (2017) study. An oval cut-out was placed on each face to remove gender specific information, such as hair. Each face oval measured 6x4cm. All faces were presented in male and female pairs with identical expressions and were tilted 35° to the left or 35° to the right (see *Figure 3.1*). There were eight possible pairs (each male with each female) for each facial expression at each level of cognitive load (high or low i.e. compatible or non-compatible), with 64 images in total. Face pairs were presented on a white background measuring 606 x 349 pixels.

3.2.2.3 Task design and procedure

Task procedures and design followed Sebastian et al. (2017). The task consisted of six blocks of trials, one block for each emotion (calm, anger and fear) x load (low, high) condition (8 trials per block), in order to replicate the original task which was set up as an fMRI block design. These six blocks (48 trials in total) were presented three times in a pseudorandomised order each time (144 trials). Randomisation was constrained so that no more than two of the same block type (e.g. fear/compatible) were presented sequentially. Within each block, randomisation was constrained so that all left (or right) response trials were not presented sequentially. Participants completed two runs of the task (288 trials in total).

Each trial was presented for 2000ms, followed by a fixation cross presented for 500ms. After every 48 trials a fixation cross was displayed for 10 seconds as a short break. Participants were given clear instructions beforehand to search for the target face (either male or female; counterbalanced across participants and stratified by gender) and indicate on the keyboard using their dominant hand whether the target face was tilting left or right. On compatible trials, the target face was located on the same side to which it was tilted (e.g. on the left and tilting left); while on incompatible trials the target face was on the opposite side (e.g. on the right and tilting left). This set up a spatial incompatibility between the required response and its location. Participants viewed the task on monitor of 1920 x 1090 pixels. The task was presented and responses were recorded using Cogent 2000 for Matlab (version R2015a).

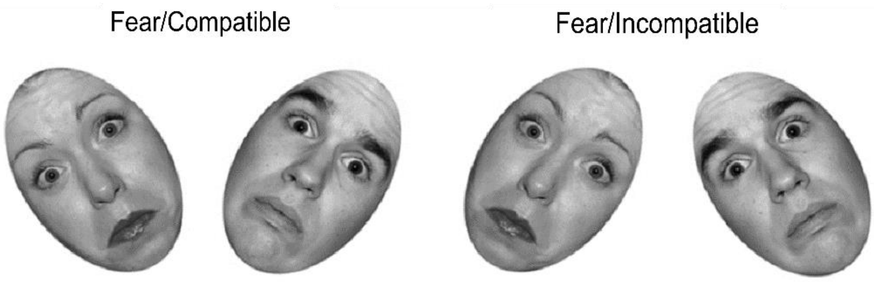


Figure 3.1. Example of the experimental task stimuli. Each stimulus consisted of two faces; one male, one female. Participants were instructed to identify the face of the target gender (counterbalanced across participants) and indicate with a button press whether it was tilted to the left or right. Facial identities are those for which permission is given to publish from the NimStim, and differed from the identities used in the study.

3.2.2.4 Individual differences measures

Aggression was assessed using The Buss-Perry Aggression Questionnaire (Buss & Perry, 1992), which is a 29-item scale that measures four aspects of human aggression: Physical Aggression, Verbal Aggression, Hostility, and Anger (Appendix 1c). These aspects map onto reactive aggression, as discussed in Chapter 1 (section 1.5.1.3). Participants are asked to rate each item using a 5-point Likert scale (1 = uncharacteristic of me, 5 = very characteristic of me). The Self-Report Psychopathy Scale-III Short Form (SRP-III-SF; Paulhus et al., in press) and the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) were also administered, as in Chapter 2 (see section 2.2.3 for more details) to measure both proactive and reactive aggression, and anxiety, respectively.

3.2.2.4 Data analysis

Behavioural data were analysed using repeated measures ANOVAs on mean correct reaction times (RTs) after removing missed trials and extreme individual RTs (<200ms or >1500ms), and error rates. Pairwise comparisons were Bonferroni corrected. Individual differences data were correlated with the difference in RTs between the negative emotional conditions (fear and anger) and calm.

3.2.3 Results

Missed trials were low overall (0.72%). For errors, a 2x3 Compatibility (compatible, incompatible) x Emotion (fear, anger, calm) repeated measures ANOVA on error rates revealed a main effect of Compatibility: $F(1, 35)=17.03$, $p<.001$, partial $\eta^2=.33$, with significantly fewer errors made on compatible (M=1.12%, SD=1.65) than incompatible trials (M=4.71%, SD=6.17 $p<.001$). The difference in error rates between incompatible and compatible trials was significant for all three emotion face types (*ps*<.005). There was no main effect of Emotion, or interaction between Compatibility and Emotion.

A 2x3 Compatibility (compatible, incompatible) x Emotion (fear, anger, calm) repeated measures ANOVA on mean correct RTs revealed a main effect of Compatibility: $F(1, 35)=96.10$, $p<.001$, partial $\eta^2=.73$, with RTs significantly faster on compatible (M=762ms, SD=112) than incompatible trials (M=834, SD=110 $p<.001$). The difference in RTs between incompatible and compatible trials was significant for all three emotion face types (*ps*<.001). There was also a significant main effect of Emotion: $F(2, 70)=11.53$, $p<.001$, partial $\eta^2=.25$, with RTs significantly slower for anger trials (M=816, SD=113) relative to calm (M=791, SD=111, $p<.001$) and fear (M=785, SD=110, $p=.001$), however there was no significant difference in RTs between fear and calm ($p>.99$).

There was also a significant interaction between Compatibility and Emotion: $F(2, 70)=6.13$, $p=.004$, partial $\eta^2=.15$ (*Figure 3.2*). We ran post-hoc t-tests to further investigate the interaction effect by determining whether the difference in RTs between compatible and incompatible trials for fear and anger significantly differed from that of calm by computing difference variables. Indeed this was the case, with the difference in RTs between compatible and incompatible trials for calm (calm compatible: *M*=741, *SD*=110; calm incompatible: *M*=841, *SD*=112; difference: *M*=100, *SD*=50) being significantly greater than the difference for fear (fear compatible: *M*=754, *SD*=116; fear incompatible: *M*=816, *SD*= 103; difference: *M*=61, *SD*=68; $t(35)=3.28$, $p=.007$) and anger (anger compatible: M=790, SD=109; anger incompatible: *M*=844, *SD*=116; difference: *M*=54, *SD*=77; $t(35)=3.11$, $p=.011$). There was no difference between anger and fear ($t(35)=.49$, $p>.99$) (see *Figure 3.2*).

Pairwise comparisons of simple effects (see *Figure 3.2*) further revealed that during the compatible blocks RTs for anger trials were significantly longer relative to fear trials ($p=.001$) and calm trials ($p<.001$), however fear trials were not significantly different from calm trials ($p=.44$). In contrast, during the incompatible block RTs for anger trials were not significantly different from fear ($p=.10$) or calm trials ($p>.99$), however fear trials were faster than calm trials ($p=.015$).

Individual differences

There were no significant correlations between any of the questionnaire measures and the difference in RTs between the negative emotional conditions (fear and anger) and calm.

There were no significant differences in RTs between males and females (*ps*>.05) thus for the following experiments we used a convenience sample which were predominantly female.

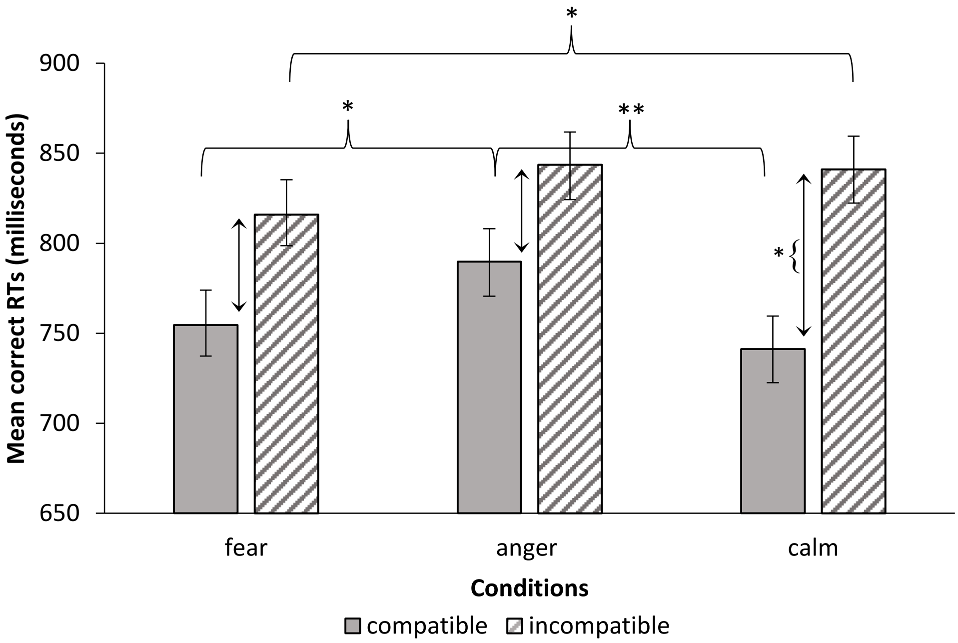


Figure 3.2. Mean RTs (ms) for correct trials across all conditions, showing a significant interaction between Compatibility and Emotion. The difference between Compatibility conditions was significantly greater for calm than for fear or anger, as indicated by *{ (p<.05). Within Compatibility conditions, differences between emotions were also seen. Main effects of both Compatibility and Emotion were found. ***p<.001, *p <.05.*

3.2.4 Discussion

As would be expected due to the relative difficulty of the task, reaction times for incompatible trials were longer compared to compatible trials. We also found a main effect of Emotion, driven by slower RTs to angry faces relative to both calm and fearful faces, with no difference between fear and calm trials. In line with Sebastian et al.'s (2017) study, the interaction between Compatibility and Emotion was significant; however while the original study found an effect for only fear, we also found it for anger. For both fear and anger, RTs were disproportionately slow in the compatible relative to the incompatible condition, with a significantly larger RT difference seen between the two calm conditions. This suggests that attention was captured disproportionately by emotion on less demanding (compatible) trials, replicating and extending the original effect found by Sebastian et al. using a larger sample.

However, some differences were also seen. For example, Sebastian et al. (2017) found no significant differences between RTs on fear, anger and calm conditions during the incompatible blocks (i.e. attention was not captured by task-irrelevant emotional stimuli (relative to calm) under high cognitive load). However, while there was no difference between anger and calm incompatible trials in the present study, reaction times to incompatible fear trials were significantly *faster* compared to incompatible calm trials, suggesting if anything a facilitation effect for this condition. Findings have shown that fearful expressions gain preferential access to awareness (Yang, Zald, & Blake, 2007), which may explain the faster reaction times; albeit speculatively since this result was not in line with predictions. Regarding compatible trials, the previous study found slower RTs on fear compatible trials relative to calm compatible trials (another line of evidence suggesting increased emotional capture specifically on compatible trials), whereas the current study found this effect for anger but not fear. Overall however, the evidence of a smaller difference between compatible and incompatible RTs for fear and anger relative to calm replicates and extends (to anger) the previous pattern of results.

These findings are in line with previous studies (e.g. Bishop et al., 2007; Hart et al., 2010; Pessoa et al., 2002) that have shown that interference from distractors (e.g. emotional faces) is decreased under high load. Since perceptual inputs were matched across conditions, a ‘bottom-up’ explanation, i.e. that perceptual inputs differ in some way, is unlikely (although without eye-tracking measures, this cannot be conclusively shown). Therefore it can be hypothesised that a top-down mechanism is involved whereby a cognitive ‘set’ or prediction is created as a result of the blocked nature of the design. On incompatible (high load) conditions, processing resources may be ‘pre-allocated’ to resolving the cognitive conflict, thereby reducing the capacity for processing the emotional information, or even actively suppressing this processing. However, during compatible (low load) trials, greater attentional capacity is available, leading to processing of the emotional information which then interferes with task performance relative to calm trials (i.e. emotional capture). In support of this explanation, Etkin et al. (2006, see section 1.3 for study details) found that the repetition of high load stimuli in an emotional Stroop task, engaged an anticipatory top-down mechanism likely implemented by the rostral anterior cingulate cortex, which facilitated performance. Thus while the task was different to the current experiment, the mechanism underlying the effect is likely to be similar.

Finally, despite predictions, there were no significant individual difference findings. It is possible that the task is not sensitive to the individual differences of interest, at least in the general population. While previous studies (e.g. Bishop et al., 2007; Dvorak-Bertsch, et al., 2007; Shackman et al., 2006; Vytal et al., 2012) have found that trait anxiety affects performance during low but not high load conditions, it is possible that aggression does not interact with the task in the same way. While we also measured trait anxiety and did not replicate previous effects, this may be because the top-down mechanisms likely underlying the basic task effects in the current study are not the same as those underlying task effects in these previous studies, in which perceptual inputs also differed across conditions. The lack of individual difference results gave us limited scope to formulate hypotheses for the following experiments, therefore the following experiments focus solely on task effects.

The findings of the current experiment broadly replicate the effects reported by Sebastian et al. (2017). As perceptual inputs were matched across conditions, a likely explanation of the key interaction effect is that the blocked nature of the task led to top-down control being imposed prospectively across the block. Therefore it can be predicted that removing the blocked structure would eliminate the effect found. This is addressed in Experiment 2 where all trials (compatible/incompatible, fear/anger/calm) are intermixed and randomised. In order to systematically investigate the conditions under which the effect of interest is found, in Experiment 3 emotion is blocked while load is randomised, and in Experiment 4 load is blocked while emotion is randomised. This will allow us to uncover what the most important factor is in the reduced interference effect from emotion seen under high (vs. low) cognitive load.

3.3 Experiment 2

3.3.1 Introduction

Experiment 1 found that under high load, emotional capture by angry and fearful faces appears comparatively reduced, as indicated by disproportionately slow RTs on compatible trials relative to incompatible trials. However, as demonstrated in the (non-emotional) study by Theeuwes et al. (2004), when high and low load trials are randomised this interference effect can disappear: participants were just as likely to show interference from the distractor in both high and low load conditions. The findings of Theeuwes et al. suggest that when high and low load trials are randomised, expectancies must be generated on a trial-by-trial basis, making it difficult to impose a top-down cognitive set that could be applied to several trials of the same type. Therefore if this is indeed the case, it would be predicted that an inability to make use of this strategy when trials are randomised would lead to interference from emotion in both high and low load trials in the present experiment.

If cognitive load per se determines whether or not emotion is processed, presenting high and low load conditions in mixed (current experiment) or in blocked (Experiment 1) conditions should result in the same pattern of findings. In contrast, if *expectation* of a high or low load trial influences the extent to which task-irrelevant emotion is processed, then mixed trial blocks that make it difficult to anticipate trial type in advance might be expected to result in emotion interference or 'capture' effects on both low and high load trials. Thus, we would not expect to see either a) a smaller difference between RTs on compatible vs. incompatible trials on emotional relative to calm trials or b) increased RTs on emotional compatible trials relative to calm compatible trials in the absence of such effects for incompatible trials, both of which were observed in Experiment 1 and by Sebastian et al. (2017). Consequently in Experiment 2, trials were fully randomised across Compatibility and Emotion.

3.3.2 Method

3.3.2.1 Participants

A total of 41 (3 males, mean age=18.68, *SD*=1.46, range=18-27) participants were recruited in the same manner as for Experiment 1 and data for all participants were analysed.

3.3.2.2 Stimuli and procedure

The stimuli, design, and procedure were exactly the same as in Experiment 1. However the presentation of the six different trial types (fear compatible, fear incompatible, anger compatible, anger incompatible, calm compatible and calm incompatible) was randomised. Randomisation was constrained so that no more than two of the same trial type were presented sequentially.

3.3.3 Results

Missed trials were low overall (0.43%). For errors, as with Experiment 1, there was a main effect of Compatibility: $F(1, 40)=41.71$, $p<.001$, partial $\eta^2=.51$, with significantly fewer errors made on compatible ($M=1.24\%$, $SD=2.37$) than incompatible trials ($M=5.34\%$, $SD=5.28$, $p<.001$). The difference in error rates between incompatible and compatible trials was significant for all three emotion face types (*ps*<.001). There were no other significant effects.

Replicating the results of Experiment 1, there was a significant main effect of Compatibility ($F(1, 40)=98.32$, p<.001, $\eta^2=.71$) with RTs significantly faster for compatible trials ($M=803$, $SD=115$), compared to incompatible trials ($M=868$, $SD=119$; $p<.001$). There was also a significant main effect of Emotion ($F(2, 80)=18.61$, $p<.001$, partial $\eta^2=.32$) with RTs significantly slower for anger trials ($M= 853$, $SD=116$) relative to calm ($M=828$, $SD=118$, $p<.001$) and fear ($M=827$, *SD*=118, *p*<.001); however there was no significant difference in RTs between fear and calm (*p*>.99).

There was, however, no significant interaction between Compatibility and Emotion (*F*(2, 80)=1.36, *p*=.26, partial η^2=.03). As with Experiment 1, we ran post-hoc tests and found that there were no significant differences in the RT difference between compatible and incompatible trials for calm (calm compatible: *M*=791, *SD*=118; calm incompatible: *M*=864, *SD*=117; difference: *M*=73, *SD*=50) and fear (fear compatible: *M*=798ms, *SD*=118; fear incompatible: *M*=856, *SD*= 118; *M*=58, *SD*=57; *t*(40)=1.56, *p*=.38) or calm and anger (anger compatible: *M*=822, *SD*=109; anger incompatible: *M*=884, *SD*=123; difference: *M*=62, *SD*=54; *t*(40)=1.08, *p*=.85), in contrast to the findings of Experiment 1. There was also no difference between fear and anger (*t*(40)=-.48, *p*>.99) (*Figure 3.3*).

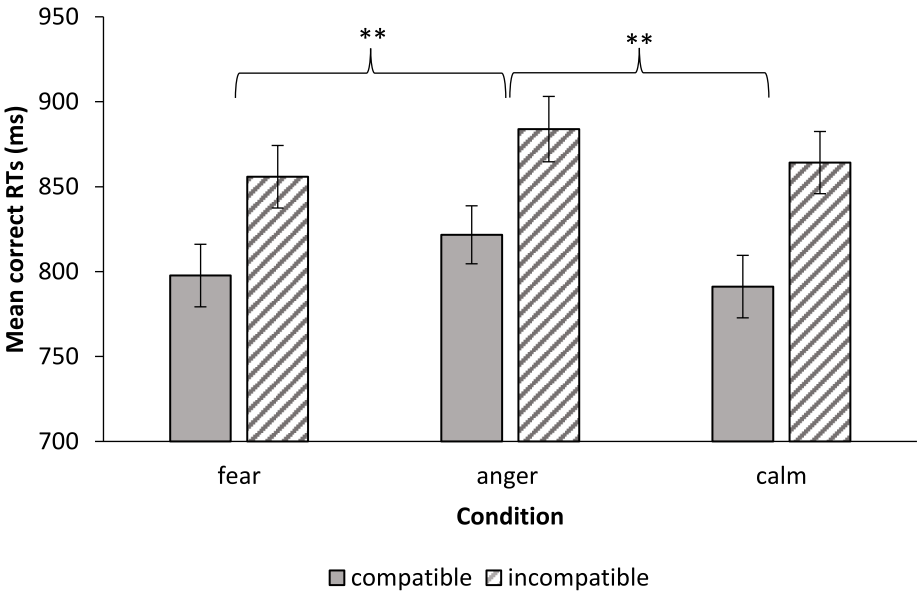


Figure 3.3. Mean RTs (ms) for correct trials across all conditions when all trials were randomised. Brackets indicate main effects of Emotion, ***p<.001*. For every Emotion there was also a main effect for Compatibility (*ps*<.001).

3.3.4 Discussion

Similar to the findings of Experiment 1, RTs for incompatible trials were longer compared to compatible trials, and RTs to angry faces were longer relative to calm and fearful faces. The interaction between Compatibility and Emotion, however, was not significant and similar patterns were observed across both compatible and incompatible trials. Therefore, despite individual trials being identical to those in Experiment 1, we did not see disproportionately slow RTs on fear and anger (emotional) compatible trials when presentation of all trial types was randomised. If cognitive load had been the only factor determining the extent to which emotion interfered with task performance, the effects of Compatibility should have been the same in the two experiments. It is likely that in randomising stimulus presentation, participants were unable to engage differential anticipatory top-down cognitive control processes for high vs. low load trials, leading to equivalent interference effects on both low and high load trials.

Previous studies which have used event-related designs and manipulated cognitive load have found similar behavioural effects as the present experiment. For example, Mitchell et al. (2007) asked participants to indicate the gender of an emotionally valenced face (low cognitive load), or judge superimposed words based on case (mid load) or judge words based on syllable number (high load). While they found that RTs were slower with increasing load, there was no significant interaction between emotion and cognitive load (although as mentioned above in the General Introduction of this chapter, an interaction was seen in amygdala response). Thus it could be that manipulating cognitive load on a trial-by-trial basis is not sufficient to elicit an interaction effect in the RT data.

In the current study the possibility of a perceptual load effect is removed, as participants have to attend to the emotion-containing stimulus on both high and low load trials equally in order to perform the gender decision part of the trial correctly. Thus when perceptual inputs are matched and it is impossible to use anticipatory cognitive mechanisms, as in the current experiment, the effect of cognitive load disappears. The involvement of a top-down longer-term mechanism was suggested as the likely explanation underpinning the effect found in Experiment 1, and the findings of Experiment 2 show that this *is* likely to be the case. Therefore cognitive load alone (as implemented in the present task) does not seem to elicit the load effects seen in previous studies and it is possible that anticipatory top-down control is what is driving the effects. It is possible that anticipatory top-down effects could also have contributed to the RT results seen in previous studies using both cognitive and (possibly) perceptual load tasks, many of which have blocked the presentation of load and/or emotion (Bishop et al., 2007; Pessoa et al., 2002). Indeed, to our knowledge no study has been published that has found the predicted cognitive load effect in RTs with a fully randomised design (although some studies have found the equivalent effect in amygdala activation e.g. Mitchell et al., 2007).

However, based on Experiment 2 and these previous studies, it is unclear which aspects of block structure are most important. In Experiment 2, two aspects of the task were varied relative to Experiment 1; randomised load, and randomised emotion. Thus in the following studies we systematically investigate whether it is the load randomisation that is the key factor in eliminating the interaction effect, or whether predictability of the emotion is also important.

3.4 Experiment 3

3.4.1 Introduction

As demonstrated in Experiment 2, when high and low load trials are intermixed expectancies seem to be generated on a trial-by-trial basis, making it difficult to predict and switch from different trial types, resulting in interference effects on both low and high load trials. But do we still see this effect if load is intermixed but emotions are blocked? It would be predicted that, like in Experiment 2, randomising load would make it difficult to prepare an anticipatory cognitive set in advance and thus we would see interference effects during both high and low load trials. Therefore in Experiment 3 compatible and incompatible trials were randomised, while emotion was blocked as in Experiment 1. Predictions were as for Experiment 2.

3.4.2 Method

3.4.2.1 Participants

A total of 40 participants were recruited in the same manner as for Experiment 1 and 2. Two participants were excluded due to error and missed trial rates 2.5 standard deviations above the group mean. Data from a final sample of 38 participants (3 males, mean age 18.97, SD=3.77, range=17-41) were analysed.

3.4.2.2 Stimuli and procedure

The stimuli, design, and procedure were identical to that of Experiment 1 and 2 except the presentation of stimuli was blocked by Emotion but Compatibility was randomised. For example, an anger block consisted of 8 anger trials, 4 of which were compatible and the remaining 4 were incompatible. Within each block, randomisation was constrained so that no more than two of the same trial type (e.g. compatible) were presented sequentially.

3.4.3 Results

Missed trials were low overall (0.42%). For the error rates, as with Experiment 1 and 2 there was a main effect of Compatibility: $F(1, 37)=52.29$, $p<.001$, partial $\eta^2=.59$, with significantly fewer errors made on compatible ($M=1.24\%$, $SD=2.68$) than incompatible trials ($M=5.15\%$, $SD=5.69$, $p<.001$). The difference in error rates between incompatible and compatible trials was significant for all three emotion face types (*ps*<.001). There were no other significant effects.

Replicating the results of Experiment 1 and 2, there was a significant main effect of Compatibility ($F(1, 37)=119.39$, $p<.001$, $\eta^2=.76$) with RTs significantly faster for compatible trials ($M=758$, $SD=85$), compared to incompatible ($M=821$, $SD=87$) trials ($p<.001$). There was also a significant main effect of Emotion (F(2, 74)=37.40, p<.001, partial η^2=.50) with RTs significantly slower for anger trials (*M*=817, *SD*=90) relative to calm (*M*=781, *SD*=81, p<.001) and fear (*M*=770, *SD*=88, p<.001), however there was no significant difference in RTs between fear and calm (*p*=.092).

As with Experiment 2, there was no significant interaction between Compatibility and Emotion: *F*(2, 74)=2.27, *p*=.111, partial η^2=.06. As with the previous experiments, we ran post-hoc tests and found that there were no significant differences between the difference in RTs between compatible and incompatible trials between calm (calm compatible: *M*=748, *SD*=81; calm incompatible: *M*=815, *SD*=80; difference: *M*=67, *SD*=43) and fear (fear compatible: *M*=744, *SD*=88; fear incompatible: *M*=797, *SD*=87; difference: *M*=53, *SD*=44; *t*(37)=2.17, *p*=.11) and calm and anger (anger compatible: *M*=783, *SD*=85; anger incompatible: *M*=850, *SD*=94; difference: *M*=67, *SD*=45; *t*(37)=.077, *p*>.99) in line with the findings of Experiment 2. There was no difference between fear and anger (*t*(37)=-1.60, *p*=.36) (*Figure 3.4*).

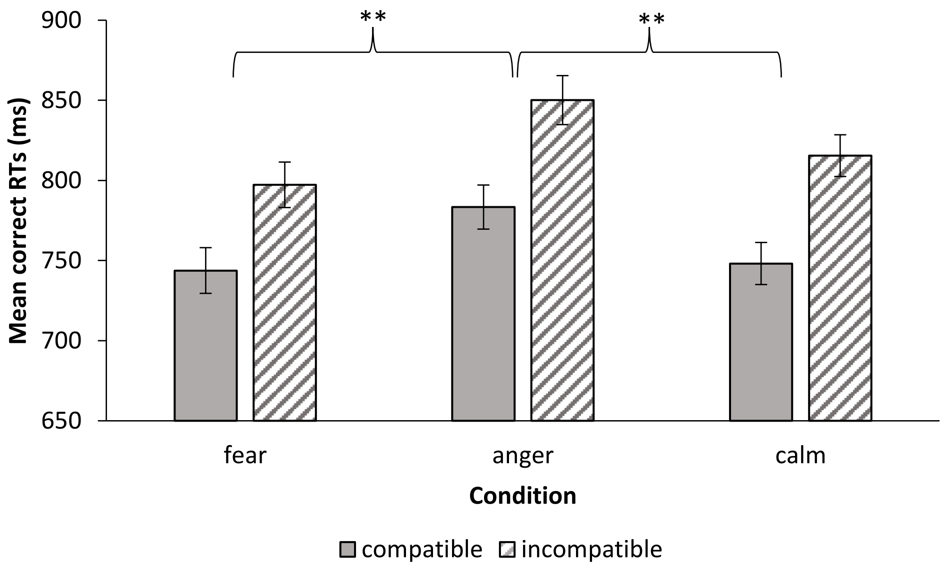


Figure 3.4. Mean RTs (ms) for correct trials across all conditions when Compatibility was randomised and Emotion was blocked. ***p<.001*. Brackets indicating main effects of Emotion ***p<.001*. For every Emotion there was also a main effect for Compatibility (*ps*<.001).

3.4.4 Discussion

Similar to the findings of Experiment 1 and 2, RTs for incompatible trials were longer compared to compatible trials and RTs to angry faces were longer relative to calm faces and fearful faces, but there were no differences in RTs between fear and calm trials. As with Experiment 2 the interaction between Compatibility and Emotion was not significant and similar patterns were observed across both compatible and incompatible trials. This supports the findings of Experiment 2 and previous studies (Etkin et al., 2006; Theeuwes et al., 2004), suggesting that when high and low load trials are intermixed, similar emotional interference effects (in this case limited to anger) occur on both low and high load trials. Further, it suggests that this result is not affected by whether emotion is predictable (blocked) or randomised. In the final experiment we randomise emotion but block high and low load trials in order to investigate whether engaging an anticipatory top-down cognitive set by blocking load is solely responsible for the effects found in Experiment 1.

3.5 Experiment 4

3.5.1 Introduction

So far all predictions have been confirmed, showing that when load is blocked, emotional interference is only seen in low load trials but when load is randomised, the Compatibility x Emotion interaction disappears. In this final experiment load was blocked but emotion was randomised. In theory this blocked load would still enable anticipatory cognitive mechanisms to differentiate between high and low load blocks, and therefore we might expect to see the same results as Experiment 1, regardless of emotion. In line with this, Erthal et al. (2005, see section 3.1 for task details) blocked load but randomised emotion and still found the effect (albeit on a perceptual load task as opposed to a cognitive load task, and only when the bar orientation task was very difficult (experiments 2 and 3)). However, it could be that both load and emotion need to be predictable in order to see the pattern of results in Experiment 1, in which case in the present iteration we would expect results more in line with Experiments 2 and 3.

3.5.2 Method

3.5.2.1 Participants

A total of 40 participants were recruited in the same manner as for Experiment 1, 2 and 3. One participant was excluded due to error rates 2.5 standard deviations above the group mean. Data from a final sample of 39 participants (6 males, mean age 18.97, SD=1.37, range=18-26) were analysed.

3.5.2.2 Stimuli and procedure

The stimuli, design, and procedure were the same as in Experiment 1, 2 and 3. However the presentation of the stimuli was blocked by Compatibility (load) but Emotion was randomised. Within each block, randomisation was constrained so that no more than three of the same emotion type were presented in the same block. For example, a compatible block consisting of 8 compatible trials could consist of 3 fear trials, 3 calm trials and 2 anger trials, all of which were randomised within that block.

3.5.3 Results

Missed trials were low overall (0.28%). For the error rates, as with Experiment 1, 2 and 3 there was a main effect of Compatibility: $F(1, 38)=43.82$, $p<.001$, partial $\eta^2=.54$, with significantly fewer errors made on compatible ($M=1.10\%$, $SD=1.67$) than incompatible trials ($M=4.88\%$, $SD=4.14$, $p<.001$). The difference in error rates between incompatible and compatible trials was significant for all three emotion face types ($ps<.001$). There were no other significant effects.

Replicating the results of Experiment 1, 2 and 3, there was a significant main effect of Compatibility ($F(1, 38)=135.7$, $p<.001$, $\eta^2=.78$) with RTs significantly faster for compatible trials ($M=729$, $SD=120$), compared to incompatible trials ($M=801$, $SD=120$; $p<.001$). There was also a significant main effect of Emotion ($F(2,76)=18.69$, $p<.001$, partial $\eta^2=.33$) with RTs significantly slower for anger trials ($M=784$, $SD=121$) relative to calm ($M=758$, $SD=120$, *p*<.001) and fear (*M*=754, *SD*=118, *p*<.001), however there was no significant difference in RTs between fear and calm (*p*>.99).

As in Experiment 2 and 3, the interaction between Compatibility and Emotion was non-significant ($F(2, 76)=1.90$, $p=.16$, partial $\eta^2=.05$). As with the previous experiments, we ran post-hoc tests and found that there were no significant differences between the difference in RTs between compatible and incompatible trials between calm (calm compatible: *M*=717, *SD*= 116; calm incompatible: *M*=798, *SD*=125; difference: *M*=82, *SD*=52) and fear (fear compatible: *M*=720ms, *SD*=122; fear incompatible: *M*=787, *SD*= 114; difference: *M*=67, *SD*=48; *t*(38)=1.58, *p*=.37) and calm and anger (anger compatible: *M*=750, *SD*=123; anger incompatible: *M*=818, *SD*=120; difference: *M*=67, *SD*=48; *t*(38)=1.59; *p*=.36) in line with the findings of Experiments 2 and 3. There was also no difference between fear and anger (*t*(38)=-.06, *p*>.99) (*Figure 3.5*).

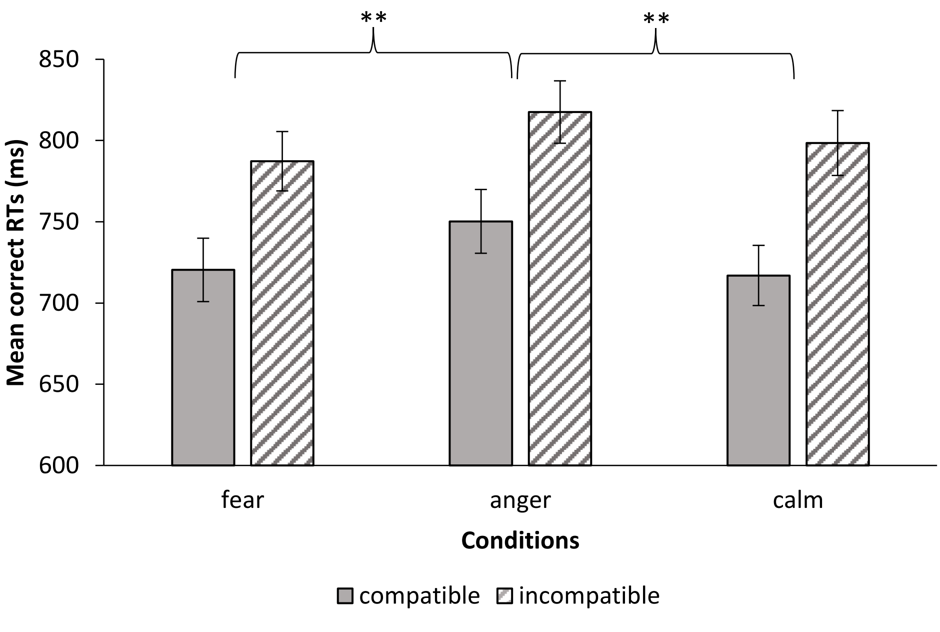


Figure 3.5. Mean RTs (ms) for correct trials across all conditions when Compatibility was blocked and Emotion was randomised ***p<.001.* Brackets indicating main effects of Emotion ***p<.001.* For every Emotion there was also a main effect for Compatibility (*ps*<.001).

3.5.4 Discussion

As with the previous experiments, RTs for incompatible trials were longer compared to compatible trials and RTs to angry faces were longer relative to calm faces and fearful faces, but there were no differences in reaction time between fear and calm trials. As with Experiments 2 and 3 the interaction between Compatibility and Emotion was not significant and surprisingly similar patterns were observed across both compatible and incompatible trials, despite load being blocked. Therefore there was no disproportionate effect of Emotion on low load trials, as was found in Experiment 1.

The findings suggest that the interference effect found in Experiment 1 was not solely due to high and low load trials being blocked but both load *and* emotion being blocked. The lack of an interference effect in the present experiment is in line with the behavioural findings of Pessoa, Padmala and Morland (2005), where facial expression (fearful and neutral) was also randomised within each block of high, medium and low load trials, and no RT effect was found (though the predicted pattern was seen in amygdala response). Therefore it appears that trials within a block need to be the same in all aspects for an anticipatory top-down emotion-specific mechanism to be implemented. If there is a single change, i.e. an emotional face being followed by a non-emotional face, it may be that that this breaks the continuous 'expectancy set'. As with Experiments 2 and 3, this result could be interpreted as showing that expectancies (this time regarding emotion only) were generated on a trial-by-trial basis, making it difficult to predict whether a specific control strategy would be required on subsequent trials. This therefore resulted in similar interference effects on both low and high load trials. It is worth noting, however, that Erthal et al. (2005) did find an RT effect in their last two experiments. Although task difficulty may have been a factor in explaining their results, their task differed from the current study in terms of stimuli and task demands (error rates were much higher than the current experiment, and load was manipulated by varying the difficulty of a perceptual decision rather than manipulating executive demands by varying stimulus-response compatibility); therefore it is difficult to make a direct comparison.

3.6 General Discussion

In the current study four experiments were conducted to investigate the conditions under which interference from emotional distractors can either be elicited or eliminated. In Experiment 1 we found that while RTs were disproportionately slowed by the presence of angry and fearful faces in the low cognitive load condition, they did not appear to be modulated by these emotional faces in the high cognitive load condition, in line with the findings of Sebastian et al. (2017). This finding, however, raised the question of whether the blocked nature of the task led to a top-down anticipatory strategy being imposed across the block and whether removing the blocks would eliminate the effect. We addressed this in a series of three experiments. In Experiment 2 all trials were randomised, and as predicted we found no disproportionate effect of emotion on low load trials. For the following experiments we intended to systematically investigate whether it is the load randomisation that was most responsible for this finding, or whether predictability of the emotion was also important. For Experiment 3 we kept emotion in blocks but randomised high and low load trials and again found the same pattern of results as Experiment 2. Finally, in Experiment 4 cognitive load was blocked but emotion was randomised. Although we predicted that we might see similar results to Experiment 1, as load was blocked, we found RT interference on both low and high load trials. We concluded that trials within a block need to be the same in all aspects (i.e. blocked by load *and* emotion) for top-down control to be imposed in a prospective manner and thus for interaction effects to be elicited, at least when perceptual inputs are also closely matched as in the present task. This is perhaps because a single difference from one trial to the next means that it is impossible to predict whether and how anticipatory top-down mechanisms should be engaged.

A key finding from this study is that when all trials were randomised the interaction effect disappeared. This was in line was the findings of Theeuwes et al. (2004), who used a non-emotional paradigm. They found that when all trial types were randomised, distractors were processed similarly during both high and low perceptual load conditions. They also found that processing of task-irrelevant stimuli for high load trials did occur in this context, but only when the previous trial was a low load trial. When a high load trial was preceded by another high load trial, little interference was observed, and overall no difference between load conditions was seen. An analysis of sequential effects would have been interesting to conduct for Experiment 3, where load was randomised but emotion was still blocked, as the extent to which top-down cognitive sets or strategies are carried over from one trial to the next could have been explored. However this analysis would have resulted in a three-way interaction (Compatibility x Emotion x Trial Type), which we likely did not have enough power for in the present study. Conducting this analysis in future research of this kind using a larger sample size would be beneficial to further understand the conditions under which interference by task-irrelevant stimuli is observed.

