PSYCHO- AND NEUROPHYSIOLOGICAL MECHANISMS UNDERLYING THE EFFICACY OF INTERPERSONAL EMOTION REGULATION

NICOLA KAREN NGOMBE
Doctor of Philosophy

ASTON UNIVERSITY
February 2022

Aston University

Psycho- and neurophysiological mechanisms underlying the efficacy of interpersonal emotion regulation

Nicola Karen Ngombe
Doctor of Philosophy, 2022

Thesis Abstract

Although humans are inherently social, emotion regulation (ER) studies often disregard how ER predominantly occurs within social interactions with others. It is currently unclear how the efficacy of inter-personal ER compares to intra-personal regulation, and what psychophysiological mechanisms underlie effective inter-personal ER. There has been behavioural evidence to suggest inter-personal ER might in fact be more effective in decreasing negative emotions than intra-personal ER. To assess whether inter-personal ER also modulates physiological responses, this thesis utilised electrodermal activity measures. A total of 146 participants regulated their emotions using a self-selected strategy (intra-personal ER) or a strategy that was recommended to them (inter-personal ER). Although participants reported greater decreases in negative emotions following intra-personal ER, the reverse pattern emerged for physiological responses: electrodermal measures exhibited greater decreases during inter-personal ER. Subsequently, the neural processes underlying these physiological benefits of inter-personal ER were scrutinised in a second-person fMRI experiment using the same experimental paradigm. Twenty-three dyads consisting of a Regulator recommending ER strategies and a Target implementing these strategies were scanned simultaneously. Although ratings responses suggested no differences in efficacy between inter- and intra-personal ER, during inter-personal ER, both Regulators and Targets exhibited activations within key nodes of the ER network, e.g., the dorsolateral prefrontal cortex, as well as socio-cognitive regions, such as the temporal parietal junction. Moreover, Regulators' neural responses during the choice of an ER strategy resembled brain responses observed in Targets during intra-personal ER, thereby suggesting Regulators engaged in processes of embodiment. Taken together, there is tentative evidence to suggest that inter-personal ER can effectively modulate physiological responses in some cases and it engages a similar neural network to intra-personal ER. Importantly, Regulators appear to engage in embodied processes when regulating another's emotions. Future studies utilising multi-method and second-person paradigms are needed to discover factors which modulate inter-personal ER.

Keywords: Interpersonal, Intrapersonal, emotion regulation, electrodermal activity, fMRI, efficacy, second-person paradigms, dyad, choice, regulation strategy

Dedication

For Momsen,

with all my love.

Acknowledgements

First of all, I would like to thank the two people without whom there would be no thesis and no need for acknowledgements. A million thanks to my supervisors, Dr Daniel Shaw and Prof Klaus Kessler, who have guided and supported me throughout this doctoral roller coaster. Thank you to Dan for giving me room to grow (yes, I'm sure all the mistakes I made along the way have made me a better researcher…), all whilst being unbelievably patient and encouraging. All your support, even in times when you were swamped, did not go unnoticed, thank you! I would also like to thank Klaus for pushing me to be a better researcher, whilst also knowing when to remind me not to be too hard on myself. Thank you for fostering the lab camaraderie, which became home for three years, and letting your hair down with us! I would also like to acknowledge Professor Shamay-Tsoory and the CEITEC researchers who designed and collected the dual-fMRI data.

Of course, I would also like to thank my lab and office fellows for making my time at Aston memorable and who inspired me with their enthusiasm for their research: Clíona Kelly for your care and kindness – often manifested in biscuit form, and the hard truths I needed to hear; Samantha Gregory for being both the Queen of academic and life advice, as well as karaoke; Rachel Green for being one caring, fun ball of (Yorkshire) energy; Ulrike Senftleben for all your support and calming presence; Foyzul Rahman for the jokes and for being vocal about what you believe in, Lynette Looi for the moral support and venting over cake; and Rochelle Hamilton for all your catching positivity when I needed it the most.

I would also like to thank the incredible technicians and radiographers, who were among the first to help me settle in at Aston and from whom I learnt so much: Niteen Mulji, Jake Diggins, Shaheen Lateef and Elisabeth Squire. Participant testing would not have been possible (or as fun!) without you and I always looked forward to our chats in between.