Our findings from Experiment 1 support Sebastian et al.'s (2017) data, however one difference was that while their interaction effect was driven by the fear condition, the interaction in Experiment 1 also showed an effect for anger, and there were significant main effects of anger in all four experiments. A large body of literature suggests that there is a bias towards fearful facial expressions relative to neutral and other emotional expressions with some suggesting that the early discrimination of fearful faces is due to signs of threat which rapidly activate neural circuits specialised for detecting danger (e.g. Esteves, Parra, Dimberg, & Öhman, 1994; Öhman & Mineka, 2001; Öhman, 2005). Indeed, experimental behavioural studies have shown that when categorising emotional faces, participants respond more quickly to fear than to anger expressions (Marsh, Ambady & Kleck, 2005). Marsh et al. (2005) suggested that the fear expression may give rise to a facilitatory effect as perceivers are easily primed by the saliency of fear (Yang et al., 2007). On the other hand, anger may make the expresser appear more aversive thus leading to avoidance-related behaviours. Although this is not direct evidence for our findings, it does suggest an explanation for the current findings, in which anger interfered with task performance to a greater extent than fear across all four experiments.

Taken together, the experiments in the present study demonstrate that top-down anticipatory control mechanisms are an important factor in the extent to which cognitive load impacts on emotional processing. This suggests that when perceptual inputs are matched, cognitive load per se does not reduce emotional capture. This finding is in line with Lavie's (2005) formulation of attentional load theory, which proposes that cognitive load may not always have the same effect as *perceptual* load. While perceptual load is commonly manipulated in the visual domain (e.g. varying number of items in the display), cognitive load pertains to altering executive demands (e.g. varying cognitive conflict). When cognitive load is high, it is more probable that distractor inhibition will fail and distractor interference effects will be observed; which is the opposite effect of perceptual load (see Murphy et al., 2016, for a review). Therefore future work should establish whether removing the possibility of using a top-down anticipatory strategy would also eliminate effects previously attributed to perceptual load (e.g. Erthal et al., 2005; Pessoa et al., 2005). Based on Lavie (2005) we might predict that we would see effects of perceptual but not cognitive load. In sum, the existing literature in this area has been somewhat disorganised; perceptual and cognitive load are often used interchangeably, studies have used a mixture of fully blocked, partially blocked, and fully randomised designs; tasks have included design confounds; and some studies find reaction time effects while others find effects in the amygdala but not reaction time. The present study has tried to address several of these issues, and in doing so, clarifies the circumstances under which cognitive load modulates the effects of emotion on task performance.

Chapter 4: Distancing as a reappraisal strategy for emotion regulation: efficacy, ease of use, and modulation by interoception and affective variables

4.1 Introduction

Chapters 2 and 3 focussed on implicit emotion processing and regulation. Here the focus is shifted onto more explicit emotion regulation. As discussed in Chapter 1, according to the Process Model (Gross, 1998), as awareness of emotional reactivity increases, regulation becomes more explicit. Ultimately, the emotional situation is deliberately appraised and evaluated. This can be achieved by engaging in cognitive change such as reappraisal, which involves cognitively reframing the meaning of the situation to reduce its emotional impact (Gross, 1998) or response modulation, which refers to direct attempts to influence physiological, experiential or behavioural emotional responses once they already have been elicited (e.g. expressive suppression; Gross, 2002). Several behavioural, physiological and neuroimaging studies have demonstrated that reappraisal is effective at down regulating negative affect, and is more flexible and adaptive compared to other emotion regulation strategies such as expressive suppression, which involves merely hiding the outward expression of an emotional response (Ochsner & Gross, 2008; Ochsner et al., 2012; Ray, McRae, Ochsner, & Gross, 2010; Schartau, Dalgleish, & Dunn, 2009).

However, reappraisal as an emotion regulation strategy is extremely broad, and refers to various ways in which one can change the meaning of an emotion-eliciting situation. One important criticism of many existing studies of reappraisal efficacy is that participants can choose from any number of possible strategies (e.g. McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008). For example, reappraisal can be operationalised as thinking “what’s happening is not real” or “things aren’t as bad as they appear to be” or imagining that injured individuals will be fine and help is on the way (i.e. situational reinterpretation). There are also strategies within reappraisal, one of which is psychologically distancing oneself from the emotional situation, such as thinking that "things will improve with time" (i.e. temporal distancing) or "it's not happening here" (i.e. spatial distancing) (McRae et al., 2008; Ochsner et al., 2004). Given the wide option of strategies, the strategy participants have actually implemented often remains unknown and may differ from trial to trial. This makes it difficult to know which aspects of reappraisal may be most effective and why. Thus recent studies have sought to more precisely delineate the efficacy of specific strategies encompassed by this definition.

A recent study by Denny and Ochsner (2014) compared two different types of reappraisal, namely reinterpretation and distancing, using a common reappraisal task in which participants were instructed to downregulate their responses to negative photos. They found that both distancing and reinterpretation training resulted in reductions over a two-week period in self-reported negative affect. Additionally, participants who used distancing also showed a longitudinal decrease in negative affect on baseline trials on which they responded naturally, i.e. did not use any strategy. This suggested that the effects of distancing training may extend beyond trials in which participants were explicitly instructed to regulate by, in effect, "spilling over" to baseline trials where negative affect was also reduced. Only the distancing group showed such a reduction over and above the reduction seen in the no-regulation control group, suggesting that effects were not attributable to habituation. A number of other studies have also found that taking a self-distanced perspective when recalling a frustrating experience reduces the intensity of negative affect and blood pressure responses (Ayduk & Kross, 2008; Kross & Ayduk, 2008; Kross, Ayduk, & Mischel, 2005). Neurally, distancing oneself from aversive photos has been found to modulate amygdala activity, an area associated with emotional reactivity, and engage brain networks implicated in cognitive control (Koenigsberg et al., 2010).

Despite the clear effectiveness of distancing as an emotion regulation strategy, very few studies have looked at sub-strategies within distancing. Denny and Ochsner (2014) recently identified three distancing sub-strategies: thinking of oneself as an objective impartial observer (e.g., “I don’t know any of the people involved”), using spatial distancing (e.g. “it is happening far away”), and using temporal distancing (e.g. “it happened a long time ago”). However, previous studies have not directly compared the efficacy of these three types of distancing, or looked at whether specific strategies may be easier to implement than others. To understand which strategies are effective and why, it is necessary to carefully isolate specific strategies, and perform a direct comparison. Thus the first aim of the present study was to move beyond the umbrella terms of reappraisal and distancing, and broaden our understanding of how the ability to regulate emotions varies with these different distancing sub-strategies. Relatedly, whilst many empirical studies of reappraisal more broadly and distancing specifically have examined strategy *efficacy*, such studies have measured this purely with participants’ numerical ratings, and have not asked participants what they are actually thinking. By assessing the ability of participants to implement the instructed strategies through random manipulation checks, we can also assess the ease with which they can use the different strategies. This is important not just to ensure participants are following instructions, but also because ease of use is an important consideration in terms of real-world applicability.

A second research question concerned the role of interoceptive awareness (see section 1.5.2 for more detail). Early theories of emotion suggest that a prerequisite of successful emotion regulation is the awareness of one’s emotional state (Craig, 2004; Damasio, 1994; James, 1884). It might therefore be hypothesised that interoceptive awareness, i.e. awareness of one’s internal bodily signals, will facilitate the regulation of emotional responses; if bodily changes (e.g. heart rate) can be detected more accurately, this may in turn create advantages in the discrimination and deployment of appropriate strategies to regulate different emotional states. For example, Barrett, Gross, Christensen and Benvenuto (2001) found that individuals with highly differentiated emotion experience, who could clearly distinguish among a variety of negative and positive discrete emotions, were better at regulating their negative emotions relative to individuals who experienced emotions in an undifferentiated manner (although awareness of bodily states was not measured directly).

Indeed, previous research has found a relationship between emotion regulation efficacy and self-related awareness. Herwig et al. (2010) found that when participants were asked to be aware of their current emotions and bodily feelings, amygdala activity significantly decreased in comparison to awaiting a photo (neutral condition) or thinking about personal goals. Therefore making oneself emotionally aware in this manner can attenuate emotional arousal. Furthermore, in a large-scale study consisting of over 400 participants, Kever, Pollatos, Vermeulen and Grynberg (2015) found that greater interoceptive awareness, measured using a heartbeat perception task (detailed in section 1.6.1 and below), was associated with greater habitual use of reappraisal. According to the Process Model, reappraisal attenuates emotional response tendencies early on, before giving rise to developed responses. Therefore Füstös et al. (2013) hypothesised that interoceptive awareness would most likely show the strongest association with this particular strategy as it supports the detection of early bodily reactions in response to emotional stimuli, thus facilitating the implementation of reappraisal. Using a standard protocol for investigating reappraisal (e.g. Denny & Ochsner, 2014; McRae et al., 2010; Ochsner et al., 2004), Füstös et al. (2013) found that interoceptive awareness, measured using a heartbeat perception task, was positively correlated with the downregulation of subjective negative affect when using reappraisal. This was accompanied by a reduction of electrophysiological responses, which were positively correlated with interoceptive awareness. As part of characterising sub-strategies within reappraisal, the second aim of the present study was to investigate whether the findings regarding interoceptive awareness and reappraisal still hold when looking at distancing specifically. Furthermore we were also interested in whether relationships between distancing and interoceptive awareness would differ between the three distancing sub-strategies.

Finally, we investigated whether distancing efficacy and interoceptive awareness would be modulated by key affective variables, specifically trait aggression and everyday reappraisal use. As discussed in section 1.5.1.1, aggression has been shown to be associated with poor emotion regulation. For example, Martin and Dahlen (2005) found a negative correlation between self-reported reappraisal and trait anger. Also less adaptive emotion regulation strategies, such as blaming others, rumination and catastrophising have been found to be positively associated with anger arousal and anger-eliciting situations (Besharat et al., 2013) (see Chapter 1 section 1.5.1.1 for more detail). In contrast, habitual usage of adaptive strategies such as reappraisal has been associated with better emotional and social outcomes (Gross & John, 2003; Troy, Wilhelm, Shallcross, & Mauss, 2010). However, to date no study has explored the relationships between distancing performance in an experimental task, affective measures of aggression, and habitual reappraisal use.

To assess and compare the efficacy of the three distancing sub-strategies (temporal, spatial, and interpersonal) we used an adaptation of a standard experimental protocol used to investigate reappraisal (e.g. Denny & Ochsner, 2014; McRae et al., 2010; Ochsner et al., 2002, 2004), whereby participants view negative and neutral photos and rate their distress and arousal following either the specific distancing instruction or passive viewing. Throughout the task participants were also instructed to write down how they implemented the particular instruction for a random selection of trials as a manipulation check. It was predicted that subjective ratings of arousal and distress would be lower in distancing conditions relative to the passive viewing conditions. However, as previous studies have not compared different distancing sub-strategies, a directional prediction as to which strategy would be the most effective or easy to implement was not made. Furthermore, based on literature investigating reappraisal more generally, it was hypothesised that those high in interoceptive awareness would be better at downregulating their negative emotions when using distancing, as would those who have lower levels of aggression and who use reappraisal more frequently in everyday life.

4.2 Method

4.2.1 Participants

An a priori power analysis indicated that 63 participants were needed to have 80% power for detecting an effect size of *d*=.36 for the difference in efficacy between reappraisal and no strategy, when employing the traditional α=.05 criterion of statistical significance. This effect size was based on a meta-analytic review by Webb, Miles and Sheeran (2012), who combined the effect sizes of 99 studies using reappraisal as an emotion regulation strategy. To investigate whether this sample size had sufficient power to detect individual differences, implied power was computed using a *d*=.50 (two-tailed, based on a medium effect size), which suggested approximately 96% power to detect an effect for a bivariate correlation. We therefore decided on a sample size of ~63 participants.

Sixty-five participants were recruited from the Royal Holloway University of London participant pool and were either paid £5 or given course credit for their participation. One participant was excluded after inspection of the manipulation check revealed intense feelings of distress towards the stimuli and a failure to adhere to task instructions, leaving 64 participants (19 males) aged between 18 and 38 (mean age=21.42, *SD*=3.54). One participant did not complete the questionnaire measures but were included in all other analyses. There were no specific exclusion criteria.

4.2.2 Behavioural task and stimuli

The distancing task was an adaptation of a standard protocol for investigating reappraisal that has been used in several prior studies (e.g., Denny & Ochsner, 2014; McRae et al., 2010; Ochsner et al., 2002, 2004; Wager et al., 2008). During the task, participants completed five conditions, which included 'Look Neutral' (participants rate natural reactions to neutral photos), 'Look Negative' (participants rate natural reactions to negative photos), and three distancing conditions. These were: 'Impartial Observer Negative' (negative pictures where the participant is instructed to view themselves as an impartial observer, e.g. “it’s a scene from a movie, so the gun is not directed at me”), ‘Spatial Distancing Negative’ (negative photos where the participant is instructed to spatially distance themselves, e.g. ”it’s happening in a country far away”), and ‘Temporal Distancing Negative’ (negative photos where the participant is instructed to temporally distance themselves e.g. “it happened a long time ago”). Each condition comprised ten different photos. The photos were taken from the International Affective Picture System (IAPS) database and sorted into five sets (four negative and one neutral) which were matched on valence and arousal ratings from 1 – 9 (1 being very distressed and 9 being very happy for the distress rating scale; and 1 being very calm and 9 being very aroused for the arousal rating scale). Each of the four sets of negative photos was randomised to one of the four negative conditions anew for each participant. For the purpose of clarity, distress ratings were reversed to match the arousal ratings whereby 1= both low distress and low arousal. The mean distress and arousal ratings for the four negative sets were 7.77 (*SD*=0.47) and 6.22 (*SD*= 0.57) respectively; the ratings between each of the negative sets did not significantly differ from each other (*ps*>.78). The average distress and arousal ratings for the neutral set were 4.89 (*SD*=0.32) and 3.16 (*SD*=0.57) respectively. Stimuli were presented in two blocks, with each of the five conditions presented in a random order, followed by a short break, followed by the second block with each of the five conditions presented in a different random order. Each condition within each block comprised 5 photos, therefore a total of 50 photos were presented throughout the whole experiment. The order in which the photos were presented within each condition was randomised across participants, and participants saw each photo only once.

Prior to the task, participants were presented with task instructions detailing the different conditions and the scales used for the ratings. For each distancing condition they were shown an example of a negative photo (different to those used in the task) along with an example of how they could implement the particular strategy. For example, for Spatial Distancing participants were shown a photo of a dead animal on dry and barren land accompanied with an example of how they could implement the instruction: “this is not England, it is always raining here so droughts do not happen here and animals do not die of thirst and hunger”. Participants were also given relevant examples for Temporal Distancing (photo of dead soldiers: “this happened 100 years ago during WWI, I wasn’t even born then”) and Impartial Observer strategies (photo of people walking away from plane crash: “I don’t know any of the people involved”). Before starting the experiment, participants were asked if they understood all instructions and if they had any questions. In the task, each condition began with the corresponding ‘Look’ or specific distancing instruction that participants had to employ and then each photo was displayed for six seconds (see *Figure 4.1*). After each photo, participants were asked to rate their levels of distress followed by arousal on Self-Assessment Manikin (SAM) scales rated 1-9 on the keyboard. During each distancing condition in each block there was a manipulation check in which participants were prompted to write down what the previous picture was (memory check), and what they thought of to make themselves feel less negative about the photo. This was to check whether participants were paying attention and fulfilling task instructions appropriately. It also enabled us to look at whether there were differences between the strategies in how easily participants were able to implement task instructions. There were six manipulation checks in total: two for each of the three distancing conditions, with one manipulation check occurring at random within each block. The task was presented and responses were recorded using Psychtoolbox for Matlab (version R2013a).

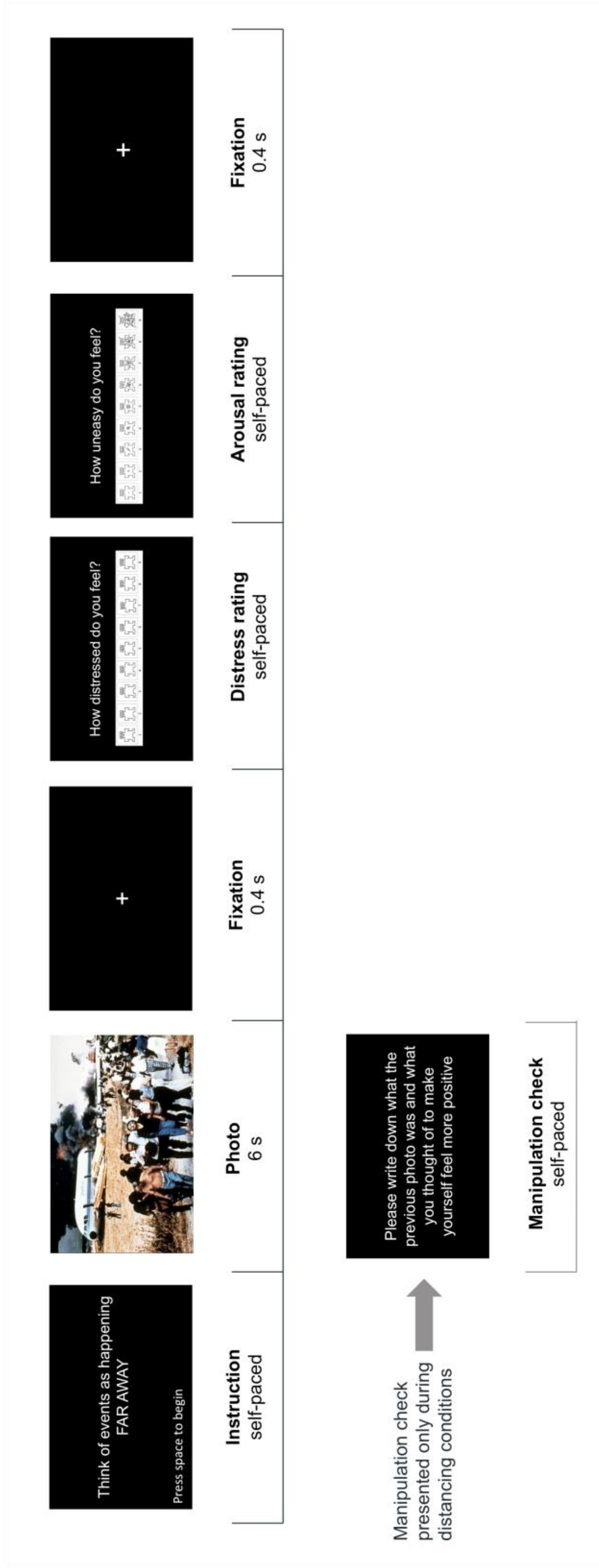


Figure 4.1. Visual depiction of a Spatial Distancing trial.

4.2.3 Interoceptive awareness and analysis

As described in Chapter 1 section 1.6.1, the most common method of assessing interoceptive awareness is the ability to perceive one's heartbeats accurately (Dunn et al., 2007; Critchley et al., 2004). Heartbeat perception was measured using the Mental Tracking Method (Schandry, 1981). Participants completed the interoceptive awareness heartbeat perception task first to avoid carryover effects of emotion into the heart rate data if it were to be conducted after the distancing task or questionnaires. Participants were instructed to start silently counting their own heartbeat when they heard an audio tone until they heard the tone again. The experiment consisted of three different time intervals of 25s, 45s and 60s, separated by 10s resting periods, presented in the same order across participants. Following each interval, participants were asked to verbally report the number of counted heartbeats. Throughout, participants were not permitted to take their pulse, and no feedback on the length of the counting phases was given. Heart rate was monitored with the RS800CX Polar watch and the H3 POLAR heart rate sensor placed under the participants' wrists. Interoceptive awareness was calculated as the mean score of the three heartbeat perception intervals according to the following transformation (as in Füstös et al., 2013):

$$1/3 \sum 1 - ([\text{recorded heartbeats} - \text{counted heartbeats}])/ \text{recorded heartbeats})$$

This equation measures the correspondence between the actual recorded heartbeats and subjective judgment (counted heartbeats). The interoceptive awareness score varies between 0 and 1 with higher scores indicating greater interoceptive awareness.

Several studies have shown that clinical anxiety and state and trait anxiety influence interoceptive sensitivity (see Domschke, Stevens, Pfleiderer & Gerlach, 2010, for a review), as well as emotion regulation in general (Goldin, Manber-Ball, Werner, Heimberg, & Gross, 2009). Therefore state and trait anxiety (measured using The State-Trait Anxiety Inventory; Spielberger et al., 1983) was controlled for when looking the relationships between interoceptive awareness and distancing performance, in line with previous studies examining interoceptive awareness (Pollatos, Traut-Mattausch, Schroeder & Schandry, 2007)

4.2.4 Questionnaire measures

4.2.4.1 Assessment of aggression

The Buss-Perry Aggression Questionnaire (Buss & Perry, 1992) was administered, as in Chapter 3 (see section 3.2.2.4 for details). Analyses focused on Total Aggression score as there were no specific hypotheses for the individual subscales, and because variance for some of the subscales (e.g. Physical Aggression) was low as a result of the university-based sample tested in the present study.

4.2.4.1 Assessment of emotion regulation

The Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) is a 10-item questionnaire consisting of two subscales corresponding to two different emotion regulation strategies: cognitive reappraisal (6 items) and expressive suppression (4 items). The items assess strategy use in everyday life and are rated on a 7-point-Likert scale from strongly disagree to strongly agree (Appendix 1d).

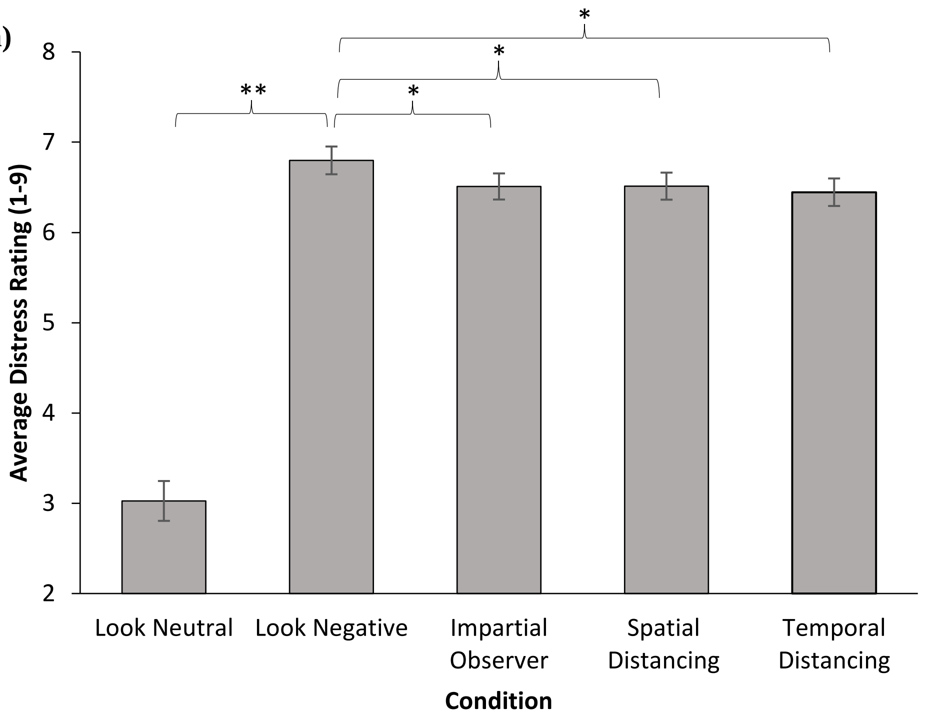
4.3 Results

4.3.1 Distancing efficacy

A repeated measures ANOVA on the recorded self-report ratings revealed a significant main effect of distress ratings ($F(4, 252)=182.12$, $p<.001$, partial $\eta^2=.74$). Planned comparisons (Bonferroni corrected) revealed that photos presented during the Look Neutral condition ($M=3.00$, $SD=1.72$) were rated as significantly less distressing relative to those presented in the Look Negative condition ($M=6.76$, $SD=1.26$, $t(63)=-15.08$, $p<.001$) and all three distancing conditions ($ps<.001$). All distancing conditions were rated as significantly less distressing than the Look Negative condition (Impartial Observer: $M=6.49$, $SD=1.20$, $t(63)=2.86$, $p=.006$; Spatial Distancing: $M=6.47$, $SD=1.23$, $t(63)=3.42$, $p=.001$; Temporal Distancing $M=6.43$, $SD=1.28$, $t(63)=3.64$, $p=.001$). There were no significant differences in distress ratings between the three distancing conditions ($ps>.58$, see *Figure 4.2a*).

There was also a significant main effect of arousal ratings ($F(4, 252)=169.08$, $p<.001$, partial $\eta^2=.73$). Photos during the Look Neutral condition ($M=1.87$, $SD=1.08$) were rated as significantly less arousing relative to Look Negative ($M=5.44$, $SD=1.56$, $t(63)=-17.13$, $p<.001$) and all three distancing conditions ($ps<.001$). All distancing conditions were rated as significantly less arousing relative to the Look Negative condition (Impartial Observer: $M=5.12$, $SD=1.54$, $t(63)=2.45$, $p=.017$; Spatial Distancing: $M=4.99$, $SD=1.60$, $t(63)=4.09$, $p<.001$; Temporal Distancing:, $M=4.94$, $SD=1.56$, $t(63)=4.55$, $p<.001$). There were no significant differences in arousal ratings between the three distancing conditions ($ps>.15$, see *Figure 4.2b*).

a)



b)

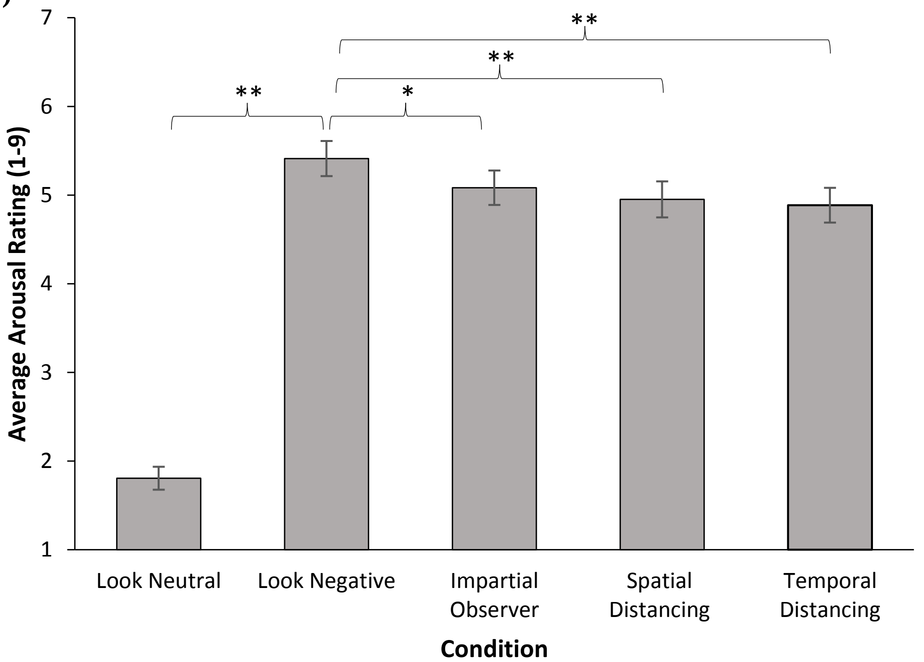


Figure 4.2. Average a) distress and b) arousal ratings across all conditions. ***p<.001 *p<.05.*

4.3.2 Distancing: Ease of use

In order to investigate the ease with which participants were able to implement distancing as a regulatory strategy when instructed, the present study employed a manipulation check whereby each participant was asked to describe how they had used an instructed strategy on six different occasions (following two random Temporal Distancing trials, two random Spatial Distancing trials and two random Impartial Observer trials). Examples of participants' written answers are presented in Table 4.1. Two independent coders with training in the reappraisal and distancing literature (one of whom is the author) coded the qualitative responses on whether they reflected: a) implementation of the correct strategy; b) implementation of any distancing strategy (both correct and incorrect) and c) implementation of any strategy that would count as reappraisal, whether correct or incorrect, distancing or non-distancing. Inter-rater reliabilities were moderate to high: for a) kappa=.78, p<.001, b) k=.62, p<.001, and c) k=.67, p<.001. Agreement was then reached between the coders by re-reading the written answers together to reach a consensus, after which percentages of trials falling into categories a), b) and c) were calculated (see Table 4.2).

Table 4.2. Strategy use reported during manipulation check trials (as a percentage of the total number of manipulation check trials across all participants).

Percentage of trials implemented for each category:				
All Distancing Conditions	*Total*	*Impartial*	*Spatial*	*Temporal*
a) Correct distancing strategy	**43%**	**38%**	**39%**	**52%**
b) Any distancing strategy	**52%**	52%	47%	58%
c) Any reappraisal strategy (distancing or non-distancing)	**87%**	85%	87%	88%

While these findings refer to only a subset of six out of 30 trials, they revealed that participants did not find it very easy to implement the instructed strategy, particularly for the Impartial Observer and Spatial Distancing conditions. A repeated measures ANOVA was performed on the group's mean correct implementation of each strategy (scores ranging from 0-2 manipulation checks) revealed a significant main effect of Condition ($F(2, 128)=3.70$, $p=.027$, partial $\eta^2=.06$). Pairwise comparisons showed that Temporal Distancing ($M=1.05$, $SD=.78$) was significantly easier to implement than Spatial Distancing ($M=.79$, $SD=.80$; ($t(64)=-2.53$, $p=.014$) and Impartial Observer Strategies ($M=.75$, $SD=.83$; $t(64)=-2.20$, $p=.031$). There was no significant difference between Impartial Observer and Spatial Distancing ($p=.79$). Interestingly, inspection of the overall data on strategy implementation showed that, where participants were unable to implement the instructed strategy, they nonetheless did use more general reappraisal strategies to reduce their distress and arousal on 87% of trials.

4.3.3. Relationships between distancing and individual difference measures

The following analyses are conducted using measures of distancing efficacy (calculated as the difference in distress/arousal ratings between Look Negative and the distancing conditions). Higher scores on this variable indicate greater efficacy. Two participants were excluded from analyses using distress ratings for having difference scores three standard deviations above the group mean. One of these same participants was also excluded from analyses using arousal ratings for the same reason. The results above were not affected by including these participants. Relationships between the different individual difference measures are reported in Table 4.3, and are largely in line with expectations, i.e. aggression and anxiety are positively correlated with each other and negatively correlated with reappraisal use in everyday life.

Table 4.1. A selection of participants' written answers during the manipulation checks.

Strategy	Examples of written answers scored as either correct use of each type of distancing or scored as reappraisal (though not the instructed distancing strategy). Description of photos participants responded to are in parentheses.
Impartial Observer	◦ "I imagined myself as a photographer, there to observe but not take part and interfere." *(Starving child)* ◦ "I was impartial by thinking I did not know anyone on the plane." *(Plane crash)* ◦ "I thought of myself seeing it on the news and not really having any way of stopping it." *(Man with guns pointed at him)*
Spatial Distancing	◦ "I thought that it is not in the UK, if you died here you would have a proper funeral and be buried in a coffin." *(Man burying a body in a ditch)* ◦ "Gun crime is much less prevalent in the UK, compared to somewhere like America for example." *(Car being held at gunpoint)* ◦ "I live in a society where this would not happen." *(Child half buried)*
Temporal Distancing	◦ "Air travel is safer now so it's unlikely to happen to me." *(Plane crash)* ◦ "This happened a long time ago so the man has *probably recovered* by now, or has passed away and is resting in peace." *(Man's face beaten and covered in blood)* ◦ "It happened too long ago for me to do anything about it. The situation was out of my hands and if I could have been there to help then I would have tried to help the man." *(Man burnt alive)*
Reappraisal	◦ "I couldn't see any people so maybe no one got hurt." *(Outdoor fire)* ◦ "The soldiers are already doing everything possible to help the man." *(Soldiers helping an injured man escape)* ◦ "I pictured the man taking a photo of himself and not actually using the knife for anything other than the photo." *(Man holding a knife).*

Table 4.3. Bivariate correlations between the individual differences measures.

	Total Aggression (Buss-Perry)	Trait Anxiety (STAI-T)	State Anxiety (STAI-S)	Reappraisal (ERQ)
Total Aggression	-			
Trait Anxiety	.59**	-		
State Anxiety	.56**	.70**	-	
Reappraisal	-.47**	-.48**	-.45**	-
Interoceptive awareness (Hearbeat perception task)	-.11	.07	-.12	.14

(** p<.001)

4.3.4 Interoceptive awareness

Controlling for State and Trait Anxiety scores, interoceptive awareness was not significantly correlated with overall distancing efficacy (Look Negative – mean distress rating for all three distancing conditions) (r(60)=.13, p=.32). However when looking at individual distancing sub-strategies, the relationship between interoceptive awareness and Temporal Distancing efficacy was significant (r(60)=.29, p=.027; *Figure 4.3*) and in the predicted direction (i.e. positive), although note this result did not survive correction for multiple comparisons across the three separate correlations conducted. The relationships between interoceptive awareness and Impartial Observer/Spatial Distancing efficacy were non-significant (r(60)=.028, p=.84; r(60)=-.022, p=.87, respectively). Steiger’s Z tests revealed that the difference between the correlation coefficients for Temporal Distancing and Impartial Observer (Z=1.96, p=.050) and Temporal Distancing and Spatial Distancing (Z=2.22, p=.027) was significant. Anxiety was controlled for, to be consistent with prior literature on interoception (Pollatos et al., 2007), however there was no difference in results when anxiety was not controlled for.

Together these findings suggest that 1) of the three distancing strategies, only Temporal Distancing was significantly associated with interoceptive awareness and 2) Temporal Distancing was significantly more strongly positively associated with interoceptive awareness than either of the other two distancing strategies. It is worth noting in this context that Temporal Distancing also seemed to be significantly easier for participants to implement accurately than the other two strategies.

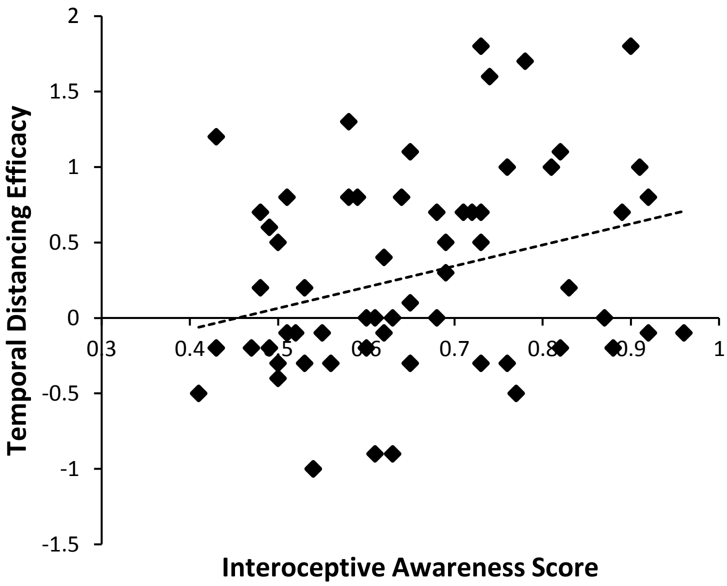


Figure 4.3. Positive correlation ($r(60)=.29$, $p=.027$) between interoceptive awareness score and Temporal Distancing efficacy (Look Negative – Temporal Distancing distress ratings). The greater the interoceptive awareness score, the greater the reduction in subjective distress relative to baseline (Look Negative) when using Temporal Distancing.

There was no significant relationship between interoceptive awareness and overall distancing efficacy as measured by arousal ratings ($r(60)=-.046$, $p=.73$), or between interoceptive awareness and any of the three distancing sub-strategies (all *ps*>.085). There were also no significant correlations between interoceptive awareness and the questionnaire measures.

4.3.5 Distancing and questionnaire measures

There were no significant relationships between any measure of distancing efficacy and our questionnaire measures of aggression and reappraisal.

4.4 Discussion

The present study represents the first evidence examining the efficacy and ease of use of three distancing sub-strategies of emotion regulation. Consistent with our predictions, task results revealed a significant down-regulation of negative affect (both distress and arousal ratings) during all three distancing conditions relative to responding naturally to negative photos. There were, however, no significant differences between the three distancing conditions. Inspection of written responses revealed that participants found implementing the different distancing strategies quite difficult and often used more general reappraisal strategies instead. Temporal distancing, however, tended to be more accurately implemented. Additionally, greater interoceptive awareness was associated with greater temporal distancing efficacy, but was not associated with the two remaining distancing sub-strategies. Finally, contrary to predictions, distancing efficacy was not related to aggression but those who scored highly on aggression (and anxiety) used reappraisal less in everyday life.

The results of the behavioural task revealed that all three of the distancing sub-strategies led to reductions in self-reported negative affect relative to passive viewing of negative stimuli. This supports the existing literature, which has shown that reappraisal and distancing are effective at downregulating negative affect at behavioural, physiological and neural levels (e.g. Ayduk & Kross, 2008; Denny & Ochsner, 2014; Koenigsberg et al., 2010; Ochsner et al., 2012; Schartau et al., 2009). While previous reappraisal studies have given participants the option to use several strategies within reappraisal (including variations of distancing, e.g. McRae et al., 2008), the difference in the efficacy of these strategies was not examined, but rather they were explored as a single reappraisal strategy. The present study therefore adds to these findings by teasing apart ‘distancing’ into sub-strategies and comparing their relative efficacy. Despite the different operationalisations of distancing, i.e. the manipulation of both the perceived spatial and temporal distance to the negative event and viewing the negative event as an objective, impartial observer, there were no significant differences between these three sub-strategies in terms of strategy efficacy.

However, the findings from the manipulation check revealed that participants used the correct strategy on fewer than half of the manipulation check trials, often resorting to more general reappraisal strategies, suggesting that implementing specific strategies appears to be more difficult than free reappraisal. It could be argued that free reappraisal may be more difficult than following a specific strategy as participants have to be more creative. Conversely, it may be difficult to apply a single rigid strategy across multiple different stimuli. According to the Extended Process Model (Sheppes et al., 2015 see section 1.2), following identification of one’s emotion state, selecting an appropriate regulatory strategy is a key stage of the emotion regulation process. Therefore participants may find it difficult to override this selection process in favour of the rigidly-imposed experimental instruction. Despite this, temporal distancing was successfully implemented more often compared to spatial distancing and impartial observer strategies. Imagining that an event has happened in the distant past may be easier to implement as an emotion regulation strategy as it may help participants realise that the situation is beyond their control; they cannot change the past or do anything to help, which may contribute to reducing emotional reactions to the situation (Ben-Ze’ev, 2000). It is important to note, however, that these findings cannot be generalised to the remaining 80% of trials that we did not obtain qualitative data for. Nonetheless, to our knowledge no other prior studies of either reappraisal or distancing have directly assessed how, or the ease with which, participants are implementing the experimental instructions, thus extending the existing literature.

Our second prediction was that greater interoceptive awareness would be associated with greater down-regulation of negative affect. While interoceptive awareness was not related to distancing efficacy as a whole, temporal distancing was significantly more positively correlated with interoceptive awareness than spatial distancing and impartial observer strategies (neither of which were significantly correlated with interoceptive awareness), suggesting that greater sensitivity for one's bodily state facilitates the regulation of emotional responses when using temporal distancing. The finding is in line with previous studies that have shown that interoceptive awareness facilitates the use of reappraisal as an emotion regulation strategy using a similar task consisting of aversive photos (Füstös et al., 2013). Our findings further indicate that this relationship only holds for a specific type of distancing, suggesting that temporal distancing may be particularly effective for individuals with high interoceptive awareness. This could be due to increased measurement error for impartial observer and spatial distancing strategies, as reflected by the significantly lower rates of implementation success relative to temporal distancing. However, across all three conditions, participants tended to use reappraisal to a similar extent even if they were unable to implement the instructed strategy. Since generic reappraisal has been positively associated with interoceptive awareness in previous studies (Füstös et al., 2013), it is unlikely that differences in strategy implementation rates can alone explain the effect. This suggests that there may be something specific to temporal distancing underlying this relationship. As mentioned above, temporal distancing seems to be effective as participants realise that although the situation was distressing at the time, there is nothing they can do now, thereby by diminishing their current emotional reactions. Those high in interoceptive awareness tend to be better at discriminating their emotional states (Craig, 2004), therefore they may be quicker and more effective at realising that their emotional states change and diminish over time. As proposed by James (1884), and more recently Barrett (2017), the perception of bodily reactions may be the crucial component for mediating the emotional experience. However, it is important to note that the correlation between temporal distancing efficacy and interoceptive awareness would not survive correction for multiple comparison across the three correlations conducted in that analysis.

Surprisingly the subjective distress findings did not extend to the subjective arousal data. Studies have shown that participants tend to find the arousal rating less clear-cut than the distress rating (e.g. Schmidtke, Schröder, Jacobs & Conrad, 2014) and the consensus is that there is an "absence of a clearly defined concept of 'arousal'" (Ribeiro, Pompéia & Bueno, 2005, p. 214). Therefore measurement of the distress ratings may be more accurate, which is why we observed associations with distress but not arousal.

Furthermore, we did not replicate Kever et al.'s (2015) finding of higher interoceptive awareness being associated with greater habitual reappraisal and suppression use. Despite using the same questionnaire and the same heartbeat perception measure, our absence of this finding is most likely attributable to their significantly larger sample size (over 400 participants) and thus greater power. Indeed, for our correlation (r=.14) to be significant (to p<.05), we would have needed at least 393 participants, mirroring Kever et al.'s (2015) sample size and effect size (r=.17).

Contrary to predictions, there were no significant relationships between self-reported everyday reappraisal use and distancing. This could be because reappraisal as measured by the ERQ questionnaire and reappraisal performed in daily life are very different from the specific instructions given in the experimental setting. While neuroimaging studies have found a significant relationship between everyday reappraisal use and activation patterns of brain areas associated successful emotion regulation during an experimental task (e.g. Drabant, McRae, Manuck, Hariri & Gross, 2009), the processes underlying distancing may be sufficiently different to reduce these associations.

We also found no supporting evidence for our prediction that aggression would be associated with poorer distancing efficacy. Although previous studies that have shown that individuals high in aggression have difficulty regulating emotions (e.g. Besharat et al., 2013; Cohn et al., 2010; Martin & Dahlen, 2005), these studies have measured emotion regulation using questionnaires, not experimental tasks, and therefore it is difficult to compare findings. Indeed, we did find that habitual reappraisal use was reduced in those high in aggression, which further supports our assumption that reappraisal as measured by the ERQ is different from distancing performance on this specific experimental task. Given that our sample consisted of undergraduate students, the lack of relationship between distancing efficacy and aggression could at least in part be due to a lack of variation in aggressive behaviour. Therefore the findings with regard to aggression would need to be extended to a general population sample or one with clinically relevant aggressive behaviour.

Another limitation of the present study should be noted. Upon inspection of the written answers to the manipulation check, overall successful instruction implementation was low and not all participants were able to utilize certain strategies for certain photos, with most using alternative reappraisal strategies. A reason for this is that certain instructions may not be equally easy for all stimuli, for example, thinking that an event is happening far away may not be effective for someone who has friends and family in that particular ‘far away’ location (e.g. for the 9/11 twin towers photo, one participant noted that they have family in America and therefore this strategy did not help them). Additionally, based on the written responses, some photos were not distressing and/or arousing to certain participants, which meant they did not need to implement any strategy as they had no negative affect to regulate. Given that we had this written insight for only 20% of the task, exclusions based on these responses could not be justified. However, our manipulation check did suggest that measurement error could be relatively high in the current task. To our knowledge no previous reappraisal or distancing study has included a manipulation check like this, which leads to the concern that it is unknown how accurately participants are implementing instructions across studies.

While this is the first study to investigate the sub-strategies of distancing, future studies could use a larger sample and provide more rigorous training to either tease apart the different effects of the distancing sub-strategies in more detail, or confirm our findings showing that there are no differences between the efficacies of the different types of distancing. Nonetheless, the findings demonstrate that psychological distancing is an effective emotion regulation strategy, and that temporal distancing efficacy in particular is modulated by individual differences in interoceptive awareness.

Chapter 5: Using temporal distancing to regulate emotion in adolescence: modulation by reactive aggression.

5.1 Introduction

As discussed in Chapter 4, distancing involves mentally changing the interpretation of an emotional event by increasing or decreasing one's psychological distance from it (Kross et al., 2005; Ochsner et al., 2004). Distancing studies typically instruct participants to vary the perceived temporal (e.g. 'it happened a long time ago') or physical ('it's happening far away') distance of an emotional event, or to adopt an impartial observer outlook on the event (Denny & Ochsner, 2014). All three of these operationalisations of distancing were equally effective at reducing subjective negative affect in our paradigm in Chapter 4, thus supporting the findings from behavioural, physiological and neuroimaging studies which have demonstrated the efficacy of distancing in adults (Ayduk & Kross, 2008; Denny & Ochsner, 2014; Koenigsberg et al., 2010) and children (Kross, Duckworth, Ayduk, Tsukayama, & Mischel, 2011). Temporal distancing, however, tended to be more accurately implemented than the other two distancing strategies suggesting that it is perhaps an easier strategy.

One aim of the current study evaluates the degree to which a manipulation of the *magnitude of temporal distance* modulates emotional responses. While we were not specific about how participants implemented the strategy in Chapter 4 (e.g. 'think about events happening a long time ago'), the current study was more stringent in how temporal distancing was operationalised, particularly focussing on thinking about the future rather than the past. Recent studies have shown that thinking about whether a stressful life event would affect you in in the distant (as opposed to near) future reduces distress (Bruehlman-Senecal & Ayduk, 2015), and that use of this strategy in everyday life is associated with greater wellbeing (Bruehlman-Senecal, Ayduk, & John, 2016). However, existing experimental evidence derives from asking participants to regulate distress associated with only one stressful event that participants had recently experienced. The present study sought to combine experimental and physiological approaches from the cognitive reappraisal literature with a novel manipulation of temporal distancing extent.

A second objective was to examine the development of temporal distancing efficacy from adolescence to adulthood. Adolescence is a key time for the emergence of internalising and externalising conditions (Bask, 2015; Moffitt, 1993; Paus et al., 2008). Many of these symptoms, such as reactive aggression, are associated with poor emotion regulation (Eisenberg, Spinrad & Eggum, 2010; Lewis et al., 2008). This may be at least in part due to on-going development of frontolimbic circuitry involved in regulatory processes (Ahmed et al., 2015; Casey et al., 2008; Sebastian et al., 2010; Somerville & Casey, 2010, see section 1.5.3 for more detail). Experimental studies of reappraisal efficacy suggest development may be protracted. For example, McRae et al. (2012) found a linear improvement in reappraisal ability with age (10–22 years), accompanied by a concomitant age-related increase in left vlPFC response, associated with cognitive control. Regarding distancing specifically, Silvers et al. (2012) instructed participants to imagine being further away from the scene and to focus more on facts than emotional details (i.e. a combination of spatial and impartial observer aspects of distancing). There was a pattern of linear improvement in regulation success from ages 10-18, with a tapering thereafter. In an fMRI study consisting of 112 participants (aged 6–23 years) using the same paradigm, Silvers et al. (2016) found that during distancing age predicted reduced amygdala activation, with vlPFC recruitment mediating this relationship.

Thus, a second aim of the present study was to isolate the developmental progression of effective temporal distancing. In the study by Bruehlman-Senecal and Ayduk (2015), the temporal distancing instruction required participants to imagine how they would feel about a recent event in the distant future, i.e. in several years' time. However, episodic future thinking, i.e. the ability to 'pre-experience' events before they happen and project oneself into the future (Schacter, Benoit, De Brigard, & Szpunar, 2015), continues to develop into adolescence, along with underlying episodic memory and executive function skills (Gott & Lah, 2014). Relatedly, research investigating temporal discounting has found that adolescents opt for smaller immediate rewards over larger longer-term rewards to a greater extent than do adults (Steinberg et al., 2009; Whelen & McHugh, 2009), suggesting that adolescents may be less able to take into account their future selves and anticipate consequences when making these types of decisions. Together, these data suggest that adolescents may be more ‘present-oriented’ than adults, and may thus have more difficulty implementing a temporal distancing strategy.

A final research question concerns the role of individual differences in aggressive behaviour. Adolescence is associated with a peak in reactive aggression (Moffitt, 1993), i.e. aggression occurring in response to a perceived provocation or threat (Berkowitz, 1993). In contrast, proactive aggression, which tends to be more stable over the lifespan, is a relatively non-emotional display of aggression that is unprovoked and used for instrumental gain (Dodge & Coie, 1987). Studies investigating adults, adolescents and children have found that reactive aggression is associated with low frustration tolerance and high affective-physiological arousal that is poorly regulated (Chase, O’Leary, & Heyman, 2001; Marsee & Frick, 2007; Vitaro, Brendgen, & Tremblay, 2002, see section 1.5.1.1). Poor emotion regulation is therefore particularly associated with reactive as opposed to proactive aggression (Eisenberg et al., 2010) and thus we would predict that reactive aggression would be specifically associated with difficulties in implementing reappraisal strategies such as temporal distancing. Experimental studies in adults suggest that while reappraisal is effective at reducing reactive anger (Fabiansson & Denson, 2012) and vengeance (Barlett & Anderson, 2011), high trait aggression is negatively associated with questionnaire-based measures of reappraisal (e.g. Martin & Dahlen, 2005). Moreover in a large-scale study of over one thousand adolescents, adaptive emotion regulation negatively predicted self- and peer-reported aggressive behaviour (Calvete & Orue, 2012). However, the relationship between self-reported aggression in everyday life and instructed reappraisal ability (in this case temporal distancing) is unknown in both adults and adolescents. In the present study, we combine an experimental manipulation of reappraisal and characterisation of aggression subtypes to test how age, individual differences in temporal distancing ability and aggression in daily life interact.

The present study investigated the efficacy of temporal distancing as an emotion regulation strategy across the transition from adolescence to adulthood, and examined the role of individual differences in aggressive behaviour. To do so, we adapted a standard protocol for investigating reappraisal of emotional images (e.g., Denny & Ochsner, 2014; McRae et al., 2012; Ochsner et al., 2002, 2004). We report a novel version with stimuli comprising written stressful 'everyday' scenarios, to facilitate episodic future thinking. Similar to the task by Bruehlman-Senecal and Ayduk (2015), participants were instructed to take a distant-future perspective, a near-future perspective, or to react naturally to each scenario, and then to rate their distress and arousal. The relative difficulty of distancing over simply reacting could distract from the distress elicited, therefore the near-future condition was included to control for the cognitive processes involved in taking a distant perspective. Skin conductance was measured to provide a more objective physiological measure to complement self-report ratings. We predicted: 1) Distant future versus near future distancing would be an effective emotion regulation strategy as indexed by self-report and skin conductance data (i.e. lower self-reported ratings and skin conductance responses during the Distant condition). 2) The efficacy of temporal distancing would increase with age from adolescence to young adulthood. 3) Reactive, but not proactive, aggression would peak in adolescence and be associated with reduced efficacy of temporal distancing.

5.2 Method

5.2.1 Participants

Eighty-four participants were recruited from Harvard University Secondary School Program and the local Boston community, using opportunity sampling. Data for one participant were excluded from all analyses due to a failure to adhere to task instructions leaving a total of 83 participants (50 females, age range 12-22 years: 12 participants aged 12-14; 33 aged 15-17; 38 aged 18-22). One participant did not complete the questionnaire measures, and two participants were excluded from the skin conductance response (SCR) analyses due to experimenter error in one case and a non-responsive dataset (no SCR>0.05 μSiemens) in the other. Participants received course credit or were paid $15 for their participation in the study. Before study participation, participants and their legal guardians provided written assent and consent under a protocol approved by the Committee for Use of Human Subjects at Harvard University.

5.2.2 Behavioural task and stimuli

The stimuli consisted of scenarios (short sentences) that were either negatively valenced (N=30; e.g. "You fail an important exam") or neutral (N=10; e.g. "The main hall is being repainted") (see Appendix 2 for an adapted version of the stimuli (used in the fMRI study in Chapter 6)). Some of these scenarios were adapted from Salemink and Wiers (2012). Prior to the main experiment, stimuli were piloted for valence, arousal and the length of time over which the scenarios were judged to impact a person's life with a sample of 16 participants (aged 16-27). Based on the pilot data, the scenarios were sorted into four sets (three sets containing negative scenarios and one set containing neutral scenarios). Negative sets were matched on valence and arousal ratings from 1–9 (1=very happy, 9=very distressed for the distress rating and 1=very calm, 9=very anxious/stressed for the arousal ratings). Average distress and arousal ratings of the 30 negative scenarios were 6.56 (SD=1.03) and 6.58 (SD=1.26) respectively; the ratings between each of the negative sets did not significantly differ from each other (ps>.99). The average distress and arousal ratings for the neutral set were 2.78 (SD=0.62) and 3.15 (SD=1.95) respectively. There were significant differences between the neutral set and all three negative sets for valence (ps<.001) and arousal (ps<.01). The negative sets were also matched on the time over which scenarios would impact a person's life (1= up to tonight/tomorrow, 6= up to 5 years). Average impact time rating across the three negative sets was 2.38 (SD=0.10) and ratings between each of the negative sets did not significantly differ from each other (ps>.99). Each of the three sets of 10 negative scenarios was randomised to one of the three negative conditions (Read, Near Future, Distant Future) for each participant. The neutral set was always paired with the 'Read' instruction.

As an additional stimulus control measure, the three negative sets were matched for type of stressor and social content (each set contained two scenarios from each of the following: social rejection, embarrassment, anger/frustration, physical pain and threatening future existence). The remaining neutral set contained scenarios that drew on features from a random selection of 10 negative scenarios e.g. the neutral scenario "your friend has blonde hair" drew on features from the negative scenario "you have a serious argument with your friend" (matched for social content). Stimuli were presented in blocks, with 5 stimuli from the same condition in each block. Participants completed two runs of the 4 conditions, presented in a different random order each time. The order in which the scenarios were presented within each condition was randomised across participants, and each participant saw each scenario only once.

Participants viewed these scenarios within four conditions. They included 'READ [neutral]' (participants read and rated natural reactions to neutral scenarios), 'READ [negative]' (participants read and rated natural reactions to negative scenarios), 'Think of whether these situations would still affect you in the DISTANT future' (negative scenarios where the participant was instructed to use distancing (further details below)) and 'Think of whether these situations would still affect you in the NEAR future' (negative scenarios where the participant was instructed to use distancing, but only to consider the near future: a control for the cognitive processes involved in distancing). Prior to beginning the task, participants were asked to read the task instructions and were shown examples of negative scenarios (different from those used in the task) and specific instructions for each condition. The task was also verbally explained to them and it was reiterated that for Near and Distant conditions, they had to project themselves into the future to consider how each scenario would likely affect them at the chosen time point, and then consider and rate how they *currently* felt after projecting themselves. This was to increase the likelihood that participants would all be using the same strategy in the same way. Participants were not given examples of what ‘near’ and ‘distant’ meant as what is regarded as the ‘near’ or ‘distant’ future may differ between individuals. They were given a timescale during the manipulation check (see below), which they could use to guide them.

At the beginning of every five trials, the corresponding READ or specific distancing instruction (5 seconds) was presented, followed by the scenario which was displayed on screen for 7 seconds (see *Figure 5.1* for trial structure). After each scenario, participants rated their distress and arousal on SAM scales rated 1-9 (low to high) on the keyboard. As a manipulation check, participants were also asked to rate the distance in time adopted on each trial for Near Future and Distant Future conditions on a timescale (1=tonight/tomorrow, 2=one week, 3=one month, 4=six months, 5=one year, 6=two years, 7=three years, 8=five years, 9=ten years from now). This also enabled us to examine whether the timeframe adopted varied with regulatory efficacy, age and aggression. Participants were given a fixed duration of 7 seconds for each rating (separated by a 0.5 second fixation cross). The task was presented and responses were recorded using Psychtoolbox for Matlab (version R2015a).

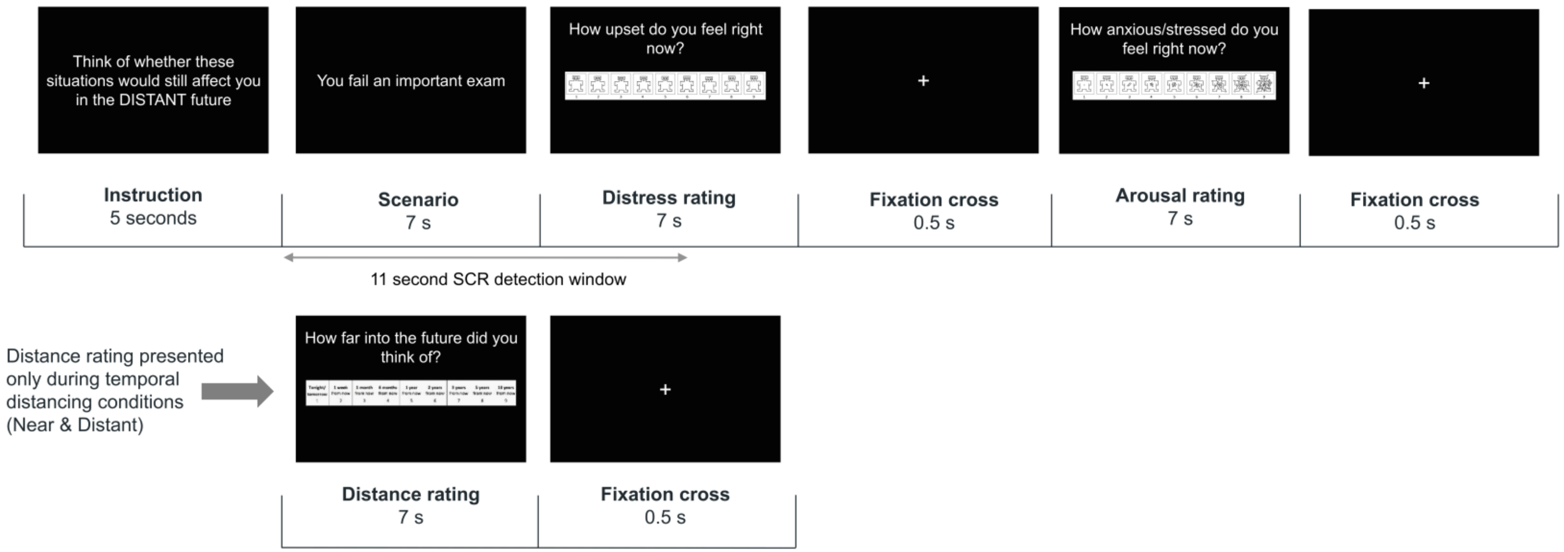


Figure 5.1. Visual depiction of a Distant Future trial.

5.2.3 Skin conductance and analysis

Prior to the task, two skin conductance electrodes were placed on the distal phalanges of the middle and index fingers of the participant's non-dominant hand, attached with a Velcro strap. This arm was also strapped onto the table to ensure that participants kept still throughout the task. A skin conductance recording system (GSR100C Biopac, Goleta, CA) together with AcqKnowledge 4.0 (Biopac; Goleta, CA) software continuously sampled skin conductance data at 100 Hertz during the task.

A 0.05Hz high-pass filter was applied to the tonic electrodermal activity (EDA) signal to yield phasic EDA. Skin conductance responses (SCR) in the following analyses refer to SCRs that were elicited in the 11 seconds following scenario onset (comprising the 7 secs during which each stimulus was presented plus 4 seconds; see *Figure 5.1* (responses later than 4 secs after the stimulus offset are usually considered a non-specific response (Boucsein et al., 2012)). A minimum threshold detection level of 0.04 µSiemens was applied during this period. For all SCRs identified during this time window (i.e. for each trial), the peak amplitude was recorded and the average peak height relative to the pre-response baseline across trials of the same condition was used as the dependent variable (amplitude). SCR data were not normally distributed and therefore were square root transformed prior to statistical analysis in line with previous similar studies (e.g. Sokol-Hessner et al., 2009; Wolgast, Lundh & Viborg, 2011).

5.2.4 Developmental analysis

As in prior work, age was invoked as a continuous predictor of developmental differences to maximise statistical power and to mitigate the need to create semi-arbitrary boundaries between age groups (e.g. Somerville et al., 2013). Age was invoked as a linear predictor of change, calculated by mean-centring each participant's actual age. As some previous studies have shown a non-linear pattern of emotion regulation development between adolescence and adulthood, suggestive of mid-adolescence as a time of maximal developmental ‘mismatch’ between emotional reactivity and regulatory processes (e.g. Silvers et al., 2012), the quadratic predictor (age^2) was also included in statistical analyses (computed by squaring mean-centred age). These predictors were uncorrelated as regressors ($r(81)=.030$, $p=.79$) and were therefore placed in the same regression model.

5.2.5 Questionnaire measures

The Reactive Proactive Aggression questionnaire (RPQ; Raine et al., 2006) consists of 23 items, and measures reactive (11 items e.g. “become angry when others threatened you”) and proactive (12 items; e.g. “Had fights with others to show who was on top”) aggression in child and adolescent samples. Each item is rated as 0 (never), 1 (sometimes), or 2 (often) for frequency of occurrence (Appendix 1e).

Participants also completed the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), as aggression and anxiety are typically moderately correlated and this allowed us to examine whether results concerning aggression would hold after controlling for anxiety.

5.3 Results

5.3.1 Hypothesis 1: Distancing efficacy

5.3.1.1 Behavioural data

Distress

A repeated measures ANOVA revealed the hypothesised main effect of Condition on distress ratings ($F(3, 246)=374.19$, $p<.001$, partial $\eta^2=.82$). Pairwise comparisons were conducted showing that Distress ratings followed the pattern: Read Neutral ($M=2.89$, $SD=1.31$) < Distant Future ($M=5.97$, $SD=1.41$) < Near Future ($M=6.54$, $SD=1.14$) < Read Negative ($M=6.78$, $SD=.84$), (all $ps<.05$, see *Figure 5.2a*). The results suggest that distancing was effective relative to using no strategy, and that a greater temporal scope of distancing was more successful at reducing distress.

There was also a positive correlation between distancing success (defined as ratings for Read Negative – Distant Future; McRae et al., 2012) and subjective reports of mean distance in time adopted during Distant Future trials ($M=4.37$, $SD=1.45$, range=1.30-8.67; $r(81)=.38$, $p<.001$, see *Figure 5.3a*), i.e. participants who were more effective in reducing their distress tended to project themselves further into the future. This remained significant after controlling for age ($r(81)=.37$, $p=.001$). The correlation between distancing success using Near Future distancing (Read Negative - Near) and time adopted during this condition ($M=2.68$, $SD=1.07$, range=1-6) was non-significant ($r(81)=.11$, $p=.33$). The difference between these correlation coefficients was marginally significant ($Z=1.81$, $p=.063$; Raghunathan, Rosenthal, & Rubin, 1996).

Arousal

A repeated measures ANOVA revealed the hypothesised main effect of Condition on arousal ratings ($F(3, 246)=481.46$, $p<.001$, partial $\eta^2=.85$). Arousal ratings followed the pattern: Read Neutral ($M=1.76$, $SD=.65$) < Distant Future ($M=5.06$, $SD=1.52$) < Near Future ($M=5.65$, $SD=1.37$) < Read Negative ($M=6.02$, *SD*= 1.04) (all ps<.005, see *Figure 5.2b*). Thus, distancing was effective in reducing arousal as well as distress, relative to control conditions.

There was also a positive correlation between distancing success (defined as above but using arousal ratings) and distance in time adopted during the Distant Future condition (*r*(81)=.35, *p*=.001, see *Figure 5.3b*). This remained significant after controlling for age (*r*(81)=.35, *p*=.001). The correlation between distancing success and time adopted during the Near Future condition was non-significant (*r*(81)=-.023, *p*=.83). The difference between these correlation coefficients was significant (*Z*=2.46, *p*=.011).

5.3.1.2 Skin Conductance Data

A repeated measures ANOVA on the mean peak amplitude of SCRs revealed a significant main effect of Condition (*F*(3, 240)=2.92, *p*=.035, partial η^2=.035). Scenarios presented during the Read Neutral condition (*M*=.54 µS, *SD*=.25) elicited significantly lower amplitudes of SCRs relative to the Read Negative condition (*M*=.61, *SD*=.23, *p*=.023) and the Near Future condition (*M*=.62, *SD*=.26; *p*=.021, see *Figure 5.4*) but was not significantly different from the Distant Future condition (*M*=.58 *SD*=.24; *p*=.16). There were no significant differences between Read Negative and either Near Future (*p*=.72) or Distant Future (*p*=.28) conditions, neither was there a difference between Distant and Near conditions (*p*=.12).

There were no significant correlations between SCR distancing success and distance in time adopted during the Distant Future condition (*r*(79)=.058, *p*=.61) or the equivalent for the Near Future condition (*r*(79)=.004, *p*=.97).

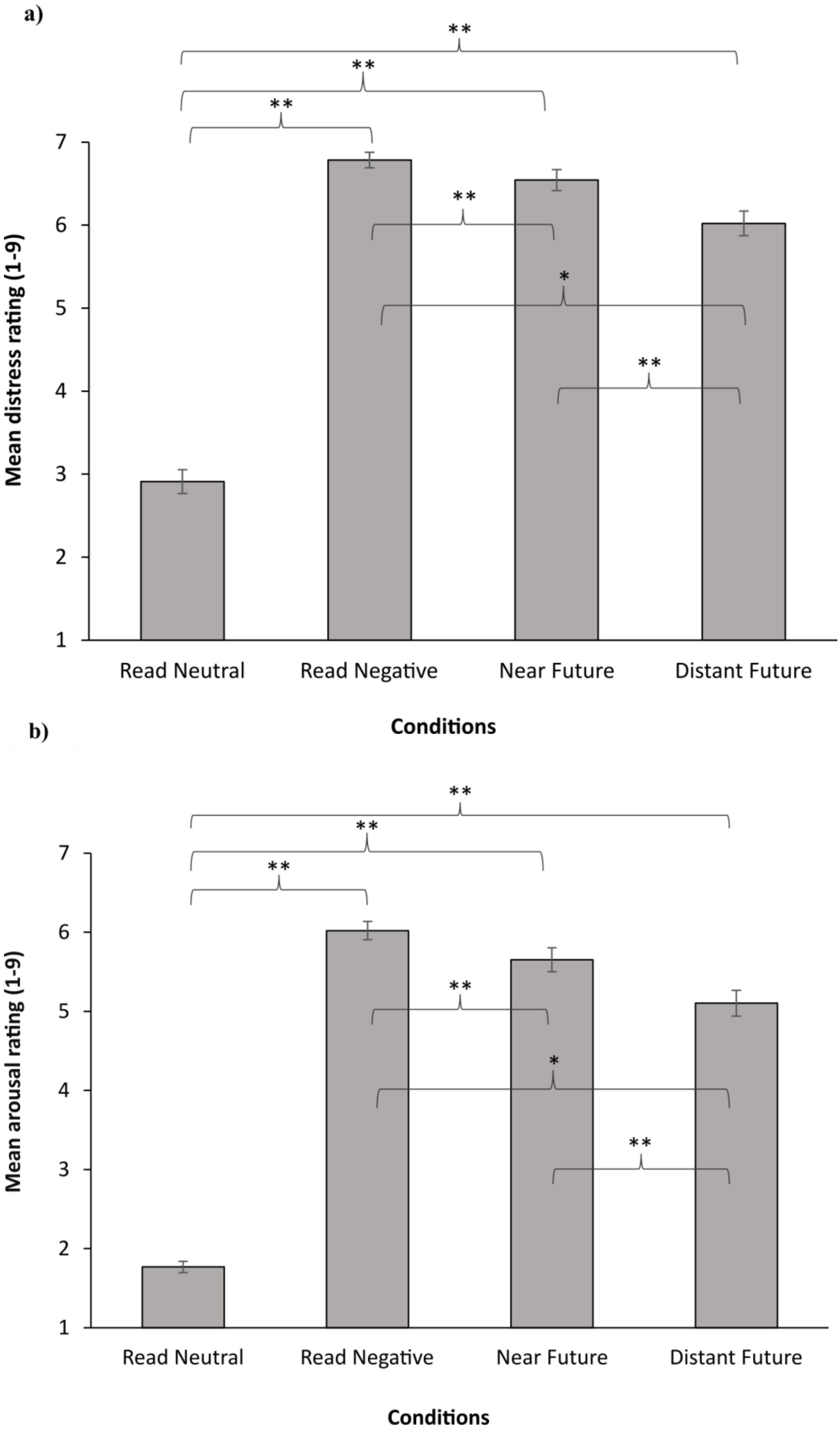
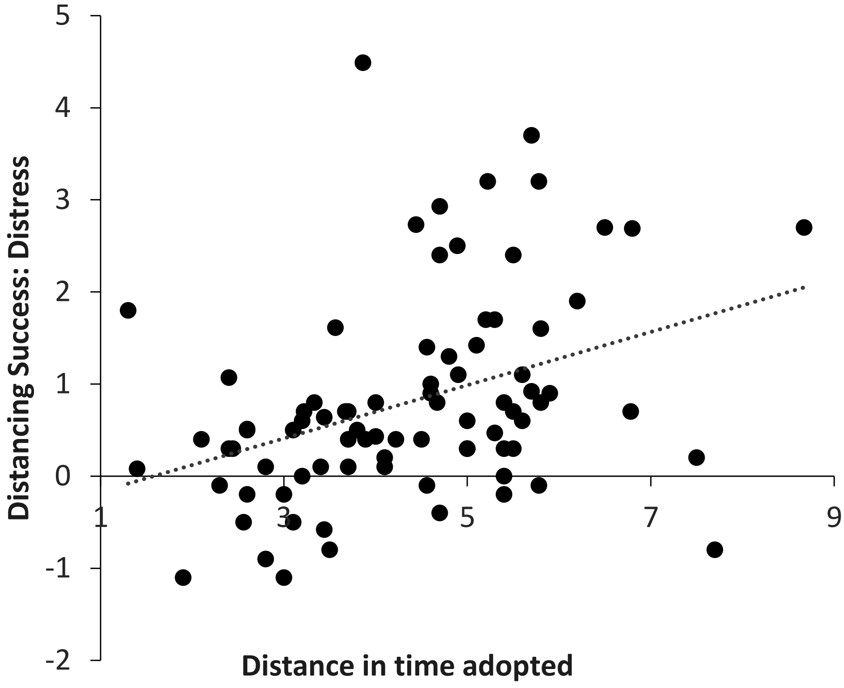


Figure 5.2. Mean ratings for a) distress and b) arousal for all conditions (**p<.001. *p<.05).

a)



b)

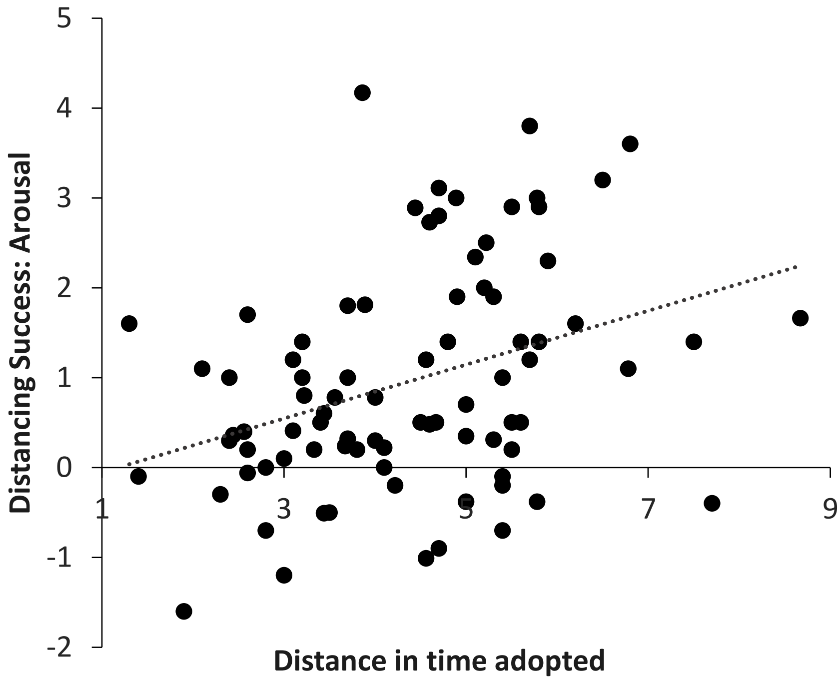


Figure 5.3. Scatterplots depicting the relationship between distance in time adopted during the distant future condition (x-axis: Likert scale (1= tonight/tomorrow, 9=ten years)) and distancing success (y-axis: reduction in a) affect, and b) arousal, relative to free viewing).

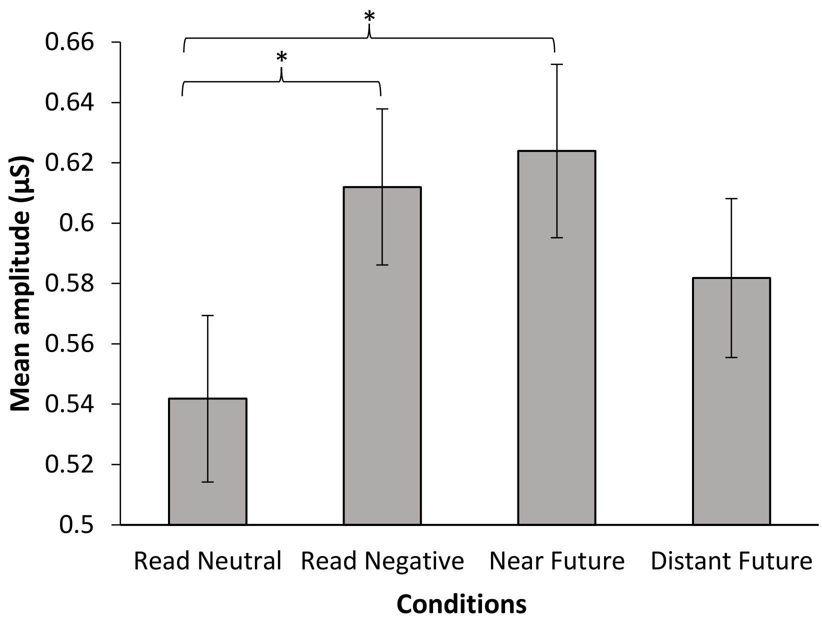


Figure 5.4. Mean peak skin conductance amplitude for each condition.

5.3.2 Hypothesis 2: Developmental effects

5.3.2.1 Distancing task

In line with previous studies (e.g. McRae et al., 2012; Silvers et al., 2012), regression analyses were performed to test for age effects on emotional reactivity (defined as ratings for Read Negative – Read Neutral) as well as distancing success.

The regression equation for emotional reactivity was not significant as measured by distress (F(2,80)=.23, p=.80) or arousal (F(2,80)=.99, p=.38) ratings. Linear and quadratic relationships between age and emotional reactivity were all non-significant (ps>.80).

The regression equation for distancing success was also non-significant as measured by distress (F(2,80)=.51, p=.60) and arousal (F(2,80)=.42, p=.66) ratings. Linear and quadratic relationships between age and distancing success were all non-significant (ps>.66).

The correlation between age and distance in time adopted during Distant Future (*r*(81)=.032, *p*=.77) was non-significant, but was marginally significant for the Near Future condition (*r*(81)= -.202, *p*=.065).

5.3.2.2 SCR data

Correlation analyses between age and SCR data also revealed non-significant relationships between age and SCR measures of emotional reactivity (*r*(79)=-.089, *p*=.43) and distancing success (*r*(79)=.031, *p*=.78).