The biggest thanks goes to the four people I love the most. Mom, words cannot express my gratitude for everything you've done and do for me. You taught me about kindness, grace, perseverance and *joie de vivre* through your actions. You inspire me every day and who would have thought my little Yorkshire adventure to walk in your shoes would lead to this! Dad, thank you for inspiring me to immerse myself in the study of something I love and for our last trip home. I'm grateful for the stories and memories you shared, which gave me roots to embark on this PhD journey. Melissa, I probably haven't and probably could never thank you enough for all that you do – thank you for all the lockdown check-ins, inside jokes, memes, side eyes, and midnight until 6 am strolls down memory lane. You make everything better and mean the world to me. (Yes, an honourable mention goes to Loki for keeping me sane during lockdown when there was just me, my thesis, and my edits). And finally, I would like to thank my partner, best friend, confidante, travel companion, fellow dreamer, part-time therapist: Julian. Thanks for making me laugh, for your patience and for helping me through the hard times of the PhD and global pandemic. Ten years on, and I love you more than ever.

Table of Contents

Abbreviations

ACC	anterior cingulate cortex
ACS	Action Control Scale
AIC	Akaike's Information Criteria
aMCC	anterior middle cingulate cortex
AmpSum	sum of amplitudes
ANOVA	analysis of variance
ANS	Autonomic Nervous System
AOD	decision-related action orientation
AOF	Action-Orientation after Failure
AQ	Autism Quotient
ASD	Autism Spectrum Disorder
BAPQ	Broad Autism Phenotype Questionnaire
BBR	boundary-based registration
bDCM	behavioural dynamic causal modelling
BOLD	blood-oxygen level dependent
BVAQ	Bermond-Vorst Alexithymia Questionnaire
COPE	contrast of parameter estimate
DCM	dynamic causal modelling
DERS	Difficulties in Emotion Regulation Scale
dlPFC	dorsolateral prefrontal cortex
dmPFC	dorsomedial prefrontal cortex
DOF	degrees of freedom
dual-fMRI	dual functional magnetic resonance imaging
EC	empathic concern (IRI subscale)
EDA	electrodermal activity
EEG	electroencephalography
ER	emotion regulation
Ext. Viewing	extended viewing
FDR	False Discovery Rate
FEAT	FMRI Expert Analysis Tool
FILM	FMRIB's Improved Linear Model
FLIRT	FMRIB's Linear Image Registration Tool
fMRI	functional magnetic resonance imaging
FMRIB	Functional Magnetic Resonance Imaging of the Brain

FS	fantasy (IRI subscale)
FSL	FMRIB Software Library
FWER	family-wise error rate
FWHM	full-width half-maximum
GLM	general linear model
hDCM	hyperscanning dynamic causal modelling
IAPS	International Affective Picture System
IFG	inferior frontal gyrus
Inter	inter-personal (condition)
Inter_{ER}	intra-personal emotion regulation (condition)
$\text{Inter}_{\text{Frame}}$	inter-personal Frame (condition)
Intra	intra-personal (condition)
Intra_{ER}	intra-personal emotion regulation (condition)
IPANAT	Implicit Positive and Negative Affect Test
IPG	inferior parietal gyrus
IRI	Interpersonal Reactivity Index
LMM	Linear Mixed Modelling
LOC	lateral occipital cortex
MCFLIRT	Motion Correction using FMRIB's Linear Image Registration Tool
MELODIC	Multivariate Exploratory Linear Optimized Decomposition into Independent Components
MFG	middle frontal gyrus
MNI	Montreal Neurological Institute
MRI	magnetic resonance imaging
MTG	middle temporal gyrus
MVPA	multi-voxel pattern analysis
NA	negative affect
nSCR	number of skin conductance responses (SCRs)
OFC	orbitofrontal cortex
PA	positive affect
PCC	posterior cingulate cortex
PD	personal distress (IRI subscale)
PerfR	Regulator performance
PerfT	Target performance
PFC	prefrontal cortex
PNS	Parasympathetic Nervous System

pre-SMA	pre-supplementary motor area
PT	perspective taking
ROI	region-of-interest
SAM	Self-Assessment Manikin
SCR	skin conductance response
SFG	superior frontal gyrus
SMA	supplementary motor area
SNS	Sympathetic Nervous System
SOCK	Spatially Organised Component Klassifikator
SRC	Social Regulatory Cycle
STG	superior temporal gyrus
T	Tesla
T1	longitudinal relaxation time
TMS	transcranial magnetic stimulation
ToM	Theory of Mind
TPJ	temporoparietal junction
TR	repetition time
UCLA	University of California Los Angeles
vlPFC	ventrolateral prefrontal cortex
vlPFC	ventrolateral prefrontal cortex