5.3.2.3 Aggression and anxiety measures

Aggression scores for the adolescents in the present sample (Proactive Aggression: *M*=1.32, *SD*=.27; Reactive Aggression: *M*=2.24, *SD*=.45) were similar to that of previous studies in typical adolescents (Calvete & Orue, 2012; Proactive Aggression: *M*=1.28, *SD*=.38; Reactive Aggression: *M*=1.86, *SD*=.42).

There were both significant linear (*r*(80)=-.24, *p*=.033) and quadratic relationships between age and reactive aggression: (*F*(2,79)=3.74, *p*=.028)**.** The quadratic relationship was an inverted U (see *Figure 5.5*), showing a peak during mid-adolescence (15.4 years). However there was neither a linear (*p*=.54) nor quadratic (*p*=.41) relationship between proactive aggression and age.

There was no significant linear relationship between Trait Anxiety and age (*p*=.68) however there was a significant quadratic relationship (*F*(2,79)=3.93, *p*=.024), with the peak during late adolescence (17.6 years).

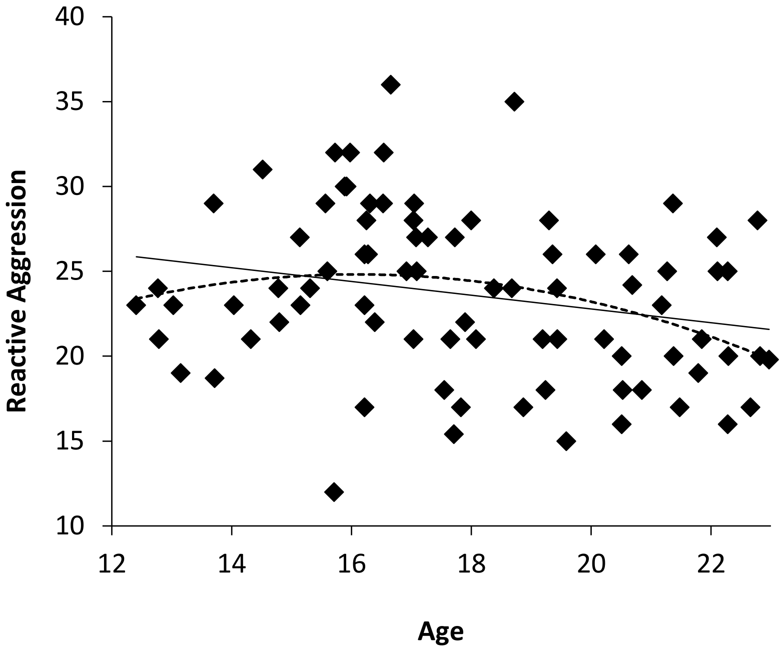


Figure 5.5. Scatterplot showing that reactive aggression peaked during mid adolescence in the present sample.

5.3.3 Hypothesis 3: Distancing success and reactive aggression

Reactive aggression was negatively correlated with distancing success, as measured by distress ratings ($r(80)=-.28$, $p=.010$; *Figure 5.6a*). This relationship remained significant after controlling for proactive aggression ($r(80)=-.22$, $p=.047$), age ($r(80)=-.27$, $p=.013$), and trait anxiety ($r(80)=-.25$, $p=.027$), all of which showed significant positive correlations with reactive aggression ($ps<.05$). Furthermore, the effect remained significant when controlling for gender, showing that gender did not modulate the relationship ($F(2, 79)=3.56$, $p=.033$). To investigate whether the negative relationship between reactive aggression and distancing success was driven by baseline reactivity or the distancing condition itself we examined correlations between reactive aggression and distress ratings during the Distant Future and Read Negative conditions separately (see *Figure 5.6b*). There was a positive relationship between reactive aggression and distress levels during the Distant Future condition ($r(80)=.312$, $p=.004$), but no relationship in the Read Negative condition ($r(80)=.144$, $p=.20$). While a Steiger's Z test did not show a significant difference between the slopes ($Z=-1.77$, $p=.077$), the pattern of results seen in *Figure 5.6b* suggests that the significant negative relationship between distancing success and reactive aggression was driven by the Distant Future condition. Indeed, inspection of the slopes reveals that for those highest in reactive aggression, distress in the Distant Future condition did not differ from distress during Read Negative (no strategy).

Given the negative relationship between distancing success and reactive aggression, and the positive relationship between distancing success and distance in time adopted, we conducted an exploratory analysis to examine the relationship between reactive aggression and distance in time adopted during the Distant Future condition. This showed a marginal negative correlation ($r(80)=-.213$, $p=.055$), i.e. those high in reactive aggression projected themselves less far into the future.

There was no significant relationship between reactive aggression and distancing success as measured by arousal ratings ($r(80)=-.19$, $p=.091$). There were also no significant relationships between proactive aggression and distancing success using either distress or arousal ratings (all $ps>.19$).

There were no significant correlations between reactive aggression and SCR measures of emotional reactivity or distancing success ($ps>.96$).

Finally, we looked for interactions between age and distancing success in predicting reactive aggression, and between age and reactive aggression predicting distancing success using the *PROCESS* toolbox for SPSS. However neither analysis was significant (b = .062, 95% CI [-.28, .40], $t=.36$, $p=.72$; b= .012, 95% CI [-.01, .03], $t=1.38$, $p=.17$, respectively).

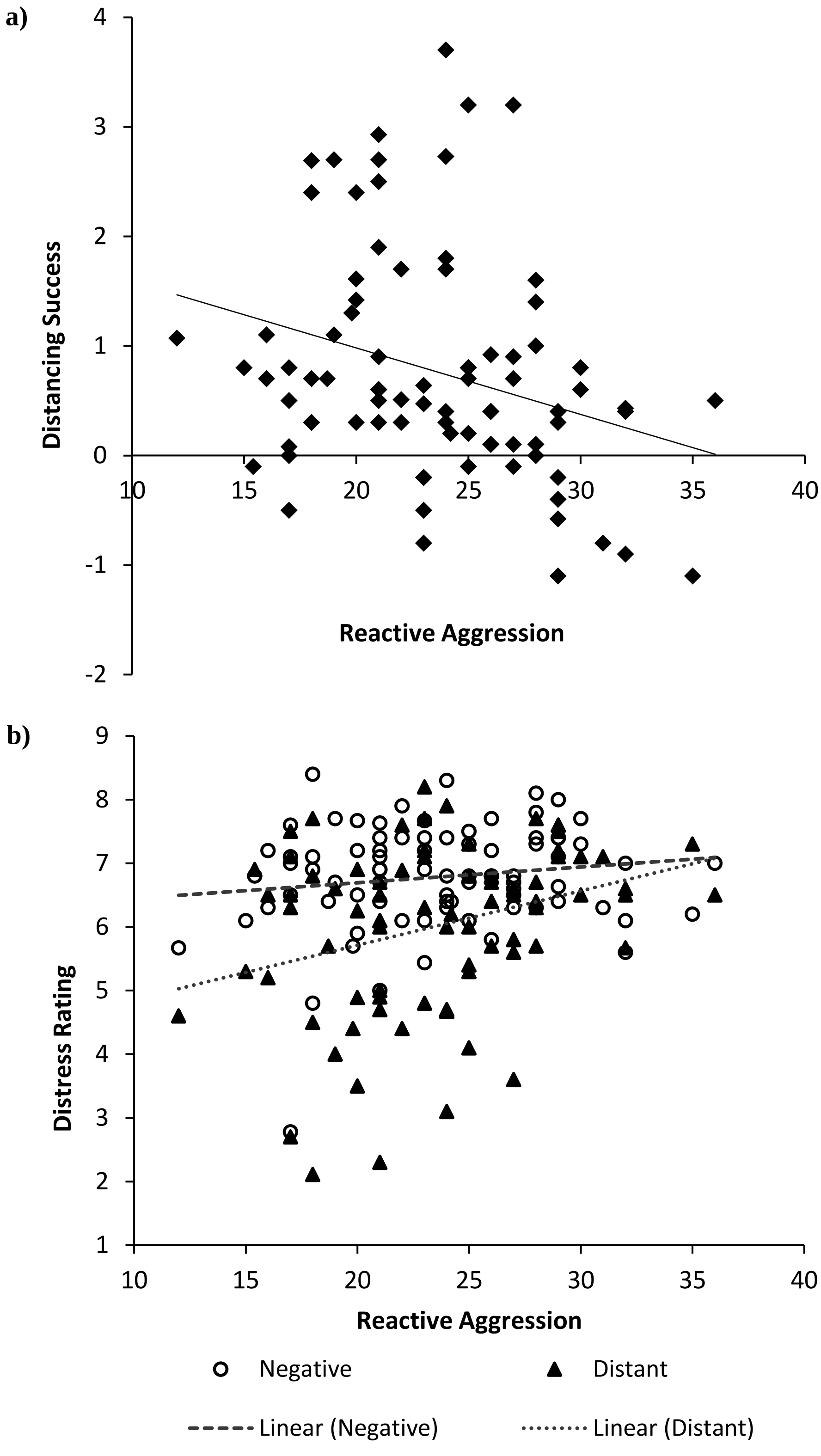


Figure 5.6. a) Relationship between Reactive Aggression and Distancing Success; b) Relationships between distress ratings for Distant Future and Read Negative conditions and Reactive Aggression.

5.4 Discussion

The present study investigated the efficacy of temporal distancing (thinking how one would be affected by a given scenario in the distant future) as an emotion regulation strategy across adolescence, and the role of individual differences in reactive aggression. Consistent with our hypotheses, temporal distancing was an effective emotion regulation strategy as indicated by subjective ratings and, to a lesser extent, skin conductance responses. However, efficacy did not vary with age between adolescence and adulthood. Finally reactive, but not proactive, aggression was associated with reduced efficacy of temporal distancing.

5.4.1 Hypothesis 1: Distancing efficacy

In line with the first prediction, subjective ratings indicated that temporal distancing (Distant Future) was an effective emotion regulation strategy over and above no strategy (Read Negative) and taking a near future perspective, as measured by both distress and arousal ratings. There was no significant difference in skin conductance between the Distant Future and Read Negative conditions, however the pattern of results was in the predicted direction. Also while SCRs were significantly higher in the Read Negative and Near Future conditions relative to reading neutral scenarios, responses did not significantly differ between taking a distant-future perspective and reading neutral scenarios. Since the present study was conducted, a study in adults comparing reappraisal, distraction and no strategy, found similar null findings of SCR (Kinner et al., 2017). Together these findings replicate and significantly extend the existing literature by showing that temporal distancing (specifically projecting oneself into the future) is effective as an emotion regulation strategy using an empirically rigorous task. Crucially, participants who projected themselves further into the future benefited most from this strategy. These findings build confidence in the effectiveness of future-oriented regulation strategies.

It could be argued that the mere act of projection into the future is a distraction from the distress elicited, leading to reduced behavioural and physiological responses. We included the Near Future condition specifically to control for the intensity of task demands. The behavioural data showed that distress and arousal were significantly lower during the Distant Future condition relative to Near Future, a condition matched as far as possible for all cognitive processes except distance in time adopted (including following instructions, using episodic future thinking and generating mental imagery). This suggests that adopting a distant perspective specifically is effective over and above any more general effects seen in the Near Future condition; a conclusion bolstered by the correlation discussed above between distancing success and distance in time adopted.

There are a number of reasons why temporal distancing may be effective. According to Construal Level Theory, adopting a distant perspective on stressful events de-emphasises their concrete and situation-specific features and instead characterises them abstractly (Liberman & Trope, 2008). This can be applied to temporal distancing whereby adopting a distant future perspective on stressful events can highlight one's awareness of the impermanence and relative insignificance of their reactions to these events, thereby reducing distress caused in the present. Another potential mechanism for temporal distancing efficacy is that psychologically healthy people tend to view their distant future as more positive (Heller, Stephan, Kifer, & Sedikides, 2011) and expect their lives and emotional experiences to be more stable relative to their view of their near future (Liberman, Sagristano, & Trope, 2002; Wakslak, Nussbaum, Liberman, & Trope, 2008). Indeed Bruehlman-Senecal and Ayduk (2015) found that the extent to which participants focused on the impermanent nature of their stressor (measured using a questionnaire) mediated the relationship between temporal distancing and reduced distress. With regards to the present study, the specific instructions and prior examples given to participants was intended to ensure that they were using episodic future thinking (actually projecting themselves into the future using mental imagery) as opposed to using cognitive rationalisations ('this probably won't affect me in future') or other strategies to reduce their distress. This emphasis on participants ‘pre-experiencing’ their future reactions may have helped them to realise the impermanent nature of the stressors presented.

5.4.2 Hypothesis 2: Developmental effects

The second hypothesis was that temporal distancing efficacy would increase with age between adolescence and adulthood as previous studies have shown that this period is associated with on-going development in emotion regulation abilities (e.g. McRae et al., 2012) and the brain systems which subserve them (e.g. Casey et al., 2008; Giedd et al., 1999). However, the data suggest that the efficacy of temporal distancing is both high and stable across the age range tested, i.e. 12-year-old adolescents were just as effective at the task as 22-year-old adults. Only two studies to date have investigated distancing across development (Silvers et al., 2012; 2016) and they found that distancing efficacy improved with age until approximately 18 years (Silvers et al., 2012). Both of these studies used event-related designs whereas the present study used a block design, which was perhaps easier for the younger participants. However, the Silvers et al. studies also used a very different task, requiring a combination of spatial and interpersonal distancing to regulate distress when viewing aversive images. It is likely that the cognitive processes underlying this strategy differed from those involved in temporal distancing as implemented here in important ways. As discussed above, our temporal distancing instruction required episodic future thinking which relies on component processes including working memory, relational memory, visual-spatial processing and apprehension of time (D’Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010), as well as self-consciousness, which has been found to predict feelings of experiencing the imagined events (D’Argembeau et al., 2010). Additionally, scene construction, which refers to the generation, maintenance and visualisation of complex scenes, has also been implicated in future thinking (Hassabis & Maguire, 2007). Existing evidence on the developmental trajectory of episodic future thinking is scarce. Gott and Lah (2014) found that episodic future thinking continues to develop between late childhood (8-10 years) and mid-adolescence (14-16 years). However, it may be that episodic future thinking in our adolescent sample (minimum age of 12) was sufficiently developed to meet the requirements of our task.

Temporal discounting research (e.g. Steinberg et al., 2009) suggests that adolescents tend to be less future-focused than adults at least when making decisions between immediate and future rewards. We might also expect adolescents to be less able to project themselves into the future simply because they have less of an idea what their future will look like. However, in the present study there was no correlation between age and distance in time adopted during the distancing conditions. Again this suggests that, at least when instructed, adolescents are able to implement the instruction to distance, with equivalent behavioural and physiological consequences regardless of age. This was particularly interesting given that individual differences associated with emotional reactivity and regulation, namely reactive aggression and anxiety, did show developmental change in line with previous accounts (e.g. Moffitt, 1993, Casey et al., 2008, Ernst, 2014). This suggests that temporal distancing could well be a fruitful strategy to focus on in helping adolescents to manage everyday stressors, regardless of age-specific change in emotional reactivity.

5.4.3 Hypothesis 3: Distancing success and reactive aggression

In line with the final hypothesis, reactive (but not proactive) aggression was negatively correlated with temporal distancing efficacy as measured by distress ratings. To our knowledge, this is the first study to demonstrate this association across adolescence using an experimental task as prior research has only looked at reactive aggression in relation to general emotion dysregulation using questionnaire measures (e.g. Marsee & Frick, 2007; Vitaro et al. 2002; Xu & Zhang, 2008). Interestingly, baseline distress ratings on the Read Negative condition did not vary across different levels of reactive aggression. Instead, the negative correlation was driven by a lower reduction of distress during the Distant Future (temporal distancing) condition relative to Read Negative in those high in reactive aggression, while those lower in reactive aggression were able to reduce their distress relative to baseline (Read Negative) on this condition.

Intriguingly, we found tentative evidence that those higher in reactive aggression projected themselves less far into the future during the Distant Future condition, which may underpin reduced efficacy. Participants high in reactive aggression may therefore benefit from training in how to apply cognitive strategies such as temporal distancing more effectively, which may in turn reduce reactive aggression over time. Fabiansson and Denson (2012) found that instructed reappraisal was effective in reducing self-reported anger during an economic bargaining task and had longer lasting effects on lowering anger than when using a distraction strategy. However, it is still an open question as to whether such training would impact more trait-like reactive aggression over the longer term. If so, training this strategy could be of considerable benefit to individuals who react aggressively to everyday stressors.

In conclusion, placing negative events into a broader temporal perspective facilitates the down-regulation of subjective and physiological negative affect. Temporal distancing is effective and easily implemented for adults and young adolescents alike and thus may be promising as a potential strategy for adolescence stress reduction. However this strategy may be of limited efficacy for those with high levels of reactive aggression, potentially due to difficulties in implementing the instruction to project oneself into the distant future. Future work could explore this link further, extending findings to a sample with clinically relevant levels of reactive aggression, and investigating whether training in this strategy could represent a potential avenue for intervention.

Chapter 6: Neural mechanisms of temporal distancing

6.1 Introduction

The behavioural and physiological data presented in Chapter 5 suggest that adopting a temporally distant perspective on stressors is an effective strategy in reducing self-reported distress and arousal, and to some extent, physiological arousal. However, the neural processes underlying the efficacy of this strategy have yet to be identified.

6.1.1 Regulation and reactivity

As discussed in Chapter 1 section 1.4, neuroimaging studies have predominantly examined reappraisal very generally, instructing participants to freely reappraise aversive stimuli in whichever way they wish. These studies have found that circuits associated with cognitive control are implemented, such that prefrontal and cingulate cortices modulate activity in regions implicated in emotional reactivity, such as the amygdala (Ochsner et al., 2012). In the first neuroimaging study of reappraisal, Ochsner et al. (2002) found that relative to passively viewing negative stimuli, reappraisal increased activation in dorsal and ventral regions of the lateral PFC and dorsomedial PFC, while decreasing activation in subcortical areas such as the amygdala. Moreover, engagement of prefrontal regions, particularly ventrolateral PFC, was inversely correlated with amygdala activation. Subsequent studies using functional connectivity analysis (Banks, Eddy, Angstadt, Nathan, & Phan, 2007) and mediation analysis (Wager et al., 2008), have supported the finding that these prefrontal regions are involved in attenuating responses in regions implicated in emotional reactivity. More recently, in the largest meta-analysis of neuroimaging studies of reappraisal to date, Buhle et al. (2014) identified 48 studies comparing neural responses during reappraisal vs. no-regulation and found extensive activation of the dorsomedial PFC (dmPFC), dorsolateral PFC (dlPFC), ventrolateral PFC (vlPFC) and posterior parietal lobe, areas which are associated with working memory, inhibition and self-reflective processes related to identifying and regulating one's affective state (Amodio & Frith, 2006; Binder, Desai, Graves, & Conant, 2009; Olsson & Ochsner, 2008). Reappraisal also modulated activity in bilateral amygdala, though no other significant activations in other subcortical regions were found in the meta-analysis (Buhle et al., 2014).

Although temporal distancing is a form of reappraisal, as discussed in Chapters 4 and 5, the cognitive processes required are likely to be more specialised than those involved in the ‘free’ reappraisal studies discussed above. While no study to date has investigated the neural mechanisms of temporal distancing, a few fMRI studies have explored distancing in general. For example, it was found that using self-distancing (i.e. viewing a scene objectively) to down-regulate emotions to negative social pictures, engages the dorsal anterior cingulate cortex (dACC), medial prefrontal cortex (mPFC), lateral prefrontal cortex, precuneus and posterior cingulate cortex, intraparietal sulci, and middle/superior temporal gyrus, which are brain networks implicated in cognitive control, social perception and perspective-taking (Koenigsberg et al., 2010). A recent study by Dörfel et al. (2014) in which participants were instructed ‘to take the position of a noninvolved observer’, also found activity in regions implicated in cognitive control such as the right dlPFC, right superior frontal cortex and bilateral inferior parietal cortex. It could be argued however, that distancing oneself from an emotional stimulus by reducing its personal relevance is different to adopting a temporally distant perspective (as implemented in Chapter 5). Thus while we might still predict the involvement of cognitive control circuitry in implementing a deliberate intention to regulate, we might also predict the recruitment of circuitry required for ‘episodic future thinking’ which is the ability to project the self forward to pre-experience an event (Atance & O’Neill, 2001).

6.1.2 Future thinking

Projecting oneself forward (and backward) in time can be defined as ‘mental time travel’ (Suddendorf & Corballis, 2007) and over the past decade, a growing number of neuroimaging studies have detected a common neural network involved in mental time travel (Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Schacter & Addis, 2007). Typically these studies involve participants remembering real past experiences (relying on episodic autobiographical memory) and imagining or simulating possible future experiences (episodic future thinking) using cue-word tasks (e.g. birthday). These studies have found that both past and future episodic thinking activate similar circuitry including medial temporal and frontal lobes, posterior cingulate and retrosplenial cortex, and lateral parietal and temporal areas (Addis, Pan, Vu, Laiser, & Schacter, 2009; Addis, Roberts, & Schacter, 2011; Addis, Wong, & Schacter, 2007; Botzung, Denkova, & Manning, 2008; Okuda et al., 2003; Szpunar, Watson, & McDermott, 2007; Viard et al., 2011). This is not surprising as there are several cognitive processes that are common to both past and future thinking. For example both are associated with self-referential processing, which has been shown to engage the medial prefrontal cortex (Gusnard, Akbudak, Shulman, & Raichle, 2001; Kelley et al., 2002; Northoff & Bermpohl, 2004). The ability to visualise spatial scenes is also needed to mentally construct past or future events, and this process has been found to be associated with the posterior cingulate cortex (Hassabis, Kumaran, & Maguire, 2007; Szpunar et al., 2007; Szpunar, Chan, & McDermott, 2009). The hippocampus has also been implicated in both past and future thinking (Addis et al., 2007; Botzung et al., 2008; Okuda et al., 2003; Szpunar et al., 2007; Viard et al., 2011), as some argue that past and future events build on similar information stored in episodic memory, and thus novel events can be created by using this stored information (Schacter & Addis, 2007).

However, thinking of the past and projecting to the future do differ with respect to temporal orientation, and this has been shown to be accompanied by neural differences. For instance, in a study by Addis et al. (2007) participants were instructed to construct a past or future event within a specified time period (a week, a year, 5–20 years) following a word cue, and then mentally elaborate on the generated events. Greater neural activity in frontopolar regions, such as the right frontopolar cortex and left vlPFC, which are involved in prospective thinking and generation processes (Burgess, Quayle, & Frith, 2001; Poldrack et al., 1999), was found when participants imagined future events compared with remembering past events. These findings are in line with earlier patient studies which have found that damage to the frontopolar cortex, particularly ventromedial PFC (vmPFC), is associated with deficits in awareness to the future consequences of actions (Bechara, Damasio, Damasio, & Anderson, 1994). Addis et al. (2007) also found greater engagement of the hippocampus during future thinking relative to remembering the past. Interestingly, in a later study, greater activation of the right anterior hippocampus for constructing future relative to recollecting past events was only observed in imagined future events that were specific, as opposed to routine or general events (Addis, Cheng, Roberts, & Schacter, 2011). These findings suggest that the process of creating novel and specific future events differentially activates the hippocampus compared with more general types of event simulation and recall.

Several other studies have also demonstrated differential activation between recalling the past and constructing future events (see Zheng, Luo, & Yu, 2014, for a review), however nearly all of these studies have investigated the role of self-projection in time to the past and future but have not examined future vs. *present* thinking. In one study by Andrews-Hanna, Reidler, Sepulcre, Poulin and Buckner (2010), participants were asked questions about hypothetical events that they would experience either in the future (Future Self) or the immediate present (Present Self), as well as parallel questions that required general semantic knowledge about the present or future which avoided reference to the participant (control conditions). Increased activation during Future Self trials was observed selectively in regions comprising the medial temporal lobe subsystem, including bilateral parahippocampal cortex, hippocampal formation, vmPFC, posterior inferior parietal lobule, and retrosplenial cortex. In contrast, a number of regions within and outside the dmPFC subsystem were recruited more during Present Self trials: i.e., dmPFC, temporoparietal junction, lateral temporal cortex, and temporal pole. However, the authors do highlight that it is not clear that this contrast isolated temporal factors as there were other differences between the future and present conditions, such as greater use of mental imagery in the Future Self condition.

6.1.3 Current study

In the current study we used the same paradigm as Chapter 5 to investigate temporal distancing, using an event-related design optimised for fMRI. Firstly we investigated whether temporal distancing would reduce neural responses in regions which typically respond during emotional distress, in particular amygdala (Buhle et al., 2014); and subgenual anterior cingulate cortex (sgACC; Drevets, Savitz, & Trimble, 2008), with which the amygdala is densely interconnected (Johansen-Berg et al., 2008). Moreover using a similar paradigm to the task used in Chapter 4, Kanske, Heissler, Schönfelder, Bongers and Wessa (2011) found that activation in the bilateral amygdala and the sgACC was increased when passively viewing emotional photos relative to reappraising the photos, indicating a reduction of activation in these areas through reappraisal.

Second, we examined whether the neural networks underpinning temporal distancing are the same as those regulatory regions found to be engaged during reappraisal more generally (e.g. vlPFC, vmPFC, dlPFC, dmPFC, as in Buhle et al., 2014), and/or whether this particular type of distancing would engage regions involved in episodic future thinking (e.g. hippocampus, vmPFC, posterior inferior parietal lobule, retrosplenial cortex, as in Andrews-Hanna et al., 2010) relative to no strategy use.

Third, we explored whether the extent to which individuals project themselves into the future influences distancing efficacy. We were able to explore temporal extent in two different ways: 1) The Near Future condition enabled us to explore whether any regions reflected Distant (as opposed to Near) future thinking, while controlling for the cognitive processes involved in temporal distancing per se. This may help shed light on why it is that thinking of the distant future is more effective for emotion regulation than thinking of the near future (see Chapter 5). We might expect that regions associated with thinking of the 'future self' in previous studies (e.g. Andrews-Hanna et al., 2010) may be more active in the Distant Future condition, and that we may find this activity to be associated with improved subjective emotion regulation. 2) The mean distance projected into the future (for both Distant and Near Future conditions, as assessed in Chapter 5) allowed us to investigate the relationship between length of future projection and recruitment of regulatory processes (involving for example, dlPFC and vlPFC). We predicted that those who projected further into the future (measured with behavioural ratings) would exhibit greater activation in regions associated with future thinking. One more speculative prediction was that we might also see reduced activation in regions associated with cognitive control aspects of reappraisal, with future thinking potentially reducing the demand on cognitive control mechanisms.

Finally, in line with findings in Chapter 5 and previous research (e.g. Blair, 2010; Coccaro et al., 2007; Sebastian et al., 2014; Viding et al., 2012), we predicted that those higher in reactive aggression would exhibit greater activation of the amygdala and/or sgACC in response to reading negative scenarios compared to both reading neutral scenarios and implementing temporal distancing for negative scenarios. In contrast, these individuals might be predicted to show reduced engagement of regions involved in cognitive control during temporal distancing (Coccaro et al., 2007; Goldin et al., 2009), with the opposite pattern predicted for psychopathic traits (Harenski et al., 2009). Finally, based on the findings by Drabant et al. (2009), in which participants who reported using reappraisal more often in everyday life exhibited decreased amygdala activation and greater activity in prefrontal regions in response to viewing negative facial expressions, we predicted that greater habitual reappraisal use would be associated with diminished amygdala activity and heightened prefrontal activity during temporal distancing.

6.2 Method

6.2.1 Participants

Twenty six (8 males) healthy right-handed adults (average age of 22.8, *SD*=3.1) were recruited from Royal Holloway University of London, and received £15 for participation. The study was approved by the Departmental Ethics Committee at Royal Holloway, University of London. Participants underwent a screening process prior to participating to ensure that they were safe to go inside the MRI scanner and had no reading impairments.

6.2.2 Experimental task and stimuli

The stimuli and experimental task were similar to that of Chapter 5 but adapted for fMRI. The same sets of stimuli (3 negative and 1 neutral set) were used; however scenarios were shortened so that the sets were also matched for number of words to control for visual input and word-reading (see Appendix 2). As with Chapter 5 each of the three sets of negative photos was randomised to one of the three negative conditions (Read Negative, Distant Future, Near Future) for each participant.

Prior to beginning the task, participants were asked to read the task instructions (see Appendix 3) which contained examples of how to implement instructions for each condition, and complete a short 4-minute practice run consisting of 12 stimuli (3 for each condition) that were different to those used in the experimental task. The task was also verbally explained to them and it was reiterated that for Near and Distant Future conditions, they had to project themselves into the future to consider how each scenario would likely affect them at the chosen time point, and then consider and rate how they currently felt after projecting themselves. This was to increase the likelihood that participants would all be using the same strategy in the same way. Only distress ratings were taken (not arousal) as similar results for both distress and arousal were found in Chapters 4 and 5, and omitting the arousal rating allowed us to limit time spent inside the scanner.

Each trial began with a scenario (4 seconds), followed by a black screen (0.5 s), then the instruction (1 s: 'READ', 'NEAR', or 'FAR' (the Distant Future condition was renamed 'far' to approximate the length of the other two instructions)) and then a green cross in the center of the screen (8 s), which was presented when participants were instructed to implement the particular strategy (see *Figure 6.1* for trial structure). For the 'READ' instruction, participants were told that during the green cross screen they should think about how the scenario makes them feel at that present moment in time. The modelling of events in the analysis was different to that of Chapter 5; participants were specifically instructed to only start implementing the instruction from the onset of the green cross, rather than during the reading of the scenario, which could introduce reading-related activation. The green cross was followed by a white fixation cross, which represented a jittered inter stimulus interval (ISI) of 2-6 seconds, generated on an exponential number generator, so that the majority of the ISIs were shorter in length, with very few being 5 or 6 seconds long. The variable ISI was followed by the 4-point distress rating (1=low distress, 4=very distressed) which was presented for 3 seconds. As a manipulation check, participants were also asked to rate the distance in time adopted on each trial for Near Future and Distant Future conditions on a timescale (1=one day, 4=five years from now), presented for 4 seconds. A jittered ISI with the same parameters as above was presented at the end of each trial. Participants made their responses using an MRI compatible button box using the four fingers of their right hand. All timings were determined from a behavioural pilot consisting of 10 participants. The task was presented and responses were recorded using Psychtoolbox for Matlab (version R2015a).

Following the task, participants also completed a manipulation check measure outside of the scanner where they were asked to write what they thought of during the green cross for a random selection of scenarios they had seen during the task. Participants were shown two scenarios from each condition (8 in total). Inspection of their responses revealed that all participants implemented each instruction correctly.

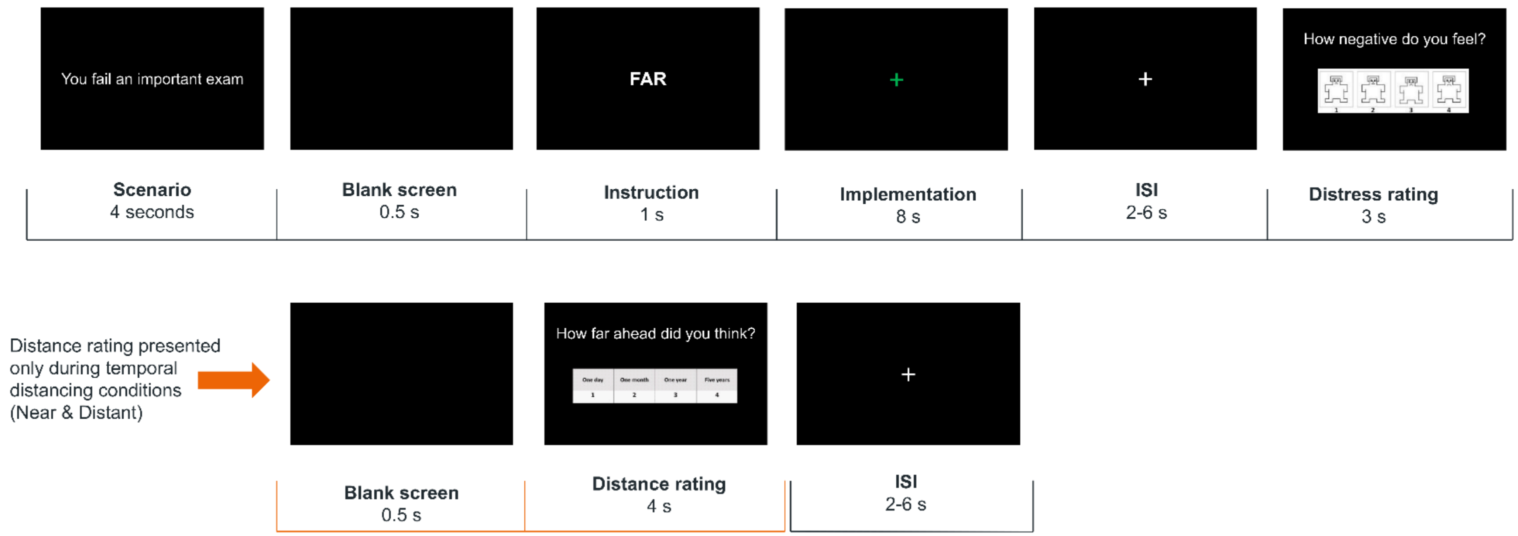


Figure 6.1. Visual depiction of a Distant Future trial.

6.2.3 Questionnaire measures

In line with Chapters, 2-4, aggression was measured using adult-specific questionnaires: The Self-Report Psychopathy Scale-III Short Form (SRP-III-SF; Paulhus et al., in press) and Buss Perry Aggression Questionnaire (Buss & Perry, 1992), in contrast to the adolescent measure used in Chapter 5. Although the questionnaires used are different, similar constructs are measured across studies. As with Chapter 5, participants were asked to complete the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) and the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003).

6.2.4 fMRI data acquisition

A 3T Siemens MRI scanner was used to acquire both T1-weighted structural images and multislice T2*-weighted echo planar volumes with blood oxygenation-level-dependent (BOLD) contrast. The T2* echo planar imaging (EPI) sequence was optimised to decrease dropout in the OFC (Weiskopf et al., 2006), and used the following acquisition parameters: 48 2mm slices acquired in a descending trajectory with a 1mm gap, TE=30ms; TR=3100ms; flip angle=78°; field of view=192mm; matrix size=64x64, yielding functional 3 x 3 x 3mm voxels. Functional data were acquired in a single scanning session of approximately 18 minutes per run, in which approximately ~350 volumes were acquired. The acquisition of a ~3 min T1-weighted anatomical image occurred in between the two functional runs for each participant.

6.2.5 Data analysis

Behavioural data were analysed as described in Chapter 5. Mean distress ratings were calculated for the Read Neutral, Read Negative, Distant Future and Near Future conditions, and then scores for Reactivity (Read Negative - Read Neutral) and Distancing Success (Read Negative - Distant Future) were also computed.

Imaging data were analysed using SPM8 software (www.fil.ion.ucl.ac.uk/spm). The first four functional image volumes from each run were discarded to allow for T1 equilibrium effects. Pre-processing included rigid-body transformation (realignment), slice timing correction, normalisation into the standard space defined by the Montreal Neurological Institute (MNI) template with a voxel size of 3x3x3mm, and smoothing with a Gaussian filter of 8mm full width at half maximum to increase the signal-to-noise ratio and to facilitate group analyses.

Statistical analysis involved the creation of statistical parametric maps representing a statistical assessment of hypothesised condition-specific effects (Friston et al., 1994), which were estimated with the general linear model. For each participant, the conditions of interest were implementation of each strategy condition (8 second green cross period for Read Neutral, Read Negative, Distant Future, Near Future).

Effects were modelled using a box-car convolved with a canonical hemodynamic response function for the 8 second trial epoch during which participants implemented the instructed strategy while the green fixation cross was on screen. The remainder of the trial (scenario, instruction, ratings and blank screens) was included as a nuisance regressor, with all conditions included within the same regressor such that it was orthogonal to the regressors of interest. The two jittered ISIs (fixation crosses) were left unmodelled and formed an implicit baseline. The six realignment parameters (derived from spatial realignment) were also included as nuisance regressors in order to account for any variance due to head movement. In addition, scans in which there was movement of greater than half a voxel (1.5mm) in any direction were visually inspected for distortion. No distortion was found and so all data were included for analysis. Finally, data were high-pass filtered at 128sec to remove low-frequency drifts. First-level analysis was conducted on the contrasts of interest (Read Negative > Read Neutral (Reactivity), Read Negative > Distant Future (No strategy compared to using Distancing i.e. unregulated responding), Distant Future > Read Negative

(Regulation), Distant Future > Near Future (Regulation, controlling for cognitive processes associated with distancing) for each participant. As we did not have specific hypotheses for the remaining contrasts (Near Future > Distant Future, Read Negative > Near Future and Near Future > Read Negative), these are reported in Appendix 4. These individual contrasts were then entered into a one-sample t-test to perform a random-effects group analysis.

At the whole brain level, results were considered significant at the voxel level using a statistical threshold of $p<.05$ after Family-Wise Error (FWE) correction for multiple comparisons.

Regions of Interest

Anatomical regions of interest (ROI) masks were defined using the Brodmann areas atlas implemented in Wake Forest University PickAtlas toolbox within SPM (Maldjian, Laurienti, Kraft, & Burdette, 2003). Based on previous studies, Brodmann areas were used to define each ROI (Andrews-Hanna et al., 2010; Lee & Siegle, 2012). As we did not have any laterality-related hypotheses, the masks combined homologous regions on the left and right hemispheres. Our ROIs were divided into three categories: *Emotional Responsivity* (encompassing Reactivity (Read Negative > Read Neutral) and Unregulated Responding (Read Negative > Distant)): amygdala, sgACC (BA 25)); *Reappraisal* (Distant > Near & Distant > Read Negative: vlPFC (BA 47), vmPFC (BA 10), dlPFC (BA 46), dmPFC (BA 9)), and *Future Thinking* ((Distant > Near & Distant > Read Negative: hippocampus, vmPFC, posterior inferior parietal lobule (BA 39), retrosplenial cortex (BA 29, 30)). Inferences within the masks were made using a statistical threshold of $p<.05$ after FWE-correction at the voxel level.

6.3 Results

6.3.1 Behavioural data

A one-way repeated measures ANOVA on the recorded distress ratings revealed a main effect of Condition ($F(3, 75)=218.38$, $p<.001$, partial $\eta^2=.90$). Replicating the results of Chapter 5, all conditions were significantly different from each other with distress ratings following the pattern: Read Neutral (*M*=1.06, *SD*=.10) < Distant Future (*M*=2.00, *SD*=.37) < Near Future (*M*=2.39, *SD*=.37) < Read Negative (*M*=2.94, *SD*=.40), (all *ps*<.005, see *Figure. 6.2*).

However, distancing success and distance in time adopted during Distant Future trials did not significantly correlate ($r(24)=.143$, $p=.487$).

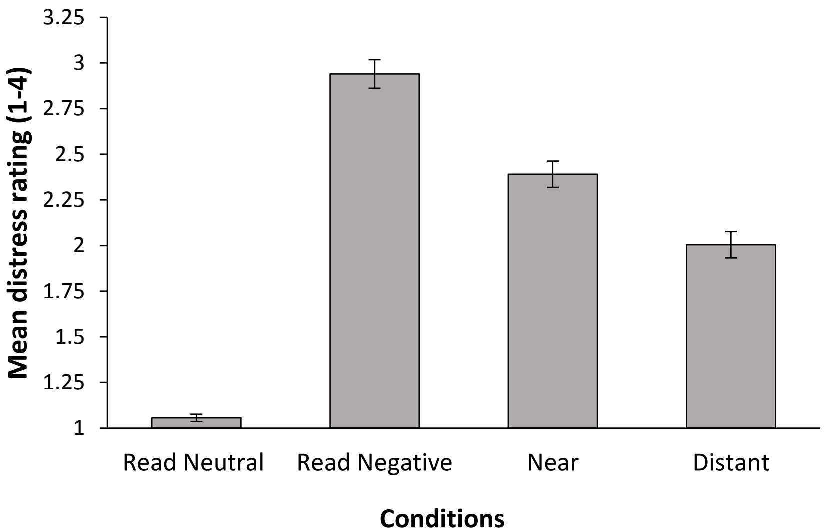


Figure 6.2. Mean distress ratings. All conditions were significantly different from each other ($p<.005$, Bonferroni corrected).

6.3.1.1. Relationships with questionnaire data

There were no significant relationships between Distancing Success and the questionnaire data. Behavioural reactivity (Read Negative – Read Neutral) was positively associated with Trait Anxiety ($r(24)=.42$, $p=.037$), i.e. those higher in trait anxiety had higher emotional reactivity to the negative scenarios relative to neutral scenarios.

6.3.2 fMRI data

6.3.2.1 Whole brain analyses

Results surviving familywise error (FWE) correction for the contrasts Read Negative > Distant Future (No strategy compared to using Distancing) and Distant Future > Read Negative (Regulation) are presented in Table 6.1. Regions activated to a greater extent when using no strategy relative to Distant Future included bilateral occipital lobe and bilateral temporal lobe, including the middle and superior temporal gyrus. The Distant Future > Read Negative contrast revealed several significant clusters, most of which were in parietal and prefrontal regions, such as the inferior parietal lobule, inferior frontal gyrus and middle frontal gyrus, as well as the posterior insula and dorsal anterior cingulate cortex.

Results from the contrasts Read Negative > Neutral (Reactivity) and Distant Future > Near Future (Regulation, controlling for cognitive processes involved in distancing) did not survive FWE-correction. We reasoned that the lack of response in the Reactivity contrast might be because this analysis was based on the 8 second 'implementation period', while strongest emotional reactivity might occur during scenario presentation. We therefore also analysed the BOLD response during the 4 second scenario viewing period separately (negative scenarios > neutral scenarios). However this analysis also failed to yield FWE-corrected significant results (although at uncorrected levels ($p<.005$, $k>10$), activations for this contrast were seen in the right occipital lobe, left middle frontal gyrus and left ventral anterior cingulate gyrus).

As mentioned above, results from the contrasts Near Future > Distant Future, Read Negative > Near Future and Near Future > Read Negative are in Appendix 4. Whole brain regressions were also conducted to explore correlations with the behavioural distress and distance in time adopted ratings and questionnaire data, however no regions survived FWE-correction.

Table 6.1. Peak cluster activations in brain regions from each contrast reaching significance at *p*<.05 (FWE-corrected at the whole brain level) BA=Brodmann area; L/R=laterality (left/right); Peak=co-ordinates of the peak voxel from the whole brain analysis (XYZ co-ordinates refer to Montreal Neurological Institute (MNI) standard space); *t*=t-value; *k*=cluster size (number of 3x3x3mm voxels: where cells are empty, activations are part of above clusters); FWE=familywise error.

Brain Regions	**Peak**						**Cluster**	
	BA	*L/R*	*x*	*y*	*z*	*T*	*k*	*p (FWE)*
Read Negative > Distant								
Cuneus	-	L	-21	-94	-2	6.97	171	<0.001
Middle Occipital Gyrus	-	R	27	-91	-8	6.25	152	<0.001
Middle Occipital Gyrus	18	R	24	-94	1	6.05	-	-
Superior Temporal Gyrus	22	L	-54	-7	-11	6.28	137	<0.001
Middle Temporal Gyrus	21	L	-54	5	-17	6.04	-	-
Superior Temporal Gyrus	22	L	-54	-40	7	5.30	31	<0.001
Middle Temporal Gyrus	21	R	57	-7	-11	5.72	50	<0.001
Superior Temporal Gyrus	38	R	48	11	-20	4.96	-	-
Distant > Read Negative								
Inferior Parietal Lobule	40	R	51	-37	49	6.33	445	<0.001
Inferior Parietal Lobule	40	R	45	-43	49	6.28	-	-
Postcentral Gyrus	3	R	57	-22	40	5.20	-	
Inferior Parietal Lobule	40	L	-48	-37	43	6.29	729	<0.001
Postcentral Gyrus	40	L	-48	-34	55	5.98	-	-
Postcentral Gyrus	2	L	-54	-28	40	5.94	-	-
Lingual Gyrus	18	R	3	-73	1	5.74	112	<0.001
Insula	13	L	-42	-4	13	5.67	145	<0.001
Insula	13	L	-39	-1	4	5.38	-	-
Putamen	-	L	-30	-16	1	4.98	-	-
Culmen	-	R	24	-52	-20	5.23	106	<0.001
Fusiform Gyrus	19	R	24	-67	-14	5.06	-	-
Inferior Frontal Gyrus	9	R	54	8	28	5.21	30	<0.001
Middle Frontal Gyrus	10	R	42	50	10	5.01	33	<0.001
Middle Frontal Gyrus	6	R	30	8	61	4.90	9	0.005
Insula	13	R	45	-1	13	5.20	10	0.004
Middle Frontal Gyrus	10	R	36	59	-8	4.83	3	0.016
Cerebellar Tonsil	-	R	18	-58	-50	4.72	3	0.016
Medial Frontal Gyrus	6	L	-6	-4	52	4.69	5	0.010
Middle Frontal Gyrus	11	R	30	50	-11	4.67	2	0.021
Thalamus, Pulvinar	-	L	-21	-25	13	4.64	1	0.029
Postcentral Gyrus	3	R	60	-16	22	4.63	4	0.013
Middle Frontal Gyrus	10	L	-39	56	7	4.60	1	0.029
Claustrum	-	R	36	2	1	4.60	1	0.029
Superior Frontal Gyrus	9	R	42	35	34	4.57	4	0.013

Brain Regions	**Peak**						**Cluster**	
	BA	*L/R*	*x*	*y*	*z*	*T*	*k*	*p (FWE)*
Distant > Read Negative								
Claustrum	-	R	30	17	4	4.54	1	0.029
Cingulate Gyrus	32	R	6	23	43	4.54	1	0.029
Precentral Gyrus	44	R	51	11	7	4.54	1	0.029
Distant > Near								
None								

6.3.2.2 Regions of interest analyses

<u>Unregulated Responding</u>

Significantly increased BOLD responses for Read Negative relative to Distant Future were found in our regions of interest for reactivity: the amygdala (left: x=-27, y=-7, z=-17; t=3.39; k=3; p=.039, FWE-small volume corrected (SVC); and the subgenual ACC (right: x=3, y=17, z=-14; t=5.55; k=19; p=.013 FWE-SVC see *Figure 6.3;* left: x=-3, y=26, z=-17; t=5.58; k=15; p=.015 FWE-SVC).

The contrast estimates across each of these clusters were averaged using the MarsBaR tool for SPM (http://marsbar.sourceforge.net/), and the resulting parameters were then used to correlate with the behavioural measures of Reactivity, Distancing Success and distance in time adopted. Activation in sgACC clusters was marginally positively correlated with Distancing Success (right: (r(24)=.39, p=.052; left: (r(24)=.37, p=.065).

<u>Regulation</u>

As shown in Table 6.1, temporal distancing (Distant Future > Read Negative) was associated with enhanced recruitment of the frontal and parietal lobes relative to no strategy. However we were also interested in whether similar activations would be found in prefrontal regions commonly found in reappraisal studies. As shown in Table 6.2, there were several significant clusters within all of our reappraisal-related ROIs (vlPFC, vmPFC, dlPFC, dmPFC). None of the ROI regions were significantly activated for the Distant Future > Near Future contrast.

Table 6.2. Peak cluster activations in the regions of interest for the Distant > Read Negative contrast reaching significance at p<.05 (FWE-corrected within ROIs) BA=Brodmann area; L/R=laterality (left/right); peak voxel=co-ordinates of the peak voxel from the whole brain analysis (XYZ co-ordinates refer to Montreal Neurological Institute (MNI) standard space); t=t-value; k=cluster size (number of 3x3x3mm voxels: where cells are empty, activations are part of above clusters); FWE=familywise error. Regulation ROIs: vlPFC, dlPFC, dmPFC; Future thinking ROIs: Posterior inferior parietal lobule. Overlapping ROIs: vmPFC.

Brain Regions	**Peak**						**Cluster**	
	BA	*L/R*	*x*	*y*	*z*	*t*	*k*	*p (FWE)*
Distant > Read Negative								
Ventrolateral PFC	47	R	48	14	1	5.61	18	0.008
		R	42	17	-5	4.99	-	-
		L	-33	17	-8	4.27	2	0.033
Dorsolateral PFC	46	R	42	47	10	6.41	23	0.009
		R	45	41	16	5.25	-	-
		R	39	35	16	4.58	-	-
		R	48	50	7	6.07	2	0.042
		R	42	50	19	5.08	1	0.048
		L	-42	47	10	4.43	2	0.042
		L	-48	47	4	4.41	1	0.048
		L	-42	38	22	3.94	1	0.048
		L	-39	50	19	3.80	1	0.048
Dorsomedial PFC	9	R	57	11	34	6.66	25	0.004
		R	51	5	28	5.93	-	
		R	42	35	34	5.79	28	0.003
		R	6	32	34	5.55	10	0.013
		L	-57	8	34	4.90	7	0.017
		L	-39	26	37	4.50	3	0.027
		L	-3	32	37	4.45	2	0.032
Ventromedial PFC	10	R	45	50	7	6.54	39	0.001
		R	33	62	-5	5.96	-	-
		R	39	59	7	5.30	-	-
		R	42	47	16	5.92	19	0.006
		R	42	44	22	5.53	11	0.011
		R	39	44	31	4.70	-	-
		R	33	50	28	4.62	-	-
		L	-42	53	4	5.44	8	0.015
		R	30	56	22	5.34	9	0.013
		L	-33	56	19	4.62	1	0.037
		L	-36	56	-5	4.57	1	0.037
		L	-36	56	4	4.34	1	0.037
Posterior inferior	39	R	36	-79	31	4.77	3	0.029
parietal lobule		R	39	-67	40	4.58	2	0.033

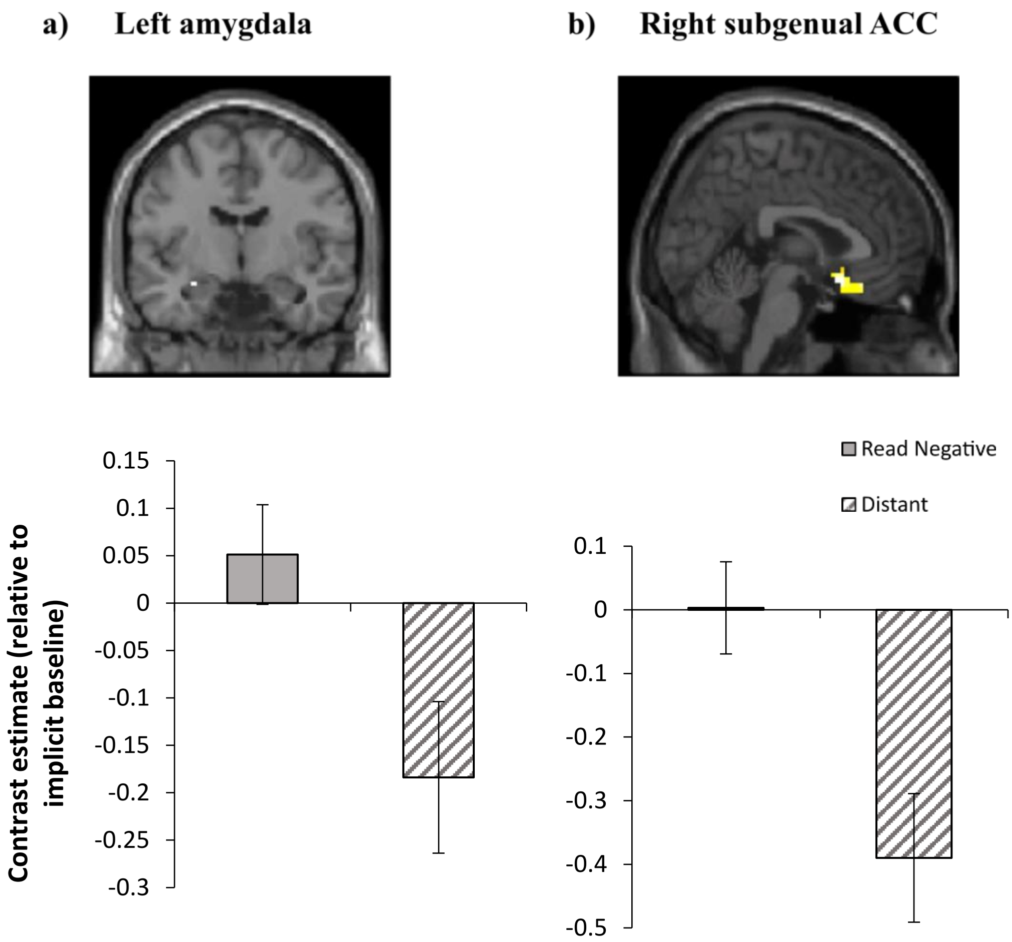


Figure 6.3. Top: Read Negative > Distant Future for a) left amygdala and b) right subgenual anterior cingulate cortex (sgACC). Significant voxels at $p < .05$ FWE-corrected are overlaid on a single-subject T1-weighted anatomical template. Bottom: Contrast estimates are shown relative to implicit baseline for the a) left amygdala ROI and b) sgACC ROI.

<u>Future Thinking</u>

The Distant Future > Read Negative contrast yielded two significant clusters within the posterior inferior parietal lobule (BA 39) as well as vmPFC, which was also a ROI for the reappraisal related regions (see Table 6.2). However there was no significant activation in the hippocampus or retrosplenial cortex. None of the ROI regions were significantly activated for the Distant Future > Near Future contrast.

Distance in time adopted

In order to investigate whether the extent to which distance in time adopted correlated with regions implicated in reappraisal and future thinking during the Distant Future > Read Negative contrast, the contrast estimates of the cluster within each ROI where the peak voxel had the strongest *t/z* value were averaged using the MarsBaR tool for SPM (http://marsbar.sourceforge.net/). These contrast estimates were then used to correlate with the distance in time adopted measure. We found that vlPFC (BA 47) activation in the Distant Future > Read Negative contrast was negatively correlated with distance in time adopted ($r(24)=-.45$, p=.021), showing that the further in time participants projected into the future, the less vlPFC responded during temporal distancing relative to no strategy use (see *Figure 6.4*). There were, however, no significant correlations between distance in time adopted and regions associated with future thinking.

Questionnaire measures

We predicted that more reactive forms of aggression and anxiety would be associated with increased activation in 'reactivity' regions. Left amygdala during the Read Negative > Distant Future contrast positively correlated with the Physical Aggression subscale of Buss-Perry Aggression Questionnaire ($r(24)=.43$, $p=.033$). To investigate whether heightened reactivity in those high in physical aggression is what is driving this effect, post-hoc correlations were conducted. The relationship between Physical Aggression score and left amygdala activation during the Read Negative > implicit baseline contrast was non-significant ($r(24)=-.19$, $p=.37$), but was significant during the Distant Future > implicit baseline contrast ($r(24)=-.55$, $p=.005$), suggesting (contrary to predictions) greater downregulation of amygdala by temporal distancing in those higher in Physical Aggression. However, it should be noted that this result would not survive correction for multiple comparison across all aggression subscales, and we did not have specific hypotheses regarding physical aggression over and above other aggression subscales. There were also no significant associations between the remaining subscales or Total Aggression score.

There were no significant correlations between the reactivity ROIs and the STAI, SRP-III-SF and ERQ measures. None of the questionnaire measures significantly correlated with the reappraisal or future thinking-related ROIs.

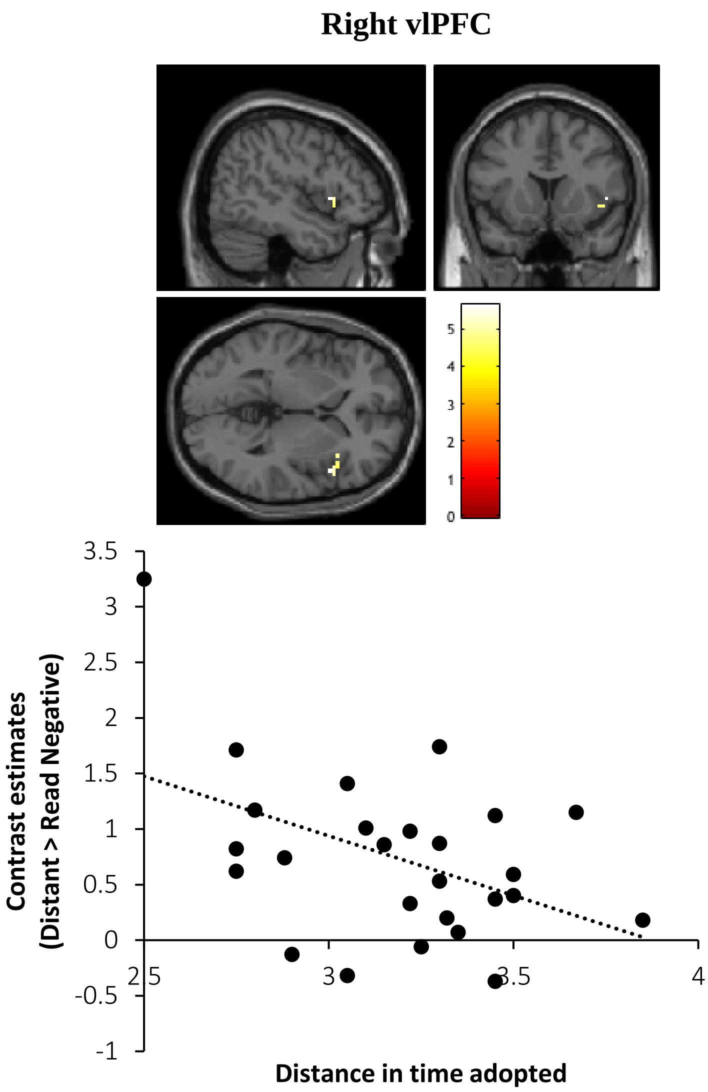


Figure 6.4. Top image: Right vlPFC (BA 47) cluster (Distant Future > Read Negative). Significant voxels at $p < .05$ FWE-corrected are overlaid on a single-subject T1-weighted anatomical template. Bottom image: negative correlation ($r(24)=-.45$, $p=.021$), between average distance in time adopted rating and right vlPFC activation (Distant Future > Read Negative). Values on the x-axis correspond to the Likert scale ratings (1=one day, 4=five years).

6.4 Discussion

The present study was the first to investigate the neural bases of temporal distancing as an emotion regulation strategy. Behavioural findings broadly replicated those of Chapter 5, illustrating that temporal distancing is an effective strategy in reducing subjective negative affect. At the neural level, in line with predictions, temporal distancing reduced neural responses in the left amygdala and bilateral sgACC, relative to using no strategy. Furthermore, whole-brain analyses revealed that temporal distancing (relative to no strategy) engaged several parietal and prefrontal regions, such as bilateral inferior parietal lobule, inferior frontal gyrus, middle frontal gyrus and superior frontal gyrus. The ROI analyses were in accordance with this, with significant activations in all of our ROIs associated with reappraisal: vlPFC, dlPFC, vmPFC, dmPFC. We also found that the further in time participants projected into the future, the less vlPFC responded during temporal distancing relative to no strategy use. Finally, in contrast to findings of previous future thinking research (Addis et al., 2007; Addis et al., 2011; Andrews-Hanna et al., 2010; Botzung et al., 2008; Okuda et al., 2003; Szpunar et al., 2007; Viard et al., 2011) there were no significant activations of the hippocampus or the retrosplenial cortex.

6.4.1 Emotional Responsivity

For Unregulated Responding (Read Negative > Distant) we expected to see activation in two ROIs, namely amygdala and sgACC. Indeed, during temporal distancing, participants showed decreased left amygdala and bilateral sgACC activation and reported proportional decreases in emotional distress relative to using no strategy. This is consistent with previous neuroimaging studies (e.g. Buhle et al., 2014; Dörfel et al., 2014; Ochsner & Gross, 2005, 2008), suggesting that temporal distancing is effective in attenuating emotional arousal. Furthermore behavioural distancing success (i.e. reduction of distress in the Distant Future relative to the Read Negative condition) was marginally correlated with sgACC, such that those reporting the greatest reduction in distress also showed the greatest reduction in sgACC during Distant Future relative to Read Negative. Although this finding was trending significance, it suggests that the more effective participants were at reducing their subjective distress using temporal distancing, the greater the reduction of sgACC activity between using no strategy and using distancing. This indicates that effective temporal distancing can attenuate activation in a brain region that has been implicated in emotional distress (Drevets et al., 2008) and is in line with previous studies that have found reductions of subjective emotional state paralleled by reductions of sgACC activation through reappraisal (e.g. Kanske et al., 2011). Perhaps surprisingly, we found no difference either in our ROIs or at the whole-brain corrected level for the Reactivity contrast (Read Negative > Read Neutral). The majority of studies examining emotion regulation use photos or videos as stimuli, for example in Buhle et al.'s (2014) meta-analysis, 39 out of 48 studies used photos or film clips. Therefore it is possible that the emotion elicited from written scenarios is perhaps more subtle than that which is produced by the presentation of aversive photos, which may be why we did not find any significant differences between these two conditions.

6.4.2 Regulation

The neural processes underlying emotion regulation typically involve interactions between prefrontal, parietal and cingulate systems that implement cognitive control and inhibition processes. More specifically, the vmPFC, dmPFC, dlPFC, vlPFC, inferior parietal cortex and the anterior cingulate cortex are considered brain regions that commonly support emotion control in general (Buhle et al., 2014; McRae et al., 2010; Ochsner et al., 2012). As temporal distancing is a form of reappraisal, it was predicted that these regions, particularly the prefrontal areas, would be activated during temporal distancing. These predictions were supported by the whole-brain and ROI analyses during temporal distancing compared to no strategy.

The whole-brain analysis (Distant Future > Read Negative) revealed several significant clusters of activations, particularly the right middle frontal gyrus, which has been implicated in the selection and control of behavioural strategies, keeping strategies in mind throughout a task, inhibiting prepotent responses, and regulating selective attention (Garavan, Ross, Murphy, Roche, & Stein, 2002; Koenigsberg et al., 2010; Miller & Cohen, 2001), which are all cognitive processes that underpin emotion regulation in general. Additionally the inferior parietal lobule has been implicated orienting and shifting attention processes (Wager et al., 2004) and has been suggested to direct attention away from the perceived stimulus towards the self during distancing (Dörfel et al., 2014). Furthermore, the dACC, which is involved in monitoring and resolving conflict between opposing tasks (Botvinick et al., 2004; Mohanty et al., 2007), was also engaged during temporal distancing. This is in line with the findings of reappraisal and distancing studies (Kim & Hamann, 2007; Koenigsberg et al., 2010; Ochsner et al., 2002). Taken together, the findings from the whole brain analysis suggest that the regions implicated in temporal distancing seem to be consistent with the neural correlates of emotion regulation (particularly reappraisal) in general.

The ROIs commonly engaged during reappraisal (vlPFC, vmPFC, dlPFC, dmPFC) were also activated during temporal distancing relative to using no strategy. This is not surprising as the vlPFC, for example, is associated with selecting goal-appropriate (and inhibiting goal-inappropriate) responses (Badre & Wagner, 2007; Thompson-Schill et al., 2005), such as using the instructed strategy and inhibiting emotional responses to the negative scenarios. Specifically, the anterior vlPFC (BA 47, which was the ROI we used) has been suggested to support controlled access to stored conceptual representations (Badre & Wagner, 2007), which may be involved in thinking of the future self. Additionally the dlPFC has been implicated in the updating and manipulation of stimuli in working memory (Wager & Smith, 2003). This executive process is common to all emotion regulation strategies, which require participants to keep in mind the goal of emotion regulation while manipulating the perceived emotional stimulus. Lastly, the medial PFC tends to be implicated in monitoring how emotional cues affect the self (Fossati et al., 2003; Ochsner et al., 2004). This information is particularly important in the present study as participants have to evaluate whether and/or how the particular scenario affects them in the present and consequently imagine the future-self reflecting on the present-self. The present study extends previous work by using a more circumscribed task in which the type of strategy implemented is more restricted relative to free reappraisal, thus showing that during emotion regulation, cognitive control processes are relied upon regardless of strategy specificity.

6.4.3 Future Thinking

As well as predicting the involvement of cognitive control circuitry in implementing a deliberate intention to regulate, the recruitment of circuitry required for future thinking was also predicted. There were significant activations in two of the predicted ROIs, namely vmPFC and posterior inferior partietal lobule, however the hippocampus and retrosplenial cortex were not significantly recruited during temporal distancing relative to no strategy. These regions of interest were based on the findings of Andrews-Hanna et al. (2010) as, to our knowledge, it is the only study to have compared thinking of the self in the future vs. the present (similar to the present study). However, the future-self questions asked during the task were about events “a few days from now”, for example, “Think about where you will be and who you will be with tomorrow afternoon during lunch. Who will you be eating lunch with: no one, your significant other, or someone else?”. As well as referring to the near future, rather than the distant future, the thought processes engaged in these types of questions are very specific. The scenarios utilised in the present study elicit much more abstract thinking and while they may be specific, such as how one would feel after failing an exam, it is perhaps much more difficult to think of how you would feel, compared to who you will go to lunch with tomorrow. A meta-analysis of neuroimaging studies using remembering and future thinking tasks suggests that details such as type of cue, task, and specificity of the retrieved and imagined information can all influence the exact location and pattern of activity in the hippocampus (Viard et al., 2012). Therefore the abstract nature of the distant future condition may explain why there was a lack of hippocampus engagement. Nonetheless, temporal distancing engaged the posterior inferior partietal lobule, which has been implicated in egocentric spatial processing (Aguirre & D’Esposito, 1999;

Andersen, Snyder, Bradley, & Xing, 1997) and the ability to visualise spatial scenes (Hassabis et al., 2007; Szpunar et al., 2009; Szpunar et al., 2007), which are necessary when constructing future events and imaging oneself in these events. This is not surprising given that the Distant Future condition requires participants to visualise themselves in the future, thus constructing future events.

In Chapter 5 the extent to which individuals projected themselves into the future influenced distancing efficacy. Furthermore, in both Chapter 5 and the current study, behavioural ratings showed reduced distress for Distant vs. Near Future conditions. Thus, it was predicted that there may be different patterns of neural activity in the Distant Future condition compared to the Near Future condition. However, this was not the case. It is likely that differences between the conditions do exist, since clear behavioural differences were seen. However, it is possible that the current fMRI design was not sensitive enough to elicit a distinction at the neural level. The use of a consistently bigger time gap between the conditions (e.g. 1 day vs. 5 years) may address this, as in the current task participants were able to interpret the near and distant future in their own way, leading to greater between-subject variation in the interpretation of 'near' and 'distant' future. Indeed, in a recent fMRI study where participants imagined engaging in an activity either tomorrow versus five years from now, neural differences were found (Stillman et al., 2017). Thinking of the distant future relative to the near future activated the dlPFC and inferior frontal gyrus, in line with our findings for the Distant Future > Read Negative, as well as engaging the medial PFC, cerebellum, orbitofrontal cortex and middle temporal gyrus (Stillman et al., 2017). Thus using a larger time gap between conditions may have led to neural differences in the present study. Additionally, there were a limited number of trials per condition in the current task. Therefore utilising a greater number of trials may provide a clearer insight into whether the lack of a difference is attributable to low power or not.

Mean ratings of the distance projected into the future allowed us to investigate temporal extent in another way. In Chapter 5 we found that the further into the future participants projected, the more effective they were at regulating negative affect. However this was not replicated in the present study, potentially due to the restricted rating scale used in the scanner environment (1-4 instead of 1-9) and the smaller sample size. Furthermore while we did not find any correlations between distance in time adopted and responses in our future thinking ROIs, we did find that vlPFC activation during temporal distancing relative to no strategy was negatively correlated with distance in time adopted, suggesting that the further in time participants projected into the future, the less vlPFC was recruited. One tentative interpretation is that the further ahead one projects into the future, the less one needs to rely on inhibitory control regions, like the vlPFC. This could have potential implications for regulatory strategies, for instance if cognitive control systems are relatively weak, alternative strategies like temporal distancing may be helpful. While speculative, this opens potential avenues for future research to investigate whether this is the case. It must be noted however that this result would not survive correction for multiple comparisons across all the number of correlations conducted within the set of 'Reappraisal' ROIs.

6.4.4 Individual Differences

Contrary to predictions, we did not find any significant associations between the individual differences measures (aggression, anxiety, and habitual reappraisal use) and the behavioural or neural responses of temporal distancing. Again, this is perhaps due to the small sample size, which has limited power to detect individual differences.

Although greater downregulation of amygdala activation by temporal distancing was found in those higher in physical aggression, this result would not survive correction for multiple comparisons across all aggression subscales in the questionnaire. Additionally, while we hypothesised a relationship with reactive aggression, we had no a priori hypothesis regarding *physical* aggression specifically. Moreover, the distribution of physical aggression was skewed in the sample, with most participants scoring 1.25-2.25 out of a maximum of 7 points. In order to investigate the relationship between aggression and the down-regulation of amygdala activity by temporal distancing, a larger and less skewed sample needs to be recruited.

6.4.5. Strengths, limitations and future directions

The present study is the first to investigate the neural correlates of temporal distancing, showing that it is effective at reducing responses in brain regions associated with emotional distress and recruiting cognitive control regions commonly implicated in other emotion regulation strategies, specifically reappraisal. A particular strength of the study was the task design, which enabled us to explore whether any regions reflected Distant (as opposed to Near) future thinking, while controlling for the cognitive processes involved in taking a distant perspective. However, despite a significant difference in the behavioural data, there was no difference between the Near and Distant Future conditions in the fMRI data. Furthermore, the lack of Reactivity results (i.e. a difference between Read Negative and Read Neutral conditions), either in the corrected whole-brain analysis or ROI analyses, was unexpected and fails to support previous studies (e.g. Buhle et al., 2014). Finally, as discussed above, contrary to predictions, there were no associations between temporal distancing efficacy and individual differences that would survive correction.

Using parametric modulation will be a fruitful direction for future research to address some of these limitations as it can be used to look at trial-by-trial changes. For example, regions can be identified where activation varies with the behavioural ratings within individual participants, such as the distress and distance in time adopted ratings. This would be more sensitive than the analysis used at present (in which participants' mean ratings for each condition were used in individual difference analyses), and could perhaps reveal the predicted effects that the current analysis failed to support.

Overall, the present study adds to the neuroimaging literature on reappraisal by demonstrating that placing negative events into a broader temporal perspective - a specific and newly investigated strategy within reappraisal, is an effective emotion regulation strategy both at the behavioural and neural level.

Cognitive control regions typically implicated in reappraisal also seem to be implicated in temporal distancing, while some regions associated with future thinking are recruited as well. However, more fine-grained analysis techniques may be required in order to understand the processes that underpin the effectiveness of projecting further into the future.

Chapter 7: General Discussion

7.1. Overview

The overall aim of the current thesis was to explore how the function and efficacy of implicit and explicit forms of emotion regulation are influenced by certain modulating factors. These included specific task demands, subtypes of aggression, interoception and age across the transition from adolescence to adulthood.

There is a substantial body of literature that suggests that emotion can capture our attention, even when we are unaware of it, and that the extent to which this occurs varies with subtypes of aggressive traits. However, there is currently limited research on whether the ability to implicitly regulate bottom-up attentional processing of emotion varies with psychopathic traits in a general non-pathological sample. This was the key aim of Chapter 2. Chapter 3 followed this by exploring the conditions under which emotion can, and cannot, interfere with task performance by varying cognitive load. The focus of the thesis then moved onto explicit emotion regulation. Chapters 4 - 6 addressed a gap in the explicit emotion regulation literature, exploring the ease of use and efficacy of distancing sub-strategies, with a particular focus on temporal distancing. Specifically these chapters all investigated the role of aggression as well as whether distancing varies with interoceptive awareness (Chapter 4), whether temporal distancing shows developmental differences in adolescence (Chapter 5) and the neural mechanisms underlying temporal distancing (Chapter 6).

The aim of this chapter is to succinctly summarise and answer the questions raised throughout the thesis, and to reflect upon how the findings fit into the wider implications of the field. Firstly, the main findings of each experimental chapter are presented in reference to the key research questions. Secondly, implications for the role of aggression in emotion regulation and the Process

Model (Gross, 1998) are discussed in light of the findings. Thirdly, limitations of the research are presented and avenues for future research are discussed. Finally, the chapter ends with the overall conclusions of the thesis.

7.2 Chapter summaries: main research questions and findings

7.2.1 Implicit emotion regulation

7.2.1.1 Does attentional capture by emotional faces vary with psychopathic traits in a community sample?

Chapter 2 of the thesis aimed to explore how aggression, specifically psychopathic traits, influences the ability for emotion to capture attention implicitly. Whilst previous studies have demonstrated that emotional processing varies with levels of psychopathic traits (e.g. Seara-Cardoso et al., 2012), few studies have investigated whether bottom-up attentional emotional processing varies continuously with these traits in an adult community sample. Using a gender-discrimination visual search paradigm in which emotion was irrelevant to the task (Hodsoll et al., 2011), angry and fearful faces interfered with search, indicated by slower reaction times relative to neutral faces, as predicted. Most importantly, emotional capture by fearful faces was reduced in those with higher levels of affective-interpersonal psychopathic traits, associated at the extreme end of the continuum with low affective reactivity and empathy. However, a moderation analyses revealed that this was only the case when lifestyle-antisocial psychopathic traits were low, consistent with evidence suggesting that these two facets of psychopathic traits display opposing relationships with emotional reactivity (Hicks & Patrick, 2006). This extended the findings of previous studies by showing a continuous effect in a community (as opposed to clinical or selective) sample. Overall, the findings demonstrated that normative variation in ‘high-level’ individual differences in psychopathic traits influence automatic bias to emotional stimuli at the very early stages of emotion processing.

7.2.1.2 Can increasing cognitive load reduce emotional interference? If so, what factors may drive this effect?

Following on from Chapter 2, which demonstrated that emotion can capture attention even when it is task-irrelevant, a key question in Chapter 3 was to establish whether this task-irrelevant information can be filtered out under different task conditions. In this study, four behavioural experiments were conducted using a gender-discrimination task consisting of high and low cognitive load trials, where perceptual inputs were matched across conditions. The findings of Experiment 1 were in line with previous studies (e.g. Sebastian et al., 2017); when emotion and cognitive load conditions were blocked, emotion captured attention (or at least resulted in increased RT interference) under low cognitive load but not high cognitive load. One interpretation is that when trials are more demanding (high load condition), processing resources may be 'pre-allocated' to resolving the cognitive conflict, thereby reducing the capacity for processing the emotional information or even actively suppressing this processing. However, during low load trials, greater attentional capacity is available, leading to processing of the emotional information which then interferes with task performance. Given the blocked nature of the experiment, it was suggested that a top-down anticipatory strategy (i.e. expectation of a high or low load trial, with or without emotional content) could be contributing to the findings. To test if this was the case, the following experiments randomised trial order to see if removing the ability to anticipate trial type in advance would result in emotion interference effects on both low- and high-load trials. Indeed this was the case; the effect seen in Experiment 1 disappeared in the following experiments as top-down expectancies could only be generated on a trial-by-trial basis, as opposed to across an entire block. Thus the experiments in Chapter 3 demonstrate that top-down anticipatory control mechanisms are an important factor in the extent to which cognitive load impacts on emotional processing. This suggests that when perceptual inputs are matched, high cognitive load per se does not reduce emotional interference. This is in line with attentional load theory as laid out by Lavie (2005), which suggests that high *perceptual* load reduces the extent to which emotion interferes with task performance, but that cognitive (e.g. executive load does not. This study helps in understanding why some studies have reported perceptual load type effects despite using cognitive tasks (e.g. Mitchell et al., 2007, Sebastian et al., 2017).

7.2.2 Explicit emotion regulation

7.2.2.1 Is distancing an effective emotion regulation strategy? Do efficacy and ease of use vary between distancing subtypes?

These questions were addressed in Chapter 4. In this chapter, the aim was to move beyond the broad definition of reappraisal by investigating three sub-strategies of psychological distancing (temporal distancing, spatial distancing, taking an impartial observer perspective), measuring their relative effectiveness and their ease of use. In keeping with one of the key broad themes of the thesis, individual differences in aggression were measured, as was interoceptive awareness, which has been found to facilitate reappraisal use (Füstös et al., 2013). Findings showed that all three strategies were effective in reducing self-reported negative affect (distress and arousal) to negatively valenced photos (relative to no strategy); however there were no significant differences between the strategies. Qualitative data revealed that temporal distancing was accurately implemented more often than the other strategies, with participants often resorting to using more general reappraisal strategies when they were unable to implement the instructed strategy. Additionally, greater interoceptive awareness, which tends be related to better discrimination of emotional states (Craig, 2004), was associated with greater temporal distancing efficacy, but was not associated with the efficacy of the two remaining distancing sub-strategies. Overall the findings demonstrated that psychological distancing is an effective emotion regulation strategy, and that, temporal distancing in particular may be modulated by individual differences in interoceptive awareness.

7.2.2.2 Is temporal distancing an effective strategy and does it show developmental differences across adolescence?

In Chapter 4 temporal distancing was operationalised as thinking of a distressing event as happening in the past, e.g. “it happened a long time ago”. However, research into adopting a temporally distant *future* perspective on stressors, e.g. “this too shall pass”, has recently been shown to effectively reduce distress in adults (Bruehlman-Senecal & Ayduk, 2015) and has been associated with greater well-being (Bruehlman-Senecal et al., 2016). Therefore Chapter 5 investigated whether the extent to which individuals project themselves into the future influences temporal distancing efficacy. Modulating effects of age across adolescence and reactive aggression were also examined as 1) adolescence has been associated with reduced future-thinking and poor emotion regulation (Ahmed et al., 2015; Schacter et al., 2015; Steinberg et al., 2009), and so it might be predicted that temporal distancing might develop during this time; 2) reactive (but not proactive) aggression has been shown to peak in adolescence (Moffitt, 1993) and is also associated with poor emotion regulation (e.g. Besharat et al., 2013; Marsee & Frick, 2007). A novel experimental paradigm was developed using more relatable stimuli such as commonly occurring ‘everyday’ scenarios instead of photos (which was used in Chapter 4). Self-report data revealed significant down-regulation of negative affect during adopting a distant future perspective relative both to using no strategy and to taking a near future perspective, with a similar though non-significant pattern of skin conductance responses. Importantly, participants who projected further ahead into the future reported the greatest distress reductions. While temporal distancing efficacy did not vary with age (contrary to predictions), participants reporting greater reactive (but not proactive) aggression showed reduced distancing efficacy, and projected themselves less far into the future. Additionally reactive aggression peaked in mid-adolescence, in line with existing findings (Moffitt, 1993), although age and aggression did not interact to predict temporal distancing efficacy. The results showed that placing negative events into a broader temporal perspective facilitates the down-regulation of negative affect and demonstrated the importance of temporal extent in effective temporal distancing; shedding light on a potential mechanism for poor emotional control associated with reactive aggression.

7.2.2.3 What are the neural mechanisms underlying temporal distancing?

In the final experimental chapter, the neural bases of temporal distancing were investigated using an fMRI-adapted version of the task used in Chapter 5. Behavioural findings replicated those of Chapter 5 and the neural results were largely in line with the neuroimaging literature on reappraisal more broadly defined in previous studies. During temporal distancing, participants showed decreased left amygdala and bilateral sgACC activation, and reported significant decreases in emotional distress relative to using no strategy. Temporal distancing engaged several parietal and prefrontal regions, such as bilateral inferior parietal lobule, inferior frontal gyrus, middle frontal gyrus and superior frontal gyrus. The ROI analyses further showed significant activations in cognitive control regions that are commonly associated with reappraisal (vlPFC, vmPFC, dlPFC, dmPFC), and some regions associated with future thinking (posterior inferior parietal lobule, vmPFC). It was also found that the further in time participants projected into the future, the less vlPFC responded during temporal distancing relative to no strategy use. One tentative interpretation is that the further ahead one projects into the future, the less one needs to rely on inhibitory control regions, like the vlPFC. The findings of this study extend previous work by using a more circumscribed task in which the type of strategy implemented is more restricted relative to free reappraisal, and thus the mental operations being performed are better specified. The results suggest that the neural circuitry important for temporal distancing overlaps to a certain extent with the cognitive control circuitry required for broadly defined reappraisal, in addition to the more specific engagement of regions involved in the mental construction of future events.

Overall, the findings of these three studies suggest that temporal distancing is an effective emotion regulation strategy at behavioural, neural, and potentially physiological levels. The findings of the thesis as a whole also suggest that the effectiveness of different emotion regulation strategies can be differentially modulated by individual differences in aggression subtypes. The following section discusses the role of aggression in light of the findings in more detail: a question that was central to the thesis.

7.3 Main implications of the thesis

7.3.1 What is the role of aggression in emotion regulation?

As discussed in Chapter 1 (section 1.5.1) several studies have suggested that individuals high in reactive forms of aggression have difficulty disengaging attention from hostile stimuli and thus are poor at implicitly regulating their emotions. Additionally they tend to use maladaptive emotion regulation strategies, such as rumination. In contrast, those characterised by proactive forms of aggression or psychopathy tend to perform better at implicit emotion regulation tasks, often showing reduced automatic orienting of attention to task-irrelevant stimuli and thus reduced reaction time interference. The majority of research has investigated pathological samples, or compared groups at the extreme ends of the continuum. Therefore the aim of the present thesis was to investigate whether aggression plays a role in implicit and explicit emotion regulation in community samples.

As summarised above, Chapter 2 showed that affective-interpersonal psychopathic traits do play a role in the implicit processing of emotional faces, with a reduction of emotional capture with increasing levels of affective-interpersonal psychopathic traits, though only when lifestyle-antisocial (reactive) traits were low. The results further support accounts suggesting that those high in affective-interpersonal psychopathic traits have difficulty processing fear (Blair et al., 2004; Veit et al., 2013), as the findings involving interpersonal-affective traits did not extend to the angry condition, despite anger capturing attention in the sample overall. Moreover this reduced interference by fearful faces (as indicated by faster RTs) in those high is these traits was significant for both distractor and target conditions, suggesting that emotion is not being processed, even when it appears in a task-relevant location. While results were not significant when using difference in reaction times (emotion – neutral), the findings are consistent with the small number of studies that have found similar effects (e.g. Maes & Brazil, 2015). The findings of Chapter 2 are particularly salient as they show that the effects of psychopathic traits on the implicit processing of emotion, particularly fear, are apparent even in a community (largely undergraduate student) sample. Therefore, although clinically elevated levels of psychopathic traits tend to be rare in the general population, continuities in the implicit regulation of emotion nonetheless exist.

In terms of explicit emotion regulation, most studies investigating the role of aggression in emotion regulation have measured regulation using self-report questionnaires, correlating these with self-reported aggression (e.g. Besharat et al., 2013; Martin & Dahlen, 2005), or a history of aggressive acts (e.g. Roberton et al., 2014; Tager et al., 2010). Findings generally suggest that individuals characterised by reactive aggressive behaviours tend to have difficulty regulating their emotions using explicit strategies, or often use maladaptive strategies. Additionally, studies using anger provocation tasks have demonstrated that those who use more adaptive emotion regulation strategies in day-to-day life, such as reappraisal, are more effective at down-regulating and controlling their anger, at subjective and objective levels (Gerin et al., 2006; Mauss et al., 2007; Memedovic et al., 2010). However, only a handful of studies have investigated the role of aggression in experimental manipulations of emotion regulation, and those that have (e.g. Germain & Kangas, 2015) have only studied individuals high in aggression. Given the lack of research on whether the efficacy of instructed reappraisal (or strategies within reappraisal) varies with levels of reactive aggression in the general population, Chapters 4-6 aimed to address this.

Despite predictions, Chapter 4 failed to show any relationships between distancing efficacy and aggression. Self-reported habitual reappraisal use, however, was negatively associated with reactive aggression, supporting the previous literature on the negative relationship between self-reported reappraisal and aggression (e.g. Besharat et al., 2013; Martin & Dahlen, 2005; Mauss et al., 2007; Memedovic et al., 2010). Chapter 5 did find that individuals higher in reactive aggression were less able to effectively down-regulate their distress using temporal distancing (note that temporal distancing was operationalised differently across Chapters 4 and 5, see section above). Those high in reactive aggression were less able to project far into the distant future, which is a possible mechanism for why they were less effective at reducing negative affect using the strategy, as greater distance projected into the future was associated with greater temporal distancing efficacy. Interestingly the findings were not explained by high levels of emotional reactivity typically seen in individuals high in reactive aggression as baseline distress ratings did not vary with different levels of reactive aggression. Given that differences were found in temporal distancing ‘success’, but not emotional reactivity, suggests that training in using temporal distancing to regulate emotion, particularly projecting further into the future, may be a potential avenue for training and intervention for those high in reactive aggression.

Chapter 6 also failed to find any significant associations between aggression and behavioural or neural responses during temporal distancing. This was possibly due to the small sample size (N=26), which likely limited power to detect individual differences. However, it was found that higher physical aggression was associated with a greater difference in left amygdala activation between no strategy and temporal distancing, which runs counter to general reactive aggression predictions as it suggests that amygdala response was reduced *more* by temporal distancing in those higher in physical aggression. While this result is not in accordance with the findings of Chapter 5, the distribution of physical aggression was skewed in the sample, with overall scores being very low. In contrast, the distribution of reactive aggression in Chapter 5 was similar to previous studies (e.g. Calvete & Orue, 2012). Furthermore we did not have a priori hypothesis regarding *physical* aggression specifically, and this result would not survive correction for multiple comparisons given the correlations conducted on the three remaining aggression dimensions and total aggression score of the Buss-Perry Questionnaire.

Overall the studies in this thesis have demonstrated several ways that aggression plays a role in the processing and regulation of emotion, demonstrating that differences can occur even in samples not normally characterised by high levels of aggression. This has key implications for the field of emotion regulation as individual differences, such as aggression, are often not taken into account despite clearly affecting emotion regulation efficacy. Considering the role of aggression in emotion regulation allows for training and treatment implications beyond the management and control of aggression. Training in adaptive emotion regulation with a view to preventing the onset or maintenance of externalising symptoms, such as aggression, would be of most practical importance.

7.3.2 Implications for the Process Model

James Gross' Process Model (1998) has been invaluable in the field of emotion regulation, simplifying a complex set of processes into five key steps. Typically emotions are viewed as unfolding over seconds (implicit emotion regulation) to minutes (explicit emotion regulation). Therefore each of the five steps in the model are differentiated by the time-point at which they unfold in the emotion-generative process and are each treated as potential targets for regulation (Gross, 2015). However, the Cognitive Change step is much broader than initially anticipated in the Process Model. Reappraisal is most commonly associated with the umbrella term of Cognitive Change, but as mentioned throughout the thesis, even the definition of reappraisal is very broad as there are several strategies within reappraisal. Fortunately there has been a move within the literature towards the notion of 'one size does not fit all'. The emotion regulation strategy of distancing, which falls under reappraisal, was of particular interest in the current thesis. More and more studies are being published indicating that increasing psychological distance, either by manipulating spatial, temporal, or social (e.g. taking the viewpoint of others) distance, is an effective emotion regulation strategy as it leads to "bigger picture" representations of negative events (Liberman & Trope, 2008). The term 'reappraisal' is now used so broadly that it often encompasses the whole range of cognitive change strategies. However, distancing is only one strategy out of several that come under the reappraisal definition, therefore more needs to be done in terms of creating a better definition of reappraisal and specifying strategies that fall into the reappraisal category, as these strategies may not all have similar underlying processes or outcomes in terms of efficacy.

In light of the findings of Chapter 4, another key implication for the Process Model is that emotion regulation strategies can also be used interchangeably and in combination. The qualitative data obtained in Chapter 4 showed that in the experimental context participants do not necessarily use only the instructed specific strategy even when explicitly trained to do so, and often resort to more general reappraisal strategies, or attentional deployment (e.g. "I looked away from the photo"), or a combination of the instructed strategy and other forms of reappraisal. To our knowledge no other studies of reappraisal have asked participants to qualitatively report on what they were thinking during the task, which raises the possibility that previous studies investigating 'reappraisal' may actually be looking at the efficacy of an even broader range of processes than was previously assumed. The Process Model seems to assume that a single strategy is used at a time, in a unidirectional manner; therefore it perhaps does not reflect the complexity of real regulatory processes.

Another point that the model does not account for is using a combination of strategies in a particular sequence. For example, although reappraisal is often seen as an adaptive strategy, it does not seem to be very effective when applied in situations of high emotional intensity (Sheppes, Catran, & Meiran, 2009). Other strategies, such as distraction, may be more adaptive in such situations. For example, in the qualitative findings of Chapter 4, some participants distracted themselves from highly emotional photos by "listing the positive things that happened today". Therefore skilful emotion regulation may not only involve using a combination of strategies, but also choosing the most adaptive sequence. For example when emotional intensity is high, distraction can be employed first to reduce the intensity of the emotion, and then reappraisal can be effectively implemented (Gross, 2015). To date, it is unknown which combinations of strategies are most effective in certain situations. This avenue of research would be beneficial, and the adopting the Extended Process Model which includes additional steps of evaluating the emotional context and selecting the appropriate strategy (see Chapter 1 section 1.2 for more detail) may be more suitable in systematically exploring this.

A central theme throughout the thesis is the role of modulating factors in emotion regulation. As discussed in Chapter 1 (section 1.5), certain factors can impact several points of the emotion regulation process. The findings of the current thesis add to this by demonstrating that even in a general sample, trait aggression can influence regulation, from the very early stages of emotional reactivity up to the implementation of explicit strategies. Similarly, interoceptive awareness is associated with effective use of temporal distancing in Chapter 4, and with more general reappraisal efficacy (Füstös et al., 2013). Several studies have shown that emotional awareness is useful for emotion regulation (e.g. Barrett et al., 2001; Gohm & Clore, 2002; Herwig et al., 2010), suggesting that difficulties at the very early perceptual stages may lead to unsuccessful emotion regulation. Interestingly, it has been posited that one of the mechanisms underlying the relationship between mindfulness training and the increased capacity for effective emotion regulation (see Chambers, Gullone & Allen, 2009, for a review) is the increased sensitivity and awareness of emotion-related bodily changes (Teper, Segal & Inzlicht, 2013). According to Teper et al. (2013), mindfulness increases responsivity to interoceptive signals, and this facilitates regulation early on in the time course of emotional processing (e.g. Attention Deployment stage), prior to intense emotional reactivity occurring. In effect, mindfulness training can improve interoceptive awareness and ultimately improve emotion regulation abilities. This may result in ‘skipping’ stages in the Process Model. Taking the example of anger, rather than focusing on the reasons behind the cause of anger, mindfulness focuses on the physical sensations of the initial signs of anger, such as increased heart rate. Attending to the somatic aspects at the beginning of the emotional experience can attenuate them before they develop into a full anger response, consequently reducing the need for cognitive change strategies such as reappraisal (Farb, Anderson, Irving & Segal, 2014). Consequently, findings and theories such as these have important implications for the Process Model, which on its own may not capture the important modulating factors that interact with, and influence the regulatory processes.

A final modulating factor that was investigated in Chapter 5 of the thesis was the development of emotion regulation across adolescence. During adolescence, brain regions involved in affect generation and regulation undergo protracted structural and functional development, therefore it is important to consider how emotion regulation abilities may consequently develop and change throughout this period. While it was found that adolescents were just as effective as adults at successfully implementing temporal distancing, several previous studies have shown adolescents are poor at more general forms of emotion regulation (Cohen et al., 2014; Hare et al., 2008; McRae et al., 2012; Silvers et al., 2012). However, a key issue of the Process Model is that it does not account for developmental changes, and how the effectiveness or the ability to implement strategies vary with age. In a recent commentary by Riediger and Luong (2015), several issues were discussed in regards to this. Specifically, a theoretical framework from the viewpoint of development would help in addressing future research on questions such as "how and why do individuals of various age groups differ in their emotion regulation goals and strategies?" and "How can we evaluate the short-term effectiveness and long-term adaptiveness of emotion regulatory efforts in different age groups?" (Riediger & Luong, 2015, p. 99). The Extended Process Model (Sheppes et al., 2015) seems to have more scope for exploring developmental trends. For example, in the Identification stage, older adults may be better at perceiving different emotional states (the Perception substep in the model) and in turn evaluating the perception of the emotional state by comparing it to an emotional state that is appropriate in the given situation (Valuation substep). It is therefore important to further develop and specify theoretical models, such as the Process and Extended Process models of emotion regulation, with the purpose of understanding how individuals at any stage of development undergo the process of emotion regulation.

7.4 Limitations and future directions

In addition to the limitations discussed within each chapter, this section discusses the key areas of limitation in the thesis and how future research may address these issues. While the issues noted below are not exhaustive, they do serve to discuss concerns that are relevant across the chapters.

One limitation that applies to all of the studies conducted is that a correlational approach was used to investigate the role of modulating factors in emotion regulation. Therefore it cannot be concluded that, for example, psychopathic traits cause reduced emotion capture or reactive aggression causes poor temporal distancing efficacy, and vice versa. However, this limitation should be evaluated in view of the parallels between the results found throughout the thesis and the findings obtained in previous experimental studies. Therefore while strong conclusions cannot be made about the causal effects of the modulating factors investigated within the thesis, the associations found could shed light on which strategies are most effective for certain individuals and uncover new targets for interventions and training, such as the role of interoceptive awareness in mindfulness, as mentioned above.

A related limitation concerns the use of cross-sectional designs, which is particularly limiting for Chapter 5's developmental study. Using this approach meant that within-individual developmental changes could not be examined. Therefore future investigations may extend the current findings by using longitudinal designs, which will enable causal conclusions to be made. Investigating the same individuals over time would be particularly effective in early adolescence when situational and individual differences seem to play crucial factors in effective emotion regulation (Steinberg, 2005). Longitudinal studies can also shed light on which emotion regulation strategies have long-lasting effects. For example, in a study by Ayduk and Kross (2010) spontaneous interpersonal distancing was investigated longitudinally whereby participants were instructed to recall an upsetting experience and then asked whether they saw the experience replay through their own eyes or whether they watched the event unfold as an outside observer. They found that the extent to which participants spontaneously self-distanced at time point 1 negatively predicted how upset they felt 7 weeks later when they recalled the same event, even after controlling for emotional reactivity at time point 1. The investigation into the longitudinal effects of temporal distancing would be a fruitful direction for future research, particularly looking at whether training adolescents to use this strategy would lead to long-term improvements in their emotion regulation abilities. It has been suggested that adolescence is a period of heightened learning and flexibility (Casey et al., 2008; Steinberg, 2005). It could therefore be a critical phase for the development of adaptive emotion regulation strategies and in turn the implementation of interventions. Targeting this window of opportunity could have positive long-term consequences for mental health (Wekerle, Waechter, Leung, & Leonard, 2007).

The findings of Chapters 4-6 extend the literature by showing that temporal distancing is effective in a controlled lab environment. However, while using the same set of stimuli across participants is a strength as the content and intensity of the stimuli can be controlled, and is particularly important for fMRI designs (Chapter 6), where controlling for potential differences is vital, it does raise certain issues. For example, as shown in the qualitative data in Chapter 4, participants may not always be affected by certain stimuli, leaving no need to regulate. Using retrospective personal stressors, such as the study by Bruehlman-Senecal and Ayduk (2015), may address this, however there is also the potential problem that a) the intensity of stressors can vary amongst participants, and b) the retrospective nature of the task means that the initial emotional reactivity can somewhat be attenuated. Thus, using lab-based experimental and retrospective measures may not capture the complex and varied contexts in which emotion regulation naturally transpires. In a recent study by Haines et al. (2016) the ecological momentary assessment (EMA) was used to measure reappraisal use in daily life and investigate whether more context-appropriate use of reappraisal is associated with greater well-being. Using an app on their smartphones, participants were prompted throughout the day over the course of one week to complete surveys about their reappraisal use and the degree to which they perceived their environment as controllable. They found that individuals with greater well-being used reappraisal more often as situations became less controllable, whereas the opposite pattern was found for individuals with lower well-being. Therefore findings showed that the adaptiveness of emotion regulation strategies outside of a laboratory setting depend on situational factors. The advancement of technology has made it much easier for researchers to investigate emotion regulation in a more naturalistic fashion. Future studies using a similar method to Haines et al. (2016) investigating a wider range of strategies will advance our understanding of the rich processes involved in emotion regulation. While Chapter 5 has shown that adolescents *can* regulate emotion using temporal distancing when instructed to do so, it would be particularly valuable in examining *whether* they use this strategy in their everyday lives.

The final limitation concerns aggression. While we found effects of aggression on emotion regulation in Chapter 2 and Chapter 5, it is possible that the lack of aggression-related findings in the remaining studies was due to smaller sample sizes. On average, Chapter 3 consisted of 40 participants per experiment; Chapter 4 consisted of approximately 60 participants and Chapter 6 consisted of 26 participants. Combined with the fact that participants were all university students, the variation in aggression is not very broad and may not be a very representative sample of the general adult population. In a recent study of over 500 university students, it was found that reactive forms of aggression were low overall, particularly in high achieving students (Qaisy, 2014). The majority of participants recruited throughout the studies of the thesis were high achieving, particularly Chapter 6 where half of the sample consisted of PhD students. Furthermore, given the small sample sizes, investigation into sex differences was not feasible, however this would have been interesting given that aggression tends to be higher in males (Anderson & Bushman, 2002). Future research would therefore benefit from using larger samples outside of a university context.

7.5 Conclusions

The field of emotion regulation research has flourished over the past two decades, however there are still many questions yet to be answered, particularly pertaining to the role of aggression. This thesis contributes to the field of emotion regulation in a number of key ways. The first experimental study demonstrated that task-irrelevant emotional faces have privileged access to attention, however individuals high in affective-interpersonal psychopathic traits, but also low in antisocial psychopathic traits, tend to display reduced attention capture by emotion, specifically fear. This is in line with accounts suggesting that those high in core psychopathic traits have a fear-processing deficit, with the findings of the thesis further extending this to a continuous community sample. The second experimental study demonstrated that top-down anticipatory control mechanisms are an important factor in the extent to which cognitive load impacts on emotional processing. In a series of four experiments, the circumstances under which cognitive load modulates the effects of emotion on task performance were clarified for the first time.

The remainder of the thesis moved away from the broad definition of reappraisal, which is the most common emotion regulation strategy investigated throughout the literature. Exploring the strategies within psychological distancing, it was found that temporal distancing was positively associated with awareness of internal bodily states, was an effective emotion regulation strategy across adolescence, and that individuals high in reactive aggression were less able to effectively implement this strategy to down-regulate their negative affect. The final experimental chapter used fMRI to examine the neural correlates of temporal distancing for the first time. A similar network of brain regions that are typically recruited in reappraisal, such as the amygdala and several prefrontal and parietal regions were engaged during temporal distancing, suggesting that a common cognitive control network underpins a range of cognitive emotion regulation strategies.

Overall, the findings of this thesis show that individual differences, particularly subtypes of aggression, influence both implicit and explicit emotion regulation. As demonstrated, individual differences in emotion regulation are related to a broad range of significant wellbeing outcomes, and therefore there is a strong need to formulate and investigate interventions designed to carefully shape emotion regulation processes in helpful directions.

References

Adams, R. B., & Kleck, R. E. (2003). Perceived gaze direction and the processing of facial displays of emotion. *Psychological Science, 14*(6), 644–647.

Addis, D. R., Cheng, T., Roberts, R. P., & Schacter, D. L. (2011). Hippocampal contributions to the episodic simulation of specific and general future events. *Hippocampus*, *21*(10), 1045–1052.

Addis, D. R., Pan, L., Vu, M. A., Laiser, N., & Schacter, D. L. (2009). Constructive episodic simulation of the future and the past: Distinct subsystems of a core brain network mediate imagining and remembering. *Neuropsychologia*, *47*(11), 2222–2238.

Addis, D. R., Roberts, R. P., & Schacter, D. L. (2011). Age-related neural changes in autobiographical remembering and imagining. *Neuropsychologia*, *49*(13), 3656–3669.

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

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature, 433*(7021), 68–72.

Aguirre, G. K., & D'Esposito, M. (1999). Topographical disorientation: A synthesis and taxonomy. *Brain, 122*(9), 1613-1628.

Ahmed, S. P., Bittencourt-Hewitt, A., & Sebastian, C. L. (2015). Neurocognitive bases of emotion regulation development in adolescence. *Developmental Cognitive Neuroscience*, *15,* 11-25.

Aldao, A., & Nolen-Hoeksema, S. (2013). One versus many: Capturing the use of multiple emotion regulation strategies in response to an emotion-eliciting stimulus. *Cognition & Emotion*, *27*(4), 753–760.

Ali, F., Amorim, I. S., & Chamorro-Premuzic, T. (2009). Empathy deficits and trait emotional intelligence in psychopathy and machiavellianism. *Personality and Individual Differences*, *47*(7), 758–762.

Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: the medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, *7*(4), 268–277.

Andersen, R., Snyder, L., Bradley, D., & Xing, J. (1997). Multimodal representation of space in the posterior parietal cortex and its use in planning movements.

Annual Review of Neuroscience, *20*(1), 303–330.

Anderson, C. A., & Bushman, B. J. (2002). Human aggression. *Annual Review of Psychology*, *53*(1), 27–51.

Anderson, N. E., & Stanford, M. S. (2012). Demonstrating emotional processing differences in psychopathy using affective ERP modulation. *Psychophysiology*, *49*(6), 792–806.

Andrews-Hanna, J. R., Reidler, J. S., Sepulcre, J., Poulin, R., & Buckner, R. L. (2010). Functional-anatomic fractionation of the brain's default network. *Neuron*, *65*(4), 550–562.

Arnett, P. A., Smith, S. S., & Newman, J. P. (1997). Approach and Avoidance Motivation in Psychopathic Criminal Offenders During Passive Avoidance. *Journal of Personality and Social Psychology*, *72*(6), 1413–1428.

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533-539.

Ayduk, Ö., & Kross, E. (2008). Enhancing the pace of recovery: Self-distanced analysis of negative experiences reduces blood pressure reactivity. *Psychological Science*, *19*(3), 229–231.

Ayduk, Ö., & Kross, E. (2010). From a distance: implications of spontaneous self-distancing for adaptive self-reflection. *Journal of Personality and Social Psychology*, *98*(5), 809.

Bach, D. R., Friston, K. J., & Dolan, R. J. (2010). Analytic measures for quantification of arousal from spontaneous skin conductance fluctuations. *International Journal of Psychophysiology*, *76*(1), 52–55.

Badre, D., & Wagner, A. D. (2007). Left ventrolateral prefrontal cortex and the cognitive control of memory. *Neuropsychologia*, *45*(13), 2883-2901.

Banks, S. J., Eddy, K. T., Angstadt, M., Nathan, P. J., & Phan, L. K. (2007). Amygdala-frontal connectivity during emotion regulation. *Social Cognitive and Affective Neuroscience*, *2*(4), 303–312.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*(1), 1–24.

Barlett, C., & Anderson, C. (2011). Reappraising the situation and its impact on aggressive behavior. *Personality and Social Psychology Bulletin*, *37*(12), 1564–1573.

Barrett, L. F. (2017). The theory of constructed emotion: An active inference account of interoception and categorization. *Social Cognitive and Affective Neuroscience, 12*(1), 1-23.

Barrett, L. F., Gross, J., Christensen, T. C., & Benvenuto, M. (2001). Knowing what you're feeling and knowing what to do about it: Mapping the relation between emotion differentiation and emotion regulation. *Cognition & Emotion*, *15*(6), 713–724.

Bask, M. (2015). Externalising and internalising problem behaviour among Swedish adolescent boys and girls. *International Journal of Social Welfare, 24*(2), 182–192.

Bechara, A., Damasio, A., Damasio, H., & Anderson, S. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*(1), 7–15.

Ben-Ze'ev, A. (2000). *The subtlety of emotions*. Cambridge: MIT Press.

Berkowitz, L. (1993). *Aggression: Its causes, consequences, and control*. New York, NY: Mcgraw-Hill Book Company.

Besharat, M. A., Nia, M. E., & Farahani, H. (2013). Anger and major depressive disorder: The mediating role of emotion regulation and anger rumination. *Asian Journal of Psychiatry*, *6*(1), 35–41.

Bettencourt, B. A., Talley, A., Benjamin, A. J., & Valentine, J. (2006). Personality and aggressive behavior under provoking and neutral conditions: A meta-analytic review. *Psychological Bulletin*, *132*(5), 751–777.

Binder, J., Desai, R., Graves, W., & Conant, L. (2009). Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. *Cerebral Cortex*, *19*(12), 2767–2796.

Birbaumer, N., Veit, R., Lotze, M., Erb, M., Hermann, C., Grodd, W., & Flor, H. (2005). Deficient fear conditioning in psychopathy: A functional magnetic resonance imaging study. *Archives of General Psychiatry, 62*(7), 799–805.

Bishop, S. J. (2009). Trait anxiety and impoverished prefrontal control of attention. *Nature Neuroscience*, *12*(1), 92–98.

Bishop, S. J., Jenkins, R., & Lawrence, A. D. (2007). Neural processing of fearful faces: Effects of anxiety are gated by perceptual capacity limitations. *Cerebral Cortex*, *17*(7), 1595–1603.

Blair, K. S., Newman, C., Mitchell, D., Richell, R. A., Leonard, A., Morton, J., & Blair, R. J. R. (2006). Differentiating among prefrontal substrates in psychopathy: Neuropsychological test findings. *Neuropsychology*, *20*(2), 153–

165.

Blair, R. J. R., & Viding, E. (2008). Psychopathy. In D. M. Rutter, D. Bishop, S. Pine, J. Scott, E. T. Stevenson, & A. Thapar (Eds.), *Rutter's child and adolescent psychiatry* (5th ed., pp. 852–863). Chichester: John Wiley & Sons.

Blair, R. J. R., Colledge, E., & Mitchell, D. G. V. (2001). Somatic markers and response reversal: is there orbitofrontal cortex dysfunction in boys with psychopathic tendencies? *Journal of Abnormal Child Psychology*, *29*(6), 499–511.

Blair, R. J. R. (2003). Neurobiological basis of psychopathy. *British Journal of Psychiatry*, *182*(1), 5–7.

Blair, R. J. R. (2004). The roles of orbital frontal cortex in the modulation of antisocial behavior. *Brain and Cognition, 55*(1), 198-208.

Blair, R. J. R. (2010). Psychopathy, frustration, and reactive aggression: The role of ventromedial prefrontal cortex. *British Journal of Psychology*, *101*(3), 383–399.

Blair, R. J. R. (2015). Psychopathic traits from an RDoC perspective. *Current Opinion in Neurobiology, 30*(1), 79-84.

Blair, R. J. R., Mitchell, D. G. V., & Blair, K. (2005). *The psychopath: Emotion and the brain.* Malden: Blackwell.

Blair, R. J. R., Mitchell, D. G. V., Richell, R. A., Kelly, S., Leonard, A., Newman, C., & Scott, S. K. (2002). Turning a deaf ear to fear: impaired recognition of vocal affect in psychopathic individuals. *Journal of Abnormal Psychology*,*111*(4), 682-686.

Blair, R. J. R., & Mitchell, D. G. V. (2009). Psychopathy, attention and emotion. *Psychological Medicine*, *39*(4), 543–555.

Blair, R. J. R., Mitchell, D. G. V, Peschardt, K. S., Colledge, E., Leonard, R. A., Shine, J. H., … Perrett, D. I. (2004). Reduced sensitivity to others' fearful expressions in psychopathic individuals. *Personality and Individual Differences*, *37*(6), 1111–1122.

Blair, R. J. R., Monson, J., & Frederickson, N. (2001). Moral reasoning and conduct problems in children with emotional and behavioural difficulties. *Personality and Individual Differences*, *31*(5), 799–811.

Blakemore, S. J., & Robbins, T. W. (2012). Decision-making in the adolescent brain. *Nature Neuroscience*, *15*(9), 1184-1191.

Bonanno, G. A., & Burton, C. L. (2013). Regulatory flexibility: An individual differences perspective on coping and emotion regulation. *Perspectives on*

Psychological Science, *8*(6), 591–612.

Borders, A., Earleywine, M., & Jajodia, A. (2010). Could mindfulness decrease anger, hostility, and aggression by decreasing rumination? *Aggressive Behavior*, *36*(1), 28–44.

Botvinick, M., Cohen, J., & Carter, C. (2004). Conflict monitoring and anterior cingulate cortex: An update. *Trends in Cognitive Sciences*, *8*(12), 539–46.

Botzung, A., Denkova, E., & Manning, L. (2008). Experiencing past and future personal events: Functional neuroimaging evidence on the neural bases of mental time travel. *Brain and Cognition*, *66*(2), 202–212.

Boucsein, W. (2012). Electrodermal activity. New York, NY: Springer Science & Business Media.

Boucsein, W., Fowles, D. C., Grimnes, S., Ben-Shakhar, G., Roth, W. T., Dawson, M. E., & Filion, D. L. (2012). Publication recommendations for electrodermal measurements. *Psychophysiology*, *49*(8), 1017–1034.

Bradley, M. M., Miccoli, L., Escrig, M. A., & Lang, P. J. (2008). The pupil as a measure of emotional arousal and autonomic activation. *Psychophysiology*, *45*(4), 602–607.

Braithwaite, J., Watson, D., Robert, J., & Mickey, R. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. *Psychophysiology, 49*(1), 1017- 1034.

Brener, J., Knapp, K., & Ring, C. (1995). The effects of manipulating beliefs about heart rate on the accuracy of heartbeat counting in the Schandry task. *Psychophysiology*, *32*, S22.

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

Bruehlman-Senecal, E., Ayduk, Ö., & John, O. P. (2016). Taking the long view: Implications of individual differences in temporal distancing for affect, stress reactivity, and well-being. *Journal of Personality and Social Psychology, 111*(4), 610-635.

Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences*, *11*(2), 49–57.

Buhle, J. T., Silvers, J. A., Wage, T. D., Lopez, R., Onyemekwu, C., Kober, H., … Ochsner, K. N. (2014). Cognitive reappraisal of emotion: A meta-analysis of human neuroimaging studies. *Cerebral Cortex, 24*(11), 2981–2990.

Burgess, P. W., Quayle, A., & Frith, C. D. (2001). Brain regions involved in prospective memory as determined by positron emission tomography. *Neuropsychologia*, *39*(6), 545–555.

Bushman, B. J. (2002). Does venting anger feed or extinguish the flame? Catharsis, rumination, distraction, anger, and aggressive responding. *Personality and Social Psychology Bulletin*, *28*(6), 724–731.

Buss, A. H., & Perry, M. (1992). The aggression questionnaire. *Journal of Personality and Social Psychology*, *63*(3), 452–459.

Calvete, E., & Orue, I. (2012). The role of emotion regulation in the predictive association between social information processing and aggressive behavior in adolescents. *International Journal of Behavioral Development*, *40*(1), 105-117.

Cameron, O. G. (2001). Interoception: The inside story - a model for psychosomatic processes. *Psychosomatic Medicine*, *63*(5), 697–710.

Capitão, L. P., Underdown, S. J., Vile, S., Yang, E., Harmer, C. J., & Murphy, S. E. (2014). Anxiety increases breakthrough of threat stimuli in continuous flash suppression. *Emotion*, *14*(6), 1027-1036.

Carolan, P. L., Jaspers-Fayer, F., Asmaro, D. T., Douglas, K. S., & Liotti, M. (2014). Electrophysiology of blunted emotional bias in psychopathic personality. *Psychophysiology*, *51*(1), 36–41.

Carré, J. M., Fisher, P. M., Manuck, S. B., & Hariri, A. R. (2012). Interaction between trait anxiety and trait anger predict amygdala reactivity to angry facial expressions in men but not women. *Social Cognitive and Affective Neuroscience*, *7*(2), 213–21.

Carré, J. M., Hyde, L. W., Neumann, C. S., Viding, E., & Hariri, A. R. A. (2013). The neural signatures of distinct psychopathic traits. *Social Neuroscience*, *8*(2), 37–41.

Carretié, L. (2014). Exogenous (automatic) attention to emotional stimuli: A review. *Cognitive, Affective & Behavioral Neuroscience*, *14*(4), 1228-1258.

Casey, B. J., Duhoux, S., & Cohen, M. M. (2010). Adolescence: What do transmission, transition, and translation have to do with it? *Neuron*, *67*(5), 749-760.

Casey, B. J., Jones, R. M., & Hare, T. A. (2008). The adolescent brain. *Annals of the New York Academy of Sciences*, *1124*(1), 111–126.

Chambers, R., Gullone, E., & Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clinical Psychology Review*, *29*(6), 560-572.

Casey, B. J., Jones, R. M., & Hare, T. A. (2008). The adolescent brain. *Annals of the New York Academy of Sciences*, *1124*(1), 111-126.

Chambers, R., Gullone, E., & Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clinical Psychology Review*, *29*(6), 560-572.

Casey, B. J., Jones, R. M., & Hare, T. A. (2008). The adolescent brain. *Annals of the New York Academy of Sciences*, *1124*(1), 111-126.

Chase, K. A., O'Leary, K. D., & Heyman, R. E. (2001). Categorizing partner-violent men within the reactive-proactive typology model. *Journal of Consulting and Clinical Psychology*, *69*(3), 567–572.

Cisler, J. M., Bacon, A. K., & Williams, N. L. (2009). Phenomenological characteristics of attentional biases towards threat: A critical review. *Cognitive Therapy and Research, 33*(2), 221-234.

Cloitre, M., Koenen, K. C., Cohen, L. R., & Han, H. (2002). Skills training in affective and interpersonal regulation followed by exposure: A phase-based treatment for PTSD related to childhood abuse. *Journal of Consulting and Clinical Psychology*, *70*(5), 1067–1074.

Coccaro, E. F., McCloskey, M. S., Fitzgerald, D. A., & Phan, K. L. (2007). Amygdala and orbitofrontal reactivity to social threat in individuals with impulsive aggression. *Biological Psychiatry*, *62*(2), 168–178.

Cohen Kadosh, K., Heathcote, L. C., & Lau, J. Y. F. (2014). Age-related changes in attentional control across adolescence: How does this impact emotion regulation capacities? *Frontiers in Psychology*, *5*, 111.

Cohn, A. M., Jakupcak, M., Seibert, L. A., Hildebrandt, T. B., & Zeichner, A. (2010). The role of emotion dysregulation in the association between men's restrictive emotionality and use of physical aggression. *Psychology of Men & Masculinity*, *11*(1), 53–64.

Cornell, D. G., Warren, J., Hawk, G., Stafford, E., Oram, G., & Pine, D. (1996). Psychopathy in instrumental and reactive violent offenders. *Journal of Consulting and Clinical Psychology*, *64*(4), 783–790.

Craig, A. D. (2002). How do you feel? Interoception: The sense of the physiological condition of the body. *Nature Reviews. Neuroscience*, *3*(8), 655–666.

Craig, A. D. (2004). Human feelings: Why are some more aware than others? *Trends in Cognitive Sciences, 8*(6), 239-241.

Craig, A. D. (2009). How do you feel — now? The anterior insula and human awareness. *Nature Reviews Neuroscience*, *10*(1), 59–70.

Critchley, H. D., Wiens, S., Rotshtein, P., Öhman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, *7*(2), 189–195.

Cutuli, D. (2014). Cognitive reappraisal and expressive suppression strategies role in the emotion regulation: an overview on their modulatory effects and neural correlates. *Frontiers in Systems Neuroscience*, *8*(175), 1-6.

D'Argembeau, A., Ortoleva, C., Jumentier, S., & Van der Linden, M. (2010). Component processes underlying future thinking. *Memory & Cognition*, *38*(6), 809–819.

Damasio, A. R. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain*. *Relations industrielles*. New York, NY: Avon Books.

Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. USA: Harcourt Trade Publishers.

Davis, M., & Whalen, P. J. (2001). The amygdala: Vigilance and emotion. *Molecular Psychiatry*, *6*(1), 13–34.

Dawel, A., O'Kearney, R., McKone, E., & Palermo, R. (2012). Not just fear and sadness: Meta-analytic evidence of pervasive emotion recognition deficits for facial and vocal expressions in psychopathy. *Neuroscience and Biobehavioral Reviews*, *36*(10), 2288-2304.

Dempster, R. J., Lyon, D. R., Sullivan, L. E., Hart, S. D., Smiley, W. C., &, & Mulloy, R. (1996). *Psychopathy and instrumental aggression in violent offenders.* Paper presented at the 104th annual convention of the American Psychological Association, Toronto, Canada.

Denny, B. T., Inhoff, M. C., Zerubavel, N., Davachi, L., & Ochsner, K. N. (2015). Getting over it: Long-lasting effects of emotion regulation on amygdala response. *Psychological Science*, *26*(9), 1377–1388.

Denny, B. T., & Ochsner, K. N. (2014). Behavioral effects of longitudinal training in cognitive reappraisal. *Emotion*, *14*(2), 425–33.

Denson, T. F., Moulds, M. L., & Grisham, J. R. (2012). The effects of analytical rumination, reappraisal, and distraction on anger experience. *Behavior Therapy*, *43*(2), 355–364.

Dodge, K. A., & Coie, J. D. (1987). Social-information-processing factors in reactive and proactive aggression in children's peer groups. *Journal of Personality and Social Psychology*, *53*(6), 1146–1158.

Domschke, K., Stevens, S., Pfleiderer, B., & Gerlach, A. L. (2010). Interoceptive sensitivity in anxiety and anxiety disorders: An overview and integration of neurobiological findings. *Clinical Psychology Review*, *30*(1), 1–11.

Donders, F. C. (1969). On the speed of psychological processes. *Acta Psychologica, 30*, 412–431 (Original work published 1868).

Dörfel, D., Lamke, J. P., Hummel, F., Wagner, U., Erk, S., & Walter, H. (2014). Common and differential neural networks of emotion regulation by detachment, reinterpretation, distraction, and expressive suppression: A comparative fMRI investigation. *NeuroImage*, *101*, 298–309.

Drabant, E. M., McRae, K., Manuck, S. B., Hariri, A. R., & Gross, J. J. (2009). Individual differences in typical reappraisal use predict amygdala and prefrontal responses. *Biological Psychiatry*, *65*(5), 367–73.

Drevets, W. C., Savitz, J., & Trimble, M. (2008). The subgenual anterior cingulate cortex in mood disorders. *CNS Spectrums, 13*(8), 663–681.

Dumontheil, I. (2014). Development of abstract thinking during childhood and adolescence: The role of rostrolateral prefrontal cortex. *Developmental Cognitive Neuroscience*, *10*, 57–76.

Dunn, B. D., Dalgleish, T., Ogilvie, A. D., & Lawrence, A. D. (2007). Heartbeat perception in depression. *Behaviour Research and Therapy*, *45*(8), 1921–1930.

Dvorak-Bertsch, J. D., Curtin, J. J., Rubinstein, T. J., & Newman, J. P. (2007). Anxiety moderates the interplay between cognitive and affective processing. *Psychological Science*, *18*(8), 699–705.

Egner, T., Etkin, A., Gale, S., & Hirsch, J. (2008). Dissociable neural systems resolve conflict from emotional versus nonemotional distracters. *Cerebral Cortex, 18*(6), 1475–1484.

Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010). Emotion-related self-regulation and its relation to children's maladjustment. *Annual Review of Clinical Psychology, 6*, 495-525.

Ernst, M. (2014). The triadic model perspective for the study of adolescent motivated behavior. *Brain and Cognition, 89*, 104–111.

Erthal, F. S., de Oliveira, L., Mocaiber, I., Pereira, M. G., Machado-Pinheiro, W., Volchan, E., & Pessoa, L. (2005). Load-dependent modulation of affective picture processing. *Cognitive, Affective & Behavioral Neuroscience*, *5*(4), 388–95.

Esteves, F., Parra, C., Dimberg, U., & Ohman, A. (1994). Nonconscious associative learning: Pavlovian conditioning of skin conductance responses to masked fear-relevant facial stimuli. *Psychophysiology, 31*(4), 375–385.

Etkin, A., Egner, T., & Kalisch, R. (2011). Emotional processing in anterior cingulate and medial prefrontal cortex. *Trends in Cognitive Sciences*, *15*(2), 85–93.

Etkin, A., Egner, T., Peraza, D. M., Kandel, E. R., & Hirsch, J. (2006). Resolving emotional conflict: A role for the rostral anterior cingulate cortex in modulating activity in the amygdala. *Neuron*, *51*(6), 871–882.

Eysenck, M. W. (1992). *Anxiety: The cognitive perspective*. Hove, England: Psychology Press.

Eysenck, M. W. (2013). *Anxiety: The cognitive perspective*. Hove, England: Psychology Press.

Fabiansson, E. C., & Denson, T. F. (2012). The effects of intrapersonal anger and its regulation in economic bargaining. *PLoS ONE, 7*(12), e51595

Farb, N. A. S., Anderson, A. K., Irving, J. A., & Segal, Z. V. (2014). Mindfulness interventions and emotion regulation. In J. J. Gross (Ed.), *Handbook of emotion regulation* (2nd ed., pp. 548–567). New York, NY: Guilford.

Feeser, M., Prehn, K., Kazzer, P., Mungee, A., & Bajbouj, M. (2014). Transcranial direct current stimulation enhances cognitive control during emotion regulation. *Brain Stimulation*, *7*(1), 105–112.

Ferri, F., Ardizzi, M., Ambrosecchia, M., & Gallese, V. (2013). Closing the gap between the inside and the outside: Interoceptive sensitivity and social distances. *PLoS ONE*, *8*(10):e75758.

Figner, B., & Murphy, R. O. (2011). Using skin conductance in judgment and decision making research. In M. Schulte-Mecklenbeck, A. Kuehberger, & R. Ranyard (Eds.), *A handbook of process tracing methods for decision research: A critical review and user's guide* (pp. 163–184). New York, NY: Psychology Press.

Fite, P. J., Raine, A., Stouthamer-Loeber, M., Loeber, R., & Pardini, D. A. (2010). Reactive and proactive aggression in adolescent males examining differential outcomes 10 years later in early adulthood. *Criminal Justice and Behavior*, *37*(2), 141–157.

Fossati, P., Hevenor, S. J., Graham, S. J., Grady, C., Keightley, M. L., Craik, F., & Mayberg, H. (2003). In search of the emotional self: An FMRI study using positive and negative emotional words. *The American Journal of Psychiatry*, *160*(11), 1938–1945.

Fox, E. (2002). Processing emotional facial expressions: The role of anxiety and awareness. *Cognitive, Affective & Behavioral Neuroscience*, *2*(1), 52–63.

Frick, P. J., O'Brien, B. S., Wootton, J. M., & McBurnett, K. (1994). Psychopathy and conduct problems in children. *Journal of Abnormal Psychology*, *103*(4), 700–707.

Frick, P. J., & Viding, E. (2009). Antisocial behavior from a developmental psychopathology perspective. *Development and Psychopathology*, *21*(4), 1111–1131.

Friston, K. J., Holmes, A. P., Worsley, K. J., Poline, J. P., Frith, C. D., & Frackowiak, R. S. J. (1994). Statistical parametric maps in functional imaging: A general linear approach. *Human Brain Mapping*, *2*(4), 189–210.

Friston, K. J., Price, C. J., Fletcher, P., Moore, C., Frackowiak, R. S., & Dolan, R. J. (1996). The trouble with cognitive subtraction. *NeuroImage*, *4*(2), 97–104.

Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2013). On the embodiment of emotion regulation: Interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience*, *8*(8), 911–917.

Gale, A. (1988). *The polygraph test: Lies truth and science.* London: Sage

Gamer, M., & Büchel, C. (2009). Amygdala activation predicts gaze toward fearful eyes. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *29*(28), 9123–9126.

Garavan, H., Ross, T. J., Murphy, K., Roche, R. A. P., & Stein, E. A. (2002). Dissociable executive functions in the dynamic control of behavior: Inhibition, error detection, and correction. *NeuroImage*, *17*(4), 1820–1829.

Gee, D. G., Humphreys, K. L., Flannery, J., Goff, B., Telzer, E. H., Shapiro, M., … Tottenham, N. (2013). A developmental shift from positive to negative connectivity in human amygdala-prefrontal circuitry. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *33*(10), 4584–4593.

Gerin, W., Davidson, K. W., Christenfeld, N. J. S., Goyal, T., & Schwartz, J. E. (2006). The role of angry rumination and distraction in blood pressure recovery from emotional arousal. *Psychosomatic Medicine*, *68*(1), 64–72.

Germain, C. L., & Kangas, M. (2015). Trait anger symptoms and emotion regulation: The effectiveness of reappraisal, acceptance and suppression strategies in regulating anger. *Behaviour Change*, *32*(1), 35–45.

Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A., … Rapoport, J. L. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. *Nature Neuroscience*, *2*(10), 861–863.

Gohm, C. L., & Clore, G. L. (2002). Four latent traits of emotional experience and their involvement in well-being, coping, and attributional style. *Cognition &*

Emotion, *16*(4), 495–518.

Goldin, P. R., Manber-Ball, T., Werner, K., Heimberg, R., & Gross, J. J. (2009). Neural mechanisms of cognitive reappraisal of negative self-beliefs in social anxiety disorder. *Biological Psychiatry*, *66*(12), 1091–1099.

Gordon, H. L., Baird, A. A., & End, A. (2004). Functional differences among those high and low on a trait measure of psychopathy. *Biological Psychiatry*, *56*(7), 516–521.

Gordts, S., Uzieblo, K., Neumann, C., Van den Bussche, E., & Rossi, G. (2015). Validity of the self-report psychopathy scales (SRP-III full and short versions) in a community sample. *Assessment,* 1-18.

Gott, C., & Lah, S. (2014). Episodic future thinking in children compared to adolescents. *Child Neuropsychology, 20*(5), 625–640.

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54.

Grimshaw, G. M., Bulman-Fleming, M. B., & Ngo, C. (2004). A signal-detection analysis of sex differences in the perception of emotional faces. *Brain and Cognition, 54*(3), 248–250.

Gross, J. J. (1998). Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology*, *74*(1), 224–237.

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*(3), 281–291.

Gross, J. J. (2014). Emotion regulation: Conceptual and empirical foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation,* (2nd ed., pp.3-20). New York, NY: Guildford Press.

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

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348–362.

Gross, J. J., & Levenson, R. W. (1993). Emotional suppression: Physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology*, *64*(3), 970–986.

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: conceptual foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation* (2nd ed., pp. 3–20). New York, NY: Guildford Press.

Gullone, E., Hughes, E. K., King, N. J., & Tonge, B. (2010). The normative development of emotion regulation strategy use in children and adolescents: A 2-year follow-up study. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *51*(1), 567–574.

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

Gyurak, A., Gross, J. J., & Etkin, A. (2011). Explicit and implicit emotion regulation : A dual-process framework. *Cognition & Emotion*, *25*(3), 400–412.

Haines, S. J., Gleeson, J., Kuppens, P., Hollenstein, T., Ciarrochi, J., Labuschagne, I., ... & Koval, P. (2016). The wisdom to know the difference: strategy-situation fit in emotion regulation in daily life is associated with well-being. *Psychological Science*, *27*(12), 1651-1659.

Haga, S. M., Kraft, P., & Corby, E. K. (2009). Emotion regulation: Antecedents and well-being outcomes of cognitive reappraisal and expressive suppression in cross-cultural samples. *Journal of Happiness Studies*, *10*(3), 271–291.

Hamilton, R. K. B., Hiatt Racer, K., & Newman, J. P. (2015). Impaired integration in psychopathy: A unified theory of psychopathic dysfunction. *Psychological Review*, *122*(4), 770–791.

Hare, R. D. (2003). Manual for the Revised Psychopathy Checklist (2nd ed.) Toronto, ON: Multi Health Systems.

Hare, R. D., & Neumann, C. S. (2008). Psychopathy as a clinical and empirical construct. *Annual Review of Clinical Psychology*, *4*, 217–246.

Hare, T. A., Tottenham, N., Davidson, M. C., Glover, G. H., & Casey, B. J. (2005). Contributions of amygdala and striatal activity in emotion regulation. *Biological Psychiatry*, *57*(6), 624–632.

Hare, T. A., Tottenham, N., Galvan, A., Voss, H. U., Glover, G. H., & Casey, B. J. (2008). Biological substrates of emotional reactivity and regulation in adolescence during an emotional go-nogo task. *Biological Psychiatry*, *63*(10), 927–934.

Harenski, C. L., Kim, S. H., & Hamann, S. (2009). Neuroticism and psychopathy predict brain activation during moral and nonmoral emotion regulation. *Cognitive, Affective & Behavioral Neuroscience*, *9*(1), 1–15.

Harpur, T. J., Hare, R. D., & Hakstian, A. R. (1989). Two-factor conceptualization of psychopathy: Construct validity and assessment implications. *A Journal of Consulting & Clinical Psychology, 1*(1), 6–17.

Hart, S. J., Green, S. R., Casp, M., & Belger, A. (2010). Emotional priming effects during Stroop task performance. *NeuroImage*, *49*(3), 2662–2670.

Hassabis, D., Kumaran, D., & Maguire, E. A. (2007). Using imagination to understand the neural basis of episodic memory. *Journal of Neuroscience*, *27*(52), 14365–14374.

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, *11*(7), 299–306.

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling. *White Paper*, 1–39.

Heller, D., Stephan, E., Kifer, Y., & Sedikides, C. (2011). What will I be? The role of temporal perspective in predictions of affect, traits, and self-narratives. *Journal of Experimental Social Psychology, 47*(3), 610–615.

Herbert, B. M., Herbert, C., & Pollatos, O. (2011). On the relationship between interoceptive awareness and alexithymia: Is interoceptive awareness related to emotional awareness? *Journal of Personality*, *79*(5), 1149–1175.

Herbert, B. M., & Pollatos, O. (2014). Attenuated interoceptive sensitivity in overweight and obese individuals. *Eating Behaviors*, *15*(3), 445–448.

Herwig, U., Kaffenberger, T., Jäncke, L., & Brühl, A. B. (2010). Self-related awareness and emotion regulation. *NeuroImage*, *50*(2), 734–741.

Hiatt, K. D., Lorenz, A. R., & Newman, J. P. (2002). Assessment of emotion and language processing in psychopathic offenders: Results from a dichotic listening task. *Personality and Individual Differences*, *32*(7), 1255–1268.

Hiatt, K. D., & Newman, J. P. (2006). Understanding psychopathy: The cognitive side. In C. J. Patrick (Ed.), *Handbook of psychopathy*, (pp. 334–352). New York, NY: Guildford Press.

Hiatt, K. D., Schmitt, W. A, & Newman, J. P. (2004). Stroop tasks reveal abnormal selective attention among psychopathic offenders. *Neuropsychology*, *18*(1), 50–59.

Hicks, B. M., & Patrick, C. J. (2006). Psychopathy and negative emotionality: analyses of suppressor effects reveal distinct relations with emotional distress, fearfulness, and anger-hostility. *Journal of Abnormal Psychology, 115*(2), 276–287.

Hodsoll, S. (2010). *Attention to emotional faces: Basic phenomena and individual differences related to psychopathic traits*. (Unpublished doctoral thesis). University College London, United Kingdom.

Hodsoll, S., Lavie, N., & Viding, E. (2014). Emotional attentional capture in children with conduct problems: The role of callous-unemotional traits. *Frontiers in Human Neuroscience*, *8*(570), 1-7.

Hodsoll, S., Viding, E., & Lavie, N. (2011). Attentional capture by irrelevant emotional distractor faces. *Emotion*, *11*(2), 346–353.

Honk, J. V., Tuiten, A., de Haan, E., vann de Hout, M., & Stam, H. (2001). Attentional biases for angry faces: Relationships to trait anger and anxiety. *Cognition & Emotion*, *15*(3), 279–297.

Huettel, S. A., Song, A. W., & McCarthy, G. (2014). *Functional magnetic resonance imaging* (Vol. 3). Sunderland, MA: Sinauer Associates.

James, W. (1884). What is an emotion? *Mind*, *9*(34), 188–205.

Johansen-Berg, H., Gutman, D. A., Behrens, T. E. J., Matthews, P. M., Rushworth, M. F. S., Katz, E., … Mayberg, H. S. (2008). Anatomical connectivity of the subgenual cingulate region targeted with deep brain stimulation for treatment-resistant depression. *Cerebral Cortex*, *18*(6), 1374–1383.

John, O. P., & Gross, J. J. (2004). Healthy and unhealthy emotion regulation: Personality processes, individual differences, and life span development. *Journal of Personality*, *72*(6), 1301-1334.

Joormann, J., & Siemer, M. (2004). Memory accessibility, mood regulation, and dysphoria: Difficulties in repairing sad mood with happy memories? *Journal of Abnormal Psychology*, *113*(2), 179–188.

Joormann, J., Siemer, M., & Gotlib, I. H. (2007). Mood regulation in depression: Differential effects of distraction and recall of happy memories on sad mood. *Journal of Abnormal Psychology*, *116*(3), 484–490.

Kanske, P., Heissler, J., Schönfelder, S., Bongers, A., & Wessa, M. (2011). How to regulate emotion? Neural networks for reappraisal and distraction. *Cerebral Cortex*, *21*(6), 1379–1388.

Kelley, W. M., Macrae, C. N., Wyland, C. L., Caglar, S., Inati, S., & Heatherton, T. F. (2002). Finding the self? An event-related fMRI study. *Journal of Cognitive Neuroscience*, *14*(5), 785–794.

Kever, A., Pollatos, O., Vermeulen, N., & Grynberg, D. (2015). Interoceptive sensitivity facilitates both antecedent- and response-focused emotion regulation strategies. *Personality and Individual Differences*, *87*(3), 20–23.

Kiehl, K. A. (2006). A cognitive neuroscience perspective on psychopathy: Evidence for paralimbic system dysfunction. *Psychiatry Research*, *142*(2), 107-128.

Kiehl, K. A., Smith, A. M., Hare, R. D., Mendrek, A., Forster, B. B., Brink, J., & Liddle, P. F. (2001). Limbic abnormalities in affective processing by criminal psychopaths as revealed by functional magnetic resonance imaging. *Biological Psychiatry*, *50*(9), 677–684.

Kim, S. H., & Hamann, S. (2007). Neural correlates of positive and negative emotion regulation. *Journal of Cognitive Neuroscience*, *19*(5), 776–798.

Kimonis, E. R., Frick, P. J., Cauffman, E., Goldweber, A., & Skeem, J. L. (2012). Primary and secondary variants of juvenile psychopathy differ in emotional processing. *Development and Psychopathology*, *24*(3), 1091–1103.

Kingsley, M., Lewis, M. J., & Marson, R. E. (2005). Comparison of Polar 810s and an ambulatory ECG system for RR interval measurement during progressive exercise. *International Journal of Sports Medicine*, *26*(1), 39–44.

Kinner, V. L., Kuchinke, L., Dierolf, A. M., Merz, C. J., Otto, T., & Wolf, O. T. (2017). What our eyes tell us about feelings: Tracking pupillary responses during emotion regulation processes. *Psychophysiology* (AOP) doi: 10.1111/psyp.12816.

Koch, A., & Pollatos, O. (2014). Interoceptive sensitivity, body weight and eating behavior in children: A prospective study. *Frontiers in Psychology*, *5*, 1003.

Koenigsberg, H. W., Fan, J., Ochsner, K. N., Liu, X., Guise, K., Pizzarello, S., … Siever, L. J. (2010). Neural correlates of using distancing to regulate emotional responses to social situations. *Neuropsychologia*, *48*(6), 1813–1822.

Koole, S. L., & Rothermund, K. (2011). “I feel better but I don’t know why”: The psychology of implicit emotion regulation. *Cognition & Emotion*, *25*(3), 389–99.

Kross, E., & Ayduk, Ö. (2008). Facilitating adaptive emotional analysis: Distinguishing distanced-analysis of depressive experiences from immersed-analysis and distraction. *Personality and Social Psychology Bulletin*, *34*(7), 924–938.

Kross, E., Ayduk, Ö., & Mischel, W. (2005). When asking “why” does not hurt: Distinguishing rumination from reflective processing of negative emotions. *Psychological Science*, *16*(9), 709–715.

Kross, E., Duckworth, A., Ayduk, O., Tsukayama, E., & Mischel, W. (2011). The effect of self-distancing on adaptive versus maladaptive self-reflection in children. *Emotion*, *11*(5), 1032–9.

Lang, P.J., Bradley, M.M., & Cuthbert, B. N. (2008). International affective picture system (IAPS): Affective ratings of pictures and instruction manual. *Technical Report A-8.* Gainesville, FL, University of Florida.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*(3), 261–273.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology: Human Perception and Performance*, *21*(3), 451–468.

Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in Cognitive Sciences*, *9*(2), 75-82.

LeDoux, J. E. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience*, *23*(1), 155–184.

Lee, B. F. S., Heimer, H., Giedd, N., Lein, E. S., Šestan, N., Weinberger, D. R., & Casey, B. J. (2014). Adolescent mental health— opportunity and obligation. *Science*, *346*(6209), 547–549.

Lee, K. H., & Siegle, G. J. (2012). Common and distinct brain networks underlying explicit emotional evaluation: A meta-analytic study. *Social Cognitive and Affective Neuroscience*, *7*(5), 521–534.

Leppänen, J. M., & Hietanen, J. K. (2004). Positive facial expressions are recognized faster than negative facial expressions, but why? *Psychological Research*, *69*(1–2), 22–29.

Levenston, G. K., Patrick, C. J., Bradley, M. M., & Lang, P. J. (2000). The psychopath as observer: Emotion and attention in picture processing. *Journal of Abnormal Psychology*, *109*(3), 373–385.

Lewis, M., Granic, I., Lamm, C., Zelazo, P. D., Stieben, J., Todd, R. M. et al. (2008). Changes in the neural bases of emotion regulation associated with clinical improvement in children with behavior problems. *Development and Psychopathology*, *20*(03), 913-939.

Lieberman, M. D., & Cunningham, W. A. (2009). Type I and Type II error concerns in fMRI research: Re-balancing the scale. *Social Cognitive and Affective Neuroscience*, *4*(4), 423–428.

Liberman, N., Sagristano, M. D., & Trope, Y. (2002). The effect of temporal distance on level of mental construal. *Journal of Experimental Social Psychology*, *38*(6), 523–534.

Liberman, N., & Trope, Y. (2008). The psychology of transcending the here and now.

Science, 322(5905), 1201-1205.

Lindquist, M. A., & Wager, T. D. (2008). Spatial smoothing in fMRI using prolate spheroidal wave functions. *Human Brain Mapping*, *29*(11), 1276-1287.

Lipp, O. V, & Derakshan, N. (2005). Attentional bias to pictures of fear-relevant animals in a dot probe task. *Emotion*, *5*(3), 365–369.

Logothetis, N. K. (2008). What we can do and what we cannot do with fMRI. *Nature*, *453*(7197), 869–878.

Lorenz, A. R., & Newman, J. P. (2002). Deficient response modulation and emotion processing in low-anxious Caucasian psychopathic offenders: Results from a lexical decision task. *Emotion*, *2*(2), 91–104.

Lykken, D. T. (1995). *The antisocial personalities*. Hillsdale, NJ: Lawrence Erlbaum Associates.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology*, *95*(1), 15–20.

Maes, J. H. R., & Brazil, I. A. (2015). Distraction from cognitive processing by emotional pictures: Preliminary evidence for an association with interactions between psychopathy-related traits in a non-clinical sample. *Personality and Individual Differences*, *75*, 53–58.

Mannie, Z. N., Taylor, M. J., Harmer, C. J., Cowen, P. J., & Norbury, R. (2011). Frontolimbic responses to emotional faces in young people at familial risk of depression. *Journal of Affective Disorders*, *130*(1), 127-132.

Marsee, M. A., & Frick, P. J. (2007). Exploring the cognitive and emotional correlates to proactive and reactive aggression in a sample of detained girls. *Journal of Abnormal Child Psychology*, *35*(6), 969–981.

Marsh, A. A., Ambady, N., & Kleck, R. E. (2005). The effects of fear and anger facial expressions on approach- and avoidance-related behaviors. *Emotion*, *5*(1), 119–124.

Marsh, A. A., & Blair, R. J. R. (2008). Deficits in facial affect recognition among antisocial populations: A meta-analysis. *Neuroscience and Biobehavioral Reviews, 32*(3), 454-465.

Martin, R. C., & Dahlen, E. R. (2005). Cognitive emotion regulation in the prediction of depression, anxiety, stress, and anger. *Personality and Individual Differences*, *39*(7), 1249–1260.

Matejka, M., Kazzer, P., Seehausen, M., Bajbouj, M., Klann-Delius, G., Menninghaus, W., … Prehn, K. (2013). Talking about emotion: Prosody and skin conductance indicate emotion regulation. *Frontiers in Psychology*, *4*, 260.

Mauss, I. B., Cook, C. L., Cheng, J. Y. J., & Gross, J. J. (2007). Individual differences in cognitive reappraisal: experiential and physiological responses to an anger provocation. *International Journal of Psychophysiology : Official Journal of the International Organization of Psychophysiology*, *66*(2), 116–124.

McRae, K., Gross, J. J., Weber, J., Robertson, E. R., Sokol-Hessner, P., Ray, R. D., et al. (2012). The development of emotion regulation: An fMRI study of cognitive reappraisal in children, adolescents and young adults. S*ocial Cognitive and Affective Neuroscience, 7*(1), 11–22.

McRae, K., Hughes, B., Chopra, S., Gabrieli, J. D. E., Gross, J. J., & Ochsner, K. N. (2010). The neural bases of distraction and reappraisal. *Journal of Cognitive Neuroscience*, *22*(2), 248–62.

McRae, K., Jacobs, S. E., Ray, R. D., John, O. P., & Gross, J. J. (2012). Individual differences in reappraisal ability: Links to reappraisal frequency, well-being, and cognitive control. *Journal of Research in Personality*, *46*(1), 2–7.

McRae, K., Ochsner, K. N., Mauss, I. B., Gabrieli, J. J. D., & Gross, J. J. (2008). Gender Differences in Emotion Regulation: An fMRI Study of Cognitive Reappraisal. *Group Processes & Intergroup Relations*, *11*(2), 143-162.

Memedovic, S., Grisham, J. R., Denson, T. F., & Moulds, M. L. (2010). The effects of trait reappraisal and suppression on anger and blood pressure in response to provocation. *Journal of Research in Personality*, *44*(4), 540–543.

Mennin, D. S., Heimberg, R. G., Turk, C. L., & Fresco, D. M. (2005). Preliminary evidence for an emotion dysregulation model of generalized anxiety disorder. *Behaviour Research and Therapy*, *43*(10), 1281–1310.

Michal, M., Reuchlein, B., Adler, J., Reiner, I., Beutel, M. E., Vögele, C., … Schulz, A. (2014). Striking discrepancy of anomalous body experiences with normal interoceptive accuracy in depersonalization-derealization disorder. *PLoS ONE*, *9*(2).

Miller, E. K. (2000). The prefrontal cortex and cognitive control. *Nature Reviews Neuroscience*, *1*(1), 59–65.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*(1), 167–202.

Mitchell, D. G. V, Nakic, M., Fridberg, D., Kamel, N., Pine, D. S., & Blair, R. J. R. (2007). The impact of processing load on emotion. *NeuroImage*, *34*(3), 1299–1309.

Mitchell, D. G. V, Richell, R. A., Leonard, A., & Blair, R. J. R. (2006). Emotion at the expense of cognition: Psychopathic individuals outperform controls on an operant response task. *Journal of Abnormal Psychology*, *115*(3), 559–566.

Moffitt, T. E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review*, *100*(4), 674–701.

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy, 36*(9), 809-848.

Mohanty, A., Engels, A. S., Herrington, J. D., Heller, W., Ringo Ho, M. H., Banich, M. T., … Miller, G. A. (2007). Differential engagement of anterior cingulate cortex subdivisions for cognitive and emotional function. *Psychophysiology*, *44*(3), 343–351.

Moul, C., Killcross, S., & Dadds, M. R. (2012). A model of differential amygdala activation in psychopathy. *Psychological Review, 119*(4), 789-806.

Müller, J. L., Sommer, M., Wagner, V., Lange, K., Taschler, H., Röder, C. H., … Hajak, G. (2003). Abnormalities in emotion processing within cortical and subcortical regions in criminal psychopaths: Evidence from a functional magnetic resonance imaging study using pictures with emotional content. *Biological Psychiatry*, *54*(2), 152–162.

Murphy, G., Groeger, J. A., & Greene, C. M. (2016). Twenty years of load theory - where are we now, and where should we go next? *Psychonomic Bulletin & Review*, 23(5), 1316-1340.

Mussgay, L., Klinkenberg, N., & Rüddel, H. (1999). Heart beat perception in patients with depressive, somatoform, and personality disorders. *Journal of Psychophysiology*, *13*(1), 27–36.

Nelson, E. E., Leibenluft, E., McClure, E. B., & Pine, D. S. (2005). The social re-orientation of adolescence: a neuroscience perspective on the process and its relation to psychopathology. *Psychological Medicine, 35*(2), 163–174.

Newman, J. P., & Lorenz, A. R. (2003). Response modulation and emotion processing: Implications for psychopathy and other dysregulatory psychopathology. In R. J. Davidson, K. Scherer, & H. H. Goldsmith (Eds.), *Handbook of affective sciences* (pp. 904–929). Oxford, England: Oxford University Press.

Newman, J. P., & Schmitt, W. A. (1998). Passive avoidance in psychopathic offenders: A replication and extension. *Journal of Abnormal Psychology*, *107*(3), 527–532.

Niskanen, J. P., Tarvainen, M. P., Ranta-Aho, P. O., & Karjalainen, P. A. (2004). Software for advanced HRV analysis. *Computer Methods and Programs in Biomedicine*, *76*(1), 73–81.

Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences*. http://doi.org/10.1016/j.tics.2004.01.004

Nunan, D., Jakovljevic, D. G., Donovan, G., Hodges, L. D., Sandercock, G. R. H., & Brodie, D. A. (2008). Levels of agreement for RR intervals and short-term heart rate variability obtained from the Polar S810 and an alternative system. *European Journal of Applied Physiology, 103*(5), 529–537.

Oaten, M., & Cheng, K. (2006). Longitudinal gains in self-regulation from regular physical exercise. *British Journal of Health Psychology*, *11*(4), 717–733.

Ochsner, K., & Gross, J. (2008). Cognitive emotion regulation insights from social cognitive and affective neuroscience. *Current Directions in Psychological Science, 17*(2), 153–158.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. E. (2002). Rethinking feelings: An FMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience*, *14*(8), 1215–1229.

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, *9*(5), 242–249.

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

Ochsner, K. N., Silvers, J. A., & Buhle, J. T. (2012). Functional imaging studies of emotion regulation: a synthetic review and evolving model of the cognitive control of emotion. *Annals of the New York Academy of Sciences*, *1251*(1), E1-24.

Öhman, A. (2005). The role of the amygdala in human fear: Automatic detection of threat. *Psychoneuroendocrinology, 30*(10), 953-958.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General*, *130*(3), 466–478.

Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: tTward an evolved module of fear and fear learning. *Psychological Review*, *108*(3), 483–522.

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., Suzuki, K., … Yamadori, A. (2003). Thinking of the future and past: The roles of the frontal pole and the medial temporal lobes. *NeuroImage*, *19*(4), 1369–1380.

Olsson, A., & Ochsner, K. N. (2008). The role of social cognition in emotion. *Trends*

Cognitive Sciences, *12*(2), 65–71.

Patrick, C. J. (1994). Emotion and psychopathy: Startling new insights. *Psychophysiology*, *31*(4), 319-330.

Patrick, C. J. (2007). Affective processes in psychopathy. In J. Rotenberg & S. L. Johnson (Eds.), *Emotion and psychopathology: Bridging affective and clinical science* (pp. 215–239). Washington, DC: American Psychological Association.

Patrick, C. J., Bradley, M. M., & Lang, P. J. (1993). Emotion in the criminal psychopath: Startle reflex modulation. *Journal of Abnormal Psychology*, *102*(1), 82–92.

Paulhus, D. L., & Neumann, C. (in press). *Manual for the Self-Report Psychopathy Scale (4th ed.)*. Toronto, Canada: Multi-Health Systems.

Paus, T., Keshavan, M., & Giedd, J. N. (2008). Why do many psychiatric disorders emerge during adolescence? *Nature Reviews Neuroscience*, *9*(12), 947–957.

Penton, T., Thierry, G. L., & Davis, N. J. (2014). Individual differences in attributional style but not in interoceptive sensitivity, predict subjective estimates of action intention. *Frontiers in Human Neuroscience*, *8*, 638.

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

Pessoa, L., Padmala, S., & Morland, T. (2005). Fate of unattended fearful faces in the amygdala is determined by both attentional resources and cognitive modulation. *NeuroImage*, *28*(1), 249–255.

Picard, R., & Scheirer, J. (2001). The galvactivator: A glove that senses and communicates skin conductivity. *Proceedings 9th International Conference on HCI*, *1093*, 228–248.

Poldrack, R. A. (2006). Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences*, *10*(2), 59–63.

Poldrack, R. A. (2008). The role of fMRI in Cognitive Neuroscience: where do we stand? *Current Opinion in Neurobiology*, *18*(2), 223-227.

Poldrack, R. A., Mumford, J. A., & Nichols, T. E. (2011). *Handbook of functional MRI data analysis* (Vol. 4). New York, NY: Cambridge University Press.

Poldrack, R. A., Wagner, A. D., Prull, M. W., Desmond, J. E., Glover, G. H., & Gabrieli, J. D. (1999). Functional specialization for semantic and phonological processing in the left inferior prefrontal cortex. *NeuroImage*, *10*(1), 15–35.

Pollatos, O., Füstös, J., & Critchley, H. D. (2012). On the generalised embodiment of pain: How interoceptive sensitivity modulates cutaneous pain perception. *Pain*, *153*(8), 1680–1686.

Pollatos, O., Kurz, A. L., Albrecht, J., Schreder, T., Kleemann, A. M., Schöpf, V., … Schandry, R. (2008). Reduced perception of bodily signals in anorexia nervosa. *Eating Behaviors*, *9*(4), 381–388.

Pollatos, O., Traut-Mattausch, E., Schroeder, H., & Schandry, R. (2007). Interoceptive awareness mediates the relationship between anxiety and the intensity of unpleasant feelings. *Journal of Anxiety Disorders*, *21*(7), 931–943.

Poulin, F., & Boivin, M. (2000). Reactive and proactive aggression: Evidence of a two-factor model. *Psychological Assessment*, *12*(2), 115–122.

Qaisy, L. M. (2014). Aggressive behavior among the university students. *British Journal of Education, Society & Behavioural Science*, *4*(9), 1221-1233.

Quintana, D., Heathers, J., & Kemp, A. (2012). On the validity of using the Polar RS800 heart rate monitor for heart rate variability research. *European Journal of Applied Physiology*, *112*(12), 4179-4180.

Raghunathan, T. E., Rosenthal, R., & Rubin, D. B. (1996). Comparing correlated but nonoverlapping correlations. *Psychological Methods*, *1*(2), 178–183.

Raine, A., Dodge, K., Loeber, R., Gatzke-Kopp, L., Lynam, D., Reynolds, C., ... & Liu, J. (2006). The reactive-proactive aggression questionnaire: Differential correlates of reactive and proactive aggression in adolescent boys. *Aggressive Behavior*, *32*(2), 159–171. doi:10.1002/ab.20115

Ray, R. D., McRae, K., Ochsner, K. N., & Gross, J. J. (2010). Cognitive reappraisal of negative affect: Converging evidence from EMG and self-report. *Emotion*, *10*(4), 587–592.

Ribeiro, R. L., Pompéia, S., & Amodeo Bueno, O. F. (2005). Comparison of Brazilian and American norms for the International Affective Picture System (IAPS). *Revista Brasileira de Psiquiatria*, *27*(3), 208–215.

Richards, H. J., Benson, V., Donnelly, N., & Hadwin, J. A. (2014). Exploring the function of selective attention and hypervigilance for threat in anxiety. *Clinical Psychology Review, 34*(1), 1-13.

Riediger, M., & Luong, G. (2015). From adolescence to old age: Developmental perspectives on the extended process model of emotion regulation. *Psychological Inquiry*, *26*(1), 99-107.

Ring, C., & Brener, J. (1996). Influence of beliefs about heart rate and actual heart rate on heartbeat counting. *Psychophysiology, 33*(5), 541–546.

Ring, C., Brener, J., Knapp, K., & Mailloux, J. (2015). Effects of heartbeat feedback on beliefs about heart rate and heartbeat counting: A cautionary tale about interoceptive awareness. *Biological Psychology, 104*, 193–198.

Roberton, T., Daffern, M., & Bucks, R. S. (2014). Maladaptive emotion regulation and aggression in adult offenders. *Psychology, Crime & Law*, *20*(10), 933–954.

Röll, J., Koglin, U., & Petermann, F. (2012). Emotion regulation and childhood aggression: Longitudinal associations. *Child Psychiatry and Human Development, 43*(6), 909-923.

Salemink, E., & Wiers, R. W. (2012). Adolescent threat-related interpretive bias and its modification: The moderating role of regulatory control. *Behaviour Research and Therapy, 50*(1), 40–46.

Sawyer, S. M., Afifi, R. A., Bearinger, L. H., Blakemore, S. J., Dick, B., Ezeh, A. C., & Patton, G. C. (2012). Adolescence: A foundation for future health. *The Lancet*, *379*, 1630–1640.

Schacter, D., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1481), 773–786.

Schacter, D. L., Benoit, R. G., De Brigard, F., & Szpunar, K. K. (2015). Episodic future thinking and episodic counterfactual thinking: Intersections between memory and decisions. *Neurobiology of Learning and Memory, 117*, 14–21.

Schaefer, M., Egloff, B., Gerlach, A. L., & Witthöft, M. (2014). Improving heartbeat perception in patients with medically unexplained symptoms reduces symptom distress. *Biological Psychology*, *101*(1), 69–76.

Schandry, R. (1981). Heart Beat Perception and Emotional Experience. *Psychophysiology*, *18*(4), 483–488.

Schartau, P. E. S., Dalgleish, T., & Dunn, B. D. (2009). Seeing the bigger picture: training in perspective broadening reduces self-reported affect and psychophysiological response to distressing films and autobiographical memories. *Journal of Abnormal Psychology, 118*(1), 15–27.

Schmidtke, D. S., Schröder, T., Jacobs, A. M., & Conrad, M. (2014). ANGST: Affective norms for German sentiment terms, derived from the affective norms for English words. *Behavior Research Methods*, 1108–1118.

Schultz, W. (2006). Behavioral theories and the neurophysiology of reward. *Annual Review of Psychology*, *57*, 87–115.

Schultz, W. (2007). Behavioral dopamine signals. *Trends in Neurosciences,* 30(5), 203-210.

Schulz, K. P., Fan, J., Magidina, O., Marks, D. J., Hahn, B., & Halperin, J. M. (2007). Does the emotional go/no-go task really measure behavioral inhibition?. Convergence with measures on a non-emotional analog. *Archives of Clinical Neuropsychology*, *22*(2), 151–160.

Schumann, C. M., Hamstra, J., Goodlin-Jones, B. L., Lotspeich, L. J., Kwon, H., Buonocore, M. H., … Amaral, D. G. (2004). The amygdala is enlarged in children but not adolescents with autism; the hippocampus is enlarged at all ages. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *24*(28), 6392–6401.

Seara-Cardoso, A., Neumann, C., Roiser, J., McCrory, E., & Viding, E. (2012). Investigating associations between empathy, morality and psychopathic personality traits in the general population. *Personality and Individual Differences*, *52*(1), 67–71.

Sebastian, C. L., McCrory, E. J. P., Cecil, C. A. M., Lockwood, P. L., De Brito, S. A., Fontaine, N. M. G., & Viding, E. (2012). Neural responses to affective and cognitive theory of mind in children with conduct problems and varying levels of callous-unemotional traits. *Archives of General Psychiatry*, *69*(8), 814–822.

Sebastian, C. L., McCrory, E. J., Dadds, M. R., Cecil, C. A. M., Lockwood, P. L., Hyde, Z. H., … Viding, E. (2014). Neural responses to fearful eyes in children with conduct problems and varying levels of callous-unemotional traits. *Psychological Medicine*, *44*(1), 99–109.

Sebastian, C. L., McCrory, E. J., De Brito, S. A., & Viding, E. (2017). Modulation of amygdala response to task-irrelevant emotion. *Social Cognitive Affective Neuroscience*, (AOP) doi: 10.1093/scan/nsw174

Sebastian, C., Viding, E., Williams, K. D., & Blakemore, S. J. (2010). Social brain development and the affective consequences of ostracism in adolescence. *Brain and Cognition*, *72*(1), 134-145.

Shackman, A. J., Sarinopoulos, I., Maxwell, J. S., Pizzagalli, D. A., Lavric, A., & Davidson, R. J. (2006). Anxiety selectively disrupts visuospatial working memory. *Emotion*, *6*(1), 40–61.

Shafir, R., Schwartz, N., Blechert, J., & Sheppes, G. (2015). Emotional intensity influences pre-implementation and implementation of distraction and reappraisal. *Social Cognitive and Affective Neuroscience*, *10*(10), 1329–1337.

Shafir, R., Thiruchselvam, R., Suri, G., Gross, J. J., & Sheppes, G. (2016). Neural processing of emotional-intensity predicts emotion regulation choice. *Social Cognitive and Affective Neuroscience*, *11*(12), 1863–1871.

Shaw, P., Kabani, N. J., Lerch, J. P., Eckstrand, K., Lenroot, R., Gogtay, N., … Wise,

S. P. (2008). Neurodevelopmental trajectories of the human cerebral cortex. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *28*(14), 3586–3594.

Sheppes, G., Catran, E., & Meiran, N. (2009). Reappraisal (but not distraction) is going to make you sweat: Physiological evidence for self-control effort. *International Journal of Psychophysiology, 71*(2), 91-96.

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

Sheppes, G., Suri, G., & Gross, J. J. (2015). Emotion regulation and psychopathology. *Annual Review of Clinical Psychology*, *11*(1), 379–405.

Siegel, A., Bhatt, S., Bhatt, R., & Zalcman, S. S. (2007). The neurobiological bases for development of pharmacological treatments of aggressive disorders. *Current Neuropharmacology*, *5*(2), 135–147.

Silvers, J. A., Insel, C., Powers, A., Franz, P., Helion, C., Martin R.E., ... & Ochsner, K. N. (2016). vlPFC-vmPFC-amygdala interactions underlie age-related differences in cognitive regulation of emotion. *Cerebral Cortex*, 1–13.

Silvers, J. A., McRae, K., Gabrieli, J. D. E., Gross, J. J., Remy, K. A., & Ochsner, K. N. (2012). Age-related differences in emotional reactivity, regulation, and rejection sensitivity inaAdolescence. *Emotion*, *12*(6), 1235-1247.

Simon, J. R., & Wolf, J. D. (1963). Choice reaction time as a function of angular stimulus-response correspondence and age. *Ergonomics*, *6*(1), 99–105.

Simonsohn, U. (2015). Small telescopes. Detectability and the evaluation of replication results. *Psychological Science, 26*(5), 559 – 569.

Skeem, J. L., Polaschek, D. L. L., Patrick, C. J., & Lilienfeld, S. O. (2011). Psychopathic personality: Bridging the gap between scientific evidence and public policy. *Psychological Science in the Public Interest*, *12*(3), 95–162.

Sladky, R., Friston, K., Trostl, J, Cunnington, R., Moser, E. & Windischberger, C. (2011). Slice-timing effects and their correction in functional MRI. *NeuroImage, 58*, 588-594

Smith, P., & Waterman, M. (2003). Processing bias for aggression words in forensic and nonforensic samples. *Cognition & Emotion, 17*(5), 681-701.

Smith, P., & Waterman, M. (2004). Role of experience in processing bias for aggressive words in forensic and non-forensic populations. *Aggressive Behavior*, *30*(2), 105–122.

Smith, P., & Waterman, M. (2005). Sex differences in processing aggression words using the emotional stroop task. *Aggressive Behavior, 31*(3), 271–282.

Sokol-Hessner, P., Hsu, M., Curley, N. G., Delgado, M. R., Camerer, C. F., & Phelps, E. A. (2009). Thinking like a trader selectively reduces individuals' loss aversion. *Proceedings of the National Academy of Sciences, 106*(13), 5035-5040.

Somerville, L. H., & Casey, B. J. (2010). Developmental neurobiology of cognitive control and motivational systems. *Current Opinion in Neurobiology, 20*(2), 236-241.

Somerville, L. H., Jones, R. M., Ruberry, E. J., Dyke, J. P., Glover, G., & Casey, B. J. (2013). The medial prefrontal cortex and the emergence of self-conscious emotion in adolescence. *Psychological Science, 24*(8), 1554-1562.

Spear, L. P. (2000). The adolescent brain and age-related behavioral manifestations. *Neuroscience and Biobehavioral Reviews, 24*(4), 417-463.

Spielberger, C. D., Gorsuch, R. L., Lushene, P. R., Vagg, P. R., & Jacobs, A. G. (1983). *Manual for the State-Trait Anxiety Inventory (Form Y)*. *Manual for the statetrait anxiety inventory STAI*.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643-662.

Steinberg, L. (2005). Cognitive and affective development in adolescence. *Trends in Cognitive Sciences, 9*(2), 69-74.

Steinberg, L., Graham, S., O'Brien, L., Woolard, J., Cauffman, E., & Banich, M. (2009). Age differences in future orientation and delay discounting. *Child Development, 80*(1), 28–44.

Stillman, P. E., Lee, H., Deng, X., Unnava, R., Cunningham, W. A., & Fujita, K. (2017). Neurological evidence for the role of construal level in future-directed thought. *Social Cognitive Affective Neuroscience*, (AOP) nsx022. doi:10.1093/scan/nsx022

Suddendorf, T., & Corballis, M. C. (2007). Mental time travel across the disciplines: The future looks bright. *Behavioral and Brain Sciences*, *30*(3), 334–336.

Sullivan, T. N., Helms, S. W., Kliewer, W., & Goodman, K. L. (2010). Associations between sadness and anger regulation coping, emotional expression, and physical and relational aggression among urban adolescents. *Social Development*, *19*(1), 30–51.

Sutton, S. K., Vitale, J. E., & Newman, J. P. (2002). Emotion among women with psychopathy during picture perception. *Journal of Abnormal Psychology, 111*(4), 610–619.

Sylvers, P. D., Brennan, P. A., & Lilienfeld, S. O. (2011). Psychopathic traits and preattentive threat processing in children a novel test of the fearlessness hypothesis. *Psychological Science, 22*(10), 1280–1287.

Szasz, P. L., Szentagotai, A., & Hofmann, S. G. (2011). The effect of emotion regulation strategies on anger. *Behaviour Research and Therapy, 49*(2), 114–119.

Szpunar, K. K., Chan, J. C. K., & McDermott, K. B. (2009). Contextual processing in episodic future thought. *Cerebral Cortex, 19*(7), 1539–1548.

Szpunar, K. K., Watson, J. M., & McDermott, K. B. (2007). Neural substrates of envisioning the future. *Proceedings of the National Academy of Sciences, 104*(2), 642–647.

Tager, D., Good, G. E., & Brammer, S. (2010). "Walking over 'em": An exploration of relations between emotion dysregulation, masculine norms, and intimate partner abuse in a clinical sample of men. *Psychology of Men & Masculinity, 11*(3), 233–239.

Teper, R., Segal, Z. V., & Inzlicht, M. (2013). Inside the mindful mind how mindfulness enhances emotion regulation through improvements in executive control. *Current Directions in Psychological Science, 22*(6), 449-454.

Theeuwes, J., Kramer, A. F., & Belopolsky, A. V. (2004). Attentional set interacts with perceptual load in visual search. *Psychonomic Bulletin & Review, 11*(4), 697–702.

Thompson-Schill, S. L., Bedny, M., & Goldberg, R. F. (2005). The frontal lobes and the regulation of mental activity. *Current Opinion in Neurobiology, 15*(2), 219-224.

Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development*, *59*(2-3), 25–52.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., … Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168*(3), 242–249.

Trope, Y., & Liberman, N. (2003). Temporal construal. *Psychological Review, 110*(3), 403–421.

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review, 117*(2), 440–463.

Troy, A. S., Wilhelm, F. H., Shallcross, A. J., & Mauss, I. B. (2010). Seeing the silver lining: Cognitive reappraisal ability moderates the relationship between stress and depressive symptoms. *Emotion, 10*(6), 783–795.

Tsakiris, M., Tajadura-Jiménez, A., & Costantini, M. (2011). Just a heartbeat away from one's body: Interoceptive sensitivity predicts malleability of body-representations. *Proceedings of the Royal Society of Biological Sciences, 278*(1717), 2470–2476.

Urry, H. L., van Reekum, C. M., Johnstone, T., & Davidson, R. J. (2009). Individual differences in some (but not all) medial prefrontal regions reflect cognitive demand while regulating unpleasant emotion. *NeuroImage, 47*(3), 852–863.

Vaidyanathan, U., Hall, J. R., Patrick, C. J., & Bernat, E. M. (2011). Clarifying the role of defensive reactivity deficits in psychopathy and antisocial personality using startle reflex methodology. *Journal of Abnormal Psychology*, *120*(1), 253–258.

Veit, R., Flor, H., Erb, M., Hermann, C., Lotze, M., Grodd, W., & Birbaumer, N. (2002). Brain circuits involved in emotional learning in antisocial behavior and social phobia in humans. *Neuroscience Letters, 328*(3), 233–236.

Veit, R., Konicar, L., Klinzing, J. G., Barth, B., Yilmaz, O., & Birbaumer, N. (2013). Deficient fear conditioning in psychopathy as a function of interpersonal and affective disturbances. *Frontiers in Human Neuroscience*, *7,* 706.

Verona, E., Sprague, J., & Sadeh, N. (2012). Inhibitory control and negative emotional processing in psychopathy and antisocial personality disorder. *Journal of Abnormal Psychology*, *121*(2), 498–510.

Viard, A., Chételat, G., Lebreton, K., Desgranges, B., Landeau, B., de La Sayette, V., … Piolino, P. (2011). Mental time travel into the past and the future in healthy aged adults: An fMRI study. *Brain and Cognition*, *75*(1), 1–9.

Viding, E., Sebastian, C. L., Dadds, M. R., Lockwood, P. L., Cecil, C. A. M., De Brito, S. A., & McCrory, E. J. (2012). Amygdala response to preattentive masked fear in children with conduct problems: The role of callous-unemotional traits. *American Journal of Psychiatry*, *169,* 1109–1116.

Vitaro, F., Brendgen, M., & Tremblay, R. E. (2002). Reactively and proactively aggressive children: Antecedent and subsequent characteristics. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 43*(4), 495–505.

Vytal, K., Cornwell, B., Arkin, N., & Grillon, C. (2012). Describing the interplay between anxiety and cognition: From impaired performance under low cognitive load to reduced anxiety under high load. *Psychophysiology*, *49*(6), 842–852.

Wager, T. D., Davidson, M. L., Hughes, B. L., Lindquist, M. A., & Ochsner, K. N. (2008). Prefrontal-subcortical pathways mediating successful emotion regulation. *Neuron, 59*(6), 1037–1050.

Wager, T. D., Jonides, J., & Reading, S. (2004). Neuroimaging studies of shifting attention: A meta-analysis. *NeuroImage*, *22*(4), 1679–1693.

Wager, T. D., & Smith, E. E. (2003). Neuroimaging studies of working memory: A meta-analysis. *Cognitive, Affective, & Behavioral Neuroscience*, *3*(4), 255–274.

Wakslak, C. J., Nussbaum, S., Liberman, N., & Trope, Y. (2008). Representations of the self in the near and distant future. *Journal of Personality and Social Psychology*, *95*(4), 757–773.

Webb, T. L., Miles, E., & Sheeran, P. (2012). Dealing with feeling: A meta-analysis of the effectiveness of strategies derived from the process model of emotion regulation. *Psychological Bulletin*, *138*(4), 775–808.

Weippert, M., Kumar, M., Kreuzfeld, S., Arndt, D., Rieger, A., & Stoll, R. (2010). Comparison of three mobile devices for measuring R-R intervals and heart rate variability: Polar S810i, Suunto t6 and an ambulatory ECG system. *European Journal of Applied Physiology*, *109*(4), 779–786.

Weiskopf, N., Hutton, C., Josephs, O., & Deichmann, R. (2006). Optimal EPI parameters for reduction of susceptibility-induced BOLD sensitivity losses: A whole-brain analysis at 3T and 1.5T. *NeuroImage*, *33*(2), 493–504.

Wells, A., & Papageorgiou, C. (1998). Social phobia: Effects of external attention on anxiety, negative beliefs, and perspective taking. *Behavior Therapy*, *29*(3), 357-370.

Wekerle, C., Waechter, R. L., Leung, E., & Leonard, M. (2007). Adolescence: A window of opportunity for positive change in mental health. *First Peoples Child & Family Review*, *3*(2), 8-16.

Werner, N. S., Kerschreiter, R., Kindermann, N. K., & Duschek, S. (2013). Interoceptive awareness as a moderator of affective responses to social exclusion. *Journal of Psychophysiology*, *27*(1), 39–50.

Whelan, R., & Mchugh, L. A. (2009). Temporal discounting of hypothetical monetary rewards by adolescents,adults,and older adults. *The Psychological Record*, *59*, 247–258.

Wickelgren, W. A. (1977). Speed-accuracy tradeoff and information processing dynamics. *Acta Psychologica*, *41*(1), 67–85.

Wilkowski, B. M., & Robinson, M. D. (2008). Clear heads are cool heads: Emotional clarity and the down-regulation of antisocial affect. *Cognition & Emotion*, *22*(2), 308–326.

Wilkowski, B. M., & Robinson, M. D. (2010). The anatomy of anger: An integrative cognitive model of trait anger and reactive aggression. *Journal of Personality*, *78*(1), 9–38.

Wilkowski, B. M., Robinson, M. D., & Meier, B. P. (2006). Agreeableness and the prolonged spatial processing of antisocial and prosocial information. *Journal of Research in Personality*, *40*(6), 1152–1168.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional stroop task and psychopathology. *Psychological Bulletin*, *120*(1), 3–24.

Williams, K. D., Cheung, C. K., & Choi, W. (2000). *Cyberostracism: Effects of being ignored over the Internet. Journal of Personality and Social Psychology, 79*(5), 748-762.

Wolgast, M., Lundh, L. G., & Viborg, G. (2011). Cognitive reappraisal and acceptance: An experimental comparison of two emotion regulation strategies. *Behaviour Research and Therapy, 49*(12), 858-866.

Xu, Y., & Zhang, Z. (2008). Distinguishing proactive and reactive aggression in Chinese children. *Journal of Abnormal Child Psychology, 36*(4), 539–552.

Yang, E., Zald, D. H., & Blake, R. (2007). Fearful expressions gain preferential access to awareness during continuous flash suppression. *Emotion*, *7*(4), 882–886.

Zeichner, A., Frey, F. C., Parrott, D. J., & Butryn, M. F. (1999). Measurement of laboratory aggression: A new response-choice paradigm. *Psychological Reports, 85*(3), 1229–1237.

Zeier, J. D., & Newman, J. P. (2013). Feature-based attention and conflict monitoring in criminal offenders: interactive relations of psychopathy with anxiety and externalizing. *Journal of Abnormal Psychology*, *122*(3), 797–806.

Zheng, H., Luo, J., & Yu, R. (2014). From memory to prospection: What are the overlapping and the distinct components between remembering and imagining? *Frontiers in Psychology, 5*, 856.

Appendices

Appendix 1: Self-report questionnaires used in the thesis.

1a) The Self-Report Psychopathy Scale-III Short Form (SRP-III-SF; Paulhus et al., in press).

Please rate the degree to which you agree with the following statements. You can be honest because your name will be detached from the answers as soon as they are submitted.

	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly
1. I'm a rebellious person.	☐	☐	☐	☐	☐
2. I have never been involved in delinquent gang activity.	☐	☐	☐	☐	☐
3. Most people are wimps.	☐	☐	☐	☐	☐
4. I've often done something dangerous just for the thrill of it.	☐	☐	☐	☐	☐
5. I have tricked someone into giving me money	☐	☐	☐	☐	☐
6. I have assaulted a law enforcement official or social worker.	☐	☐	☐	☐	☐
7. I have pretended to be someone else in order to get something.	☐	☐	☐	☐	☐
8. I like to see fist-fights.	☐	☐	☐	☐	☐
9. I would get a kick out of 'scamming' someone.	☐	☐	☐	☐	☐
10. It's fun to see how far you can push people before they get upset.	☐	☐	☐	☐	☐
11. I enjoy doing wild things.	☐	☐	☐	☐	☐
12. I have broken into a building or vehicle in order to steal something or vandalize	☐	☐	☐	☐	☐
13. I don't bother to keep in touch with my family any more	☐	☐	☐	☐	☐
14. I rarely follow the rules.	☐	☐	☐	☐	☐
15. You should take advantage of other people before they do it to you.	☐	☐	☐	☐	☐
16. People sometimes say that I'm cold-hearted.	☐	☐	☐	☐	☐

	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly
17. I like to have sex with people I barely know.	☐	☐	☐	☐	☐
18. I love violent sports and movies.	☐	☐	☐	☐	☐
19. Sometimes you have to pretend you like people to get something out of them.	☐	☐	☐	☐	☐
20. I was convicted of a serious crime.	☐	☐	☐	☐	☐
21. I keep getting in trouble for the same things over and over.	☐	☐	☐	☐	☐
22. Every now and then I carry a weapon (knife or gun) for protection.	☐	☐	☐	☐	☐
23. You can get what you want by telling people what they want to hear.	☐	☐	☐	☐	☐
24. I never feel guilty over hurting others.	☐	☐	☐	☐	☐
25. I have threatened people into giving me money, clothes, or makeup.	☐	☐	☐	☐	☐
26. A lot of people are “suckers” and can easily be fooled.	☐	☐	☐	☐	☐
27. I admit that I often “mouth off” without thinking.	☐	☐	☐	☐	☐
28. I sometimes dump friends that I don’t need any more.	☐	☐	☐	☐	☐
29. I purposely tried to hit someone with the vehicle I was driving.	☐	☐	☐	☐	☐

1b) The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983).

State Anxiety:

Read each statement and then select the answer that reflects how you feel **right now**, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not at all	Somewhat	Moderately so	Very much so
1. I feel calm	☐	☐	☐	☐
2. I feel secure	☐	☐	☐	☐
3. I am tense	☐	☐	☐	☐
4. I feel strained	☐	☐	☐	☐
5. I feel at ease	☐	☐	☐	☐
6. I feel upset	☐	☐	☐	☐
7. I am presently worrying over possible misfortunes	☐	☐	☐	☐
8. I feel satisfied	☐	☐	☐	☐
9. I feel frightened	☐	☐	☐	☐
10. I feel comfortable	☐	☐	☐	☐
11. I feel self-confident	☐	☐	☐	☐
12. I feel nervous	☐	☐	☐	☐
13. I am jittery	☐	☐	☐	☐
14. I feel indecisive	☐	☐	☐	☐
15. I am relaxed	☐	☐	☐	☐
16. I feel content	☐	☐	☐	☐
17. I am worried	☐	☐	☐	☐
18. I feel confused	☐	☐	☐	☐
19. I feel steady	☐	☐	☐	☐
20. I feel pleasant	☐	☐	☐	☐

Trait Anxiety:

Read each statement and then select the answer that reflects how you **generally feel**. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	Not at all	Somewhat	Moderately so	Very much so
21. I feel pleasant	☐	☐	☐	☐
22. I feel nervous and restless	☐	☐	☐	☐
23. I feel satisfied with myself	☐	☐	☐	☐
24. I wish I could be as happy as others seem to be	☐	☐	☐	☐
25. I feel like a failure	☐	☐	☐	☐
26. I feel rested	☐	☐	☐	☐
27. I am "calm, cool, and collected"	☐	☐	☐	☐
28. I feel that difficulties are piling up so that I cannot overcome them	☐	☐	☐	☐
29. I worry too much over something that really doesn't matter	☐	☐	☐	☐
30. I am happy	☐	☐	☐	☐
31. I have disturbing thoughts	☐	☐	☐	☐
32. I lack self-confidence	☐	☐	☐	☐
33. I feel secure	☐	☐	☐	☐
34. I make decisions easily	☐	☐	☐	☐
35. I feel inadequate	☐	☐	☐	☐
36. I am content	☐	☐	☐	☐
37. Some unimportant thought runs through my mind and bothers me	☐	☐	☐	☐
38. I take disappointments so keenly that I can't put them out of my mind	☐	☐	☐	☐
39. I am a steady person	☐	☐	☐	☐
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	☐	☐	☐	☐

1c) Buss-Perry Aggression Questionnaire (Buss & Perry, 1992)

Please rate each of the following items in terms of how characteristic they are of you. Use the following scale for answering these items.

1	2	3	4	5
Extremely uncharacteristic of me	Somewhat uncharacteristic of me	Neither uncharacteristic nor characteristic of me	Somewhat characteristic of me	Extremely characteristic of me

1) Once in a while I can't control the urge to strike another person.
2) Given enough provocation, I may hit another person.
3) If somebody hits me, I hit back.
4) I get into fights a little more than the average person.
5) If I have to resort to violence to protect my rights, I will.
6) There are people who pushed me so far that we came to blows.
7) I can think of no good reason for ever hitting a person.
8) I have threatened people I know.
9) I have become so mad that I have broken things.
10) I tell my friends openly when I disagree with them.
11) I often find myself disagreeing with people.
12) When people annoy me, I may tell them what I think of them.
13) I can't help getting into arguments when people disagree with me.
14) My friends say that I'm somewhat argumentative.
15) I flare up quickly but get over it quickly.
16) When frustrated, I let my irritation show.
17) I sometimes feel like a powder keg ready to explode.
18) I am an even-tempered person.
19) Some of my friends think I'm a hothead.
20) Sometimes I fly off the handle for no good reason.
21) I have trouble controlling my temper.
22) I am sometimes eaten up with jealousy.
23) At times I feel I have gotten a raw deal out of life.
24) Other people always seem to get the breaks.
25) I wonder why sometimes I feel so bitter about things.
26) I know that "friends" talk about me behind my back.
27) I am suspicious of overly friendly strangers.
28) I sometimes feel that people are laughing at me behind me back.
29) When people are especially nice, I wonder what they want.

1d) Emotion Regulation Questionnaire (ERQ; Gross & John, 2003).

For each item please answer as honestly and accurately as possible.

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

1) When I want to feel more *positive* emotion (such as joy or amusement), I *change what I'm thinking about*.

2) I keep my emotions to myself.

3) When I want to feel less *negative* emotion (such as sadness or anger), I *change what I'm thinking about.*

4) When I am feeling *positive* emotions, I am careful not to express them.

5) When I'm faced with a stressful situation, I make myself *think about it* in a way that helps me stay calm.

6) I control my emotions by *not expressing them*.

7) When I want to feel more *positive* emotion, I *change the way I'm thinking* about the situation.

8) I control my emotions by *changing the way I think about* the situation I'm in.

9) When I am feeling *negative* emotions, I make sure not to express them.

10) When I want to feel less *negative* emotion, I *change the way I'm thinking* about the situation.

1e) Reactive and Proactive Questionnaire (RPQ; Raine et al., 2006)

There are times when most of us feel angry, or have done things we should not have done. Rate each of the items below by crossing the box around either never, sometimes or often. Do not spend a lot of time thinking about the items – just give your first response. Make sure you answer all the items.

How often have you …	Never	Sometimes	Often
1. Yelled at others when they have annoyed you	☐	☐	☐
2. Had fights with others to show who was on top	☐	☐	☐
3. Reacted angrily when provoked by others	☐	☐	☐
4. Taken things from others	☐	☐	☐
5. Become angry when frustrated	☐	☐	☐
6. Vandalised something just for fun	☐	☐	☐
7. Had temper tantrums	☐	☐	☐
8. Damaged something because you felt mad	☐	☐	☐
9. Had a fight just to be cool	☐	☐	☐
10. Hurt others to win a game	☐	☐	☐
11. Become angry when you don’t get your way	☐	☐	☐
12. Used force to get others to do what you want	☐	☐	☐
13. Become angry or mad when you lost a game	☐	☐	☐
14. Become angry when others threatened you	☐	☐	☐
15. Used force to obtain money or things from others	☐	☐	☐
16. Felt better after hitting or yelling at someone	☐	☐	☐
17. Threatened and bullied someone	☐	☐	☐
18. Made obscene phone calls for fun	☐	☐	☐
19. Hit others to defend yourself	☐	☐	☐
20. Got others to gang up on somebody else	☐	☐	☐
21. Carried a weapon to use in a fight	☐	☐	☐
22. Become angry or mad or hit others when teased	☐	☐	☐
23. Yelled at others so they would do things for you	☐	☐	☐

Appendix 2: Scenario stimuli used in Chapter 6.

The following list comprises the sets of scenarios used in the fMRI study in Chapter 6, adapted from the scenarios created for Chapter 5.

Set 1 (neutral)

- Your friend has blue eyes and blonde curly hair
- The person next to you is using a red pen
- You pass a colleague as you walk up the stairs
- You ask your superior a question and they answer
- You see your doctor walking down the street
- The main hall in the science building is being repainted
- You put your hockey stick in the cupboard
- You overhear someone taking on the phone about the weather
- You use the computer to do your work
- You put on your jumper in the morning

Set 2 (negative)

- You catch someone talking about you behind your back
- Someone makes a nasty comment about your looks
- As you're walking onto the stage you trip and fall
- After giving an important presentation you realise your fly is undone
- You fail one of your most important exams
- You fail to qualify for the sports team
- Your finger gets trapped in a door and breaks
- Whilst playing hockey someone hits you hard with their stick
- You get splashed by dirty water by a passing car
- Your computer crashes before you've saved your work

Set 3 (negative)

- You have a serious argument with your best friend
- Your workmates throw a party but don't invite you

- You address your superior by the wrong name
- You get a nosebleed in public and everyone stares at you
- Your doctor tells you that your eyesight has gotten worse
- You miss an important interview because your car breaks down
- You are in a fight and get punched in the face
- You stub your toe really hard on the table leg
- You get blamed for something you didn’t do
- You’re meeting your friend but they’re over an hour late

Set 4 (negative)

- Your best friend starts ignoring you for no reason
- Someone steals your bag and runs away
- You spill your drink in a fancy restaurant
- You accidently send a rude joke to your superior
- Your hair starts falling out because of ongoing stress
- Someone copies your work but you get in trouble, not them
- You’re in a car crash and end up with serious injuries
- Someone runs into you and knocks you over on purpose
- You forget your keys and get locked out of your house
- You find that someone has ripped your favourite top

Appendix 3: Instructions given to participants in Chapter 6.

This study is about putting events into a broader time perspective

In this study…

- You will be shown scenarios (sentences) that you have to read and imagine yourself in.
- After each scenario you will be given an instruction. **Keep this in mind.**
- When you see **+** you will have to implement this instruction in your mind.
- You will then have to rate how you feel after following that instruction.

Example:

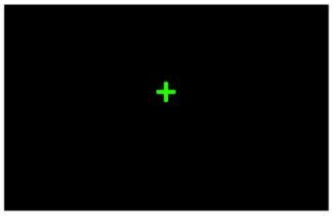
You get a bad grade on your essay

Remember: These scenarios are all happening in the **present moment.**

↓

You will then see the instruction **NOW** or **NEAR** or **FAR**

When you see this…

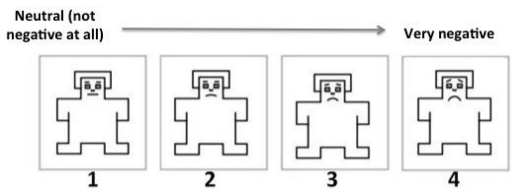


When the instruction is…

- **NOW:** During the **+** screen, think about how the scenario would affect you **right now,** e.g. '*I'm really disappointed. I didn't do as well as I expected*' or '*I don't really care'*
- **NEAR:** During the **+** screen, think about how you would feel about the scenario **when looking back on it from the near future**. e.g. '*It wasn't the highlight of the term but it's not the end of the world*' or '*I'm still really disappointed because it affected my whole module mark*'
- **FAR:** During the **+** screen, think about how you would feel about the scenario **when looking back on it from the distant future**. For example: '*e.g. I won't care at all any more because I will have a job by then and my performance on an essay will be completely irrelevant*' or '*Yes it happened a while ago but I still care*'

Ratings

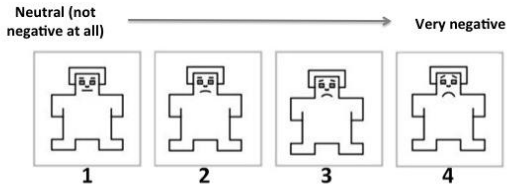
You will then be asked to rate **how you feel in the present moment** after implementing the instruction:



E.g. **NEAR** or **FAR**: rate how reflecting on the scenario in the future makes you feel at *the present moment*

Ratings

How negative do you feel?



What we mean by **negative**: *any feeling that's not positive e.g. anger, frustration, sadness, embarrassment, distress etc.*

Ratings

When your instruction is about thinking of the **NEAR or FAR** future you will also be asked:

How far into the future did you think of?

One day	One month	One year	Five years
1	2	3	4

These are example time points so pick whichever is closest to what you thought of, e.g. if you thought of a couple of months pick 'one month etc.

Please try to…

- **Keep focused** on the scenario itself. Don't think about something unrelated or take your mind off the scenario.
- **Put yourself in the situation.** When reading the scenarios try to imagine it really happening to you.
- **Be honest.** There are no right or wrong answers. Just rate how you honestly feel.
- The main thing is that during the **Near/Far** conditions that you concentrate on **projecting** yourself into those time frames.

Appendix 4: Peak cluster activations in brain regions reaching significance at *p*<.05 (FWE-corrected at the whole brain level) for contrasts with no specific hypotheses in Chapter 6. BA=Brodmann area; L/R=laterality (left/right); peak voxel=co-ordinates of the peak voxel from the whole brain analysis (XYZ co-ordinates refer to Montreal Neurological Institute (MNI) standard space); k=cluster size (number of 3x3x3mm voxels: where cells are empty, activations are part of above clusters); FWE=familywise error.

Brain Regions	**Peak**						**Cluster**	
	BA	*L/R*	*x*	*y*	*z*	*t*	*k*	*p (FWE)*
Near > Distant								
None								
Read Negative > Near								
Lingual Gyrus	17	L	-21	-94	-5	7.29	156	<0.001
Middle Occipital Gyrus	18	R	24	-94	-2	6.77	184	<0.001
Middle Occipital Gyrus	-	R	27	-88	-8	6.76	-	-
Superior Temporal Gyrus	22	L	-54	-7	-11	6.24	92	<0.001
Middle Temporal Gyrus	21	R	51	-10	-14	5.40	40	<0.001
Middle Temporal Gyrus	21	R	51	8	-20	5.28	-	-
Superior Temporal Gyrus	22	L	-54	-40	7	5.00	10	0.002
Fusiform Gyrus	37	R	39	-43	-17	4.70	1	0.024
Medial Frontal Gyrus	25	L	-3	26	-17	4.64	1	0.024
Near > Read Negative								
Inferior Parietal Lobule	40	R	45	-40	52	7.44	827	<0.001
Inferior Parietal Lobule	7	R	36	-64	46	5.74	-	-
Superior Parietal Lobule	7	R	33	-64	58	5.68	-	-
Inferior Parietal Lobule	40	L	-45	-43	46	6.87	981	<0.001
Postcentral Gyrus	2	L	-51	-28	31	6.83	-	-
Postcentral Gyrus	2	L	-42	-31	37	6.67	-	-
Lingual Gyrus	18	L	0	-73	-2	6.24	213	<0.001
Fusiform Gyrus	19	L	-24	-70	-14	5.06	-	-
Parahippocampal Gyrus	19	L	-27	-58	-5	4.81	-	-
Lentiform Nucleus, Putamen	-	L	-30	-19	1	5.98	299	<0.001
Claustrum	-	L	-33	-1	4	5.73	-	-
Insula	13	L	-42	8	4	5.25	-	-
Middle Frontal Gyrus	6	R	30	8	61	5.85	48	<0.001
Culmen	-	R	21	-49	-20	5.51	78	<0.001
Cerebellum	6	R	24	-70	-17	5.24	12	0.001
Inferior Temporal Gyrus	37	R	54	-49	-11	5.21	21	<0.001
Medial Frontal Gyrus	6	L	-6	-4	52	5.18	13	0.001
Insula	13	R	42	-1	13	5.16	40	<0.001

Brain Regions	Peak						Cluster	
	BA	*L/R*	*x*	*y*	*z*	*t*	*k*	*p (FWE)*
Putamen	-	R	33	-1	10	5.04	-	-
Culmen	-	L	-24	-61	-32	5.14	13	0.001
Inferior Frontal Gyrus	44	R	54	8	22	5.11	16	<0.001
Middle Temporal Gyrus	19	L	-39	-79	16	5.08	7	0.003
Claustrum	-	R	30	17	7	4.94	8	0.003
Middle Frontal Gyrus	10	R	42	47	16	4.93	12	0.001
Middle Frontal Gyrus	10	L	-33	53	-8	4.78	2	0.016
Cingulate Gyrus	32	R	6	23	46	4.73	4	0.008
Middle Frontal Gyrus	9	R	39	32	37	4.68	3	0.011
Insula	-	R	39	14	1	4.64	1	0.024
Lingual Gyrus	-	L	-21	-64	1	4.63	1	0.024