List of Tables

List of Figures

Chapter 1: Exploring Inter-Personal Emotion Regulation

The work presented in this thesis centres around emotion regulation. Emotions are a somewhat elusive psychological construct, however, and must be defined before we can consider how they are regulated. The first half of this introductory chapter therefore presents a working definition of emotions that will be used throughout this thesis – one that aligns with the emotion regulation frameworks that guided the empirical work to follow.

Emotions are a somewhat ambiguous psychological construct, as can be seen in the different conceptualisations emerging from various schools of thought. 'Affect' refers to internal representations of someone's experiences, which are often used synonymously with the term 'emotion', as they can be defined using two dimensions of the Affective Circumplex: hedonic valence and arousal (Barrett & Bliss-Moreau, 2009). Hedonic valence refers to the degree to which a stimulus is experienced as pleasant or unpleasant, whereas arousal describes the level of engagement with, attention to, and physiological response to a stimulus (Barrett & Russell, 1999). These two dimensions are represented on orthogonal dimensions in order to capture qualitative and quantitative differences of affective experiences. These affective experiences can be classified further into moods, emotions and feelings. Moods are diffuse affective experiences which commonly last for long periods of times, generally do not have a clear trigger and which can be experienced vaguely as negative or positive affectivity, without distinct categorisations (Kaufmann, Agalawatta, Bell, & S Malhi, 2020). Unlike emotions, moods exhibit very poor affective granularity; i.e. poor specificity for affective experience (Smidt & Suvak, 2015). Whilst we might be able to distinguish between negative emotions, such as disappointment and desperation, moods would be experienced diffusely as negative or positive. In addition to valence and arousal, the dimension of time is often used to distinguish between moods and emotions; with moods generally lasting up to a few hours or days, whereas emotions are thought to last for seconds or minutes (Kaufmann et al., 2020). Feelings resemble closely our lay understanding of emotions and the two terms are often used interchangeably, although feelings refer exclusively to subjective experiences and are often used within phenomenological contexts (Barrett, 2006; Ratcliffe, 2005). Thus, feelings are one aspect of the multi-facetted construct of emotions, which for instance also include physiological changes (Scherer, 2005). Quantitative psychological domains, which often focus on physiological emotional responses often use the term 'emotion' instead of feelings to highlight the multi-facetted nature of this affective experience (Craig, 2002). Due to the multi-dimensional conceptualisation of emotions, different aspects of the construct are accessible with distinctly different methods, which will be discussed in chapter 2. Key definitions of emotions are provided below.

1.1. Emotions

Affective researchers often disagree on what exactly an emotion is, and often rely on determining what an emotion is *not* in order to conceptualise the construct in question (Gross & Feldman Barrett, 2011). Emotion theories can be categorised based on some key assumptions. However, it is not uncommon for researchers to diverge on some criteria within each group of theories. Despite this diversity, fundamental frameworks can be identified: basic emotion theories, constructionist theories, and appraisal theories. When the various approaches conceptualise emotions, they often discuss valence and arousal as two key components of emotions, which is described in the circumplex model of affect (Posner, Russell, & Peterson, 2005; Russell, 1980). Valence describes the evaluation of how positive or negative the stimulus is. Whereas physiological arousal describes the activation of the autonomic nervous system in response to both internal and external stimuli, such as increases in heart rate or the dilation of pupils, which allows the individual to respond to these internal or external stimuli.

1.1.1. Basic Emotion Theories

Theorists in support of basic emotions once assumed there to be universal and distinct emotion categories, such as happiness, anger or fear, which can be observed across various cultures (Ekman, 1992b), and each category is assumed to have a distinct physiological response pattern (Ekman, 1992a). Stephens, Christie, and Friedman (2010) measured various physiological responses from 27 female participants, which included heart rate variability and electrodermal activity in response to emotion-eliciting films and music. The researchers were able to correctly identify the emotion category using principle component analyses with an accuracy of 44.6%, which was regarded as support for the existence of distinct physiological signatures of basic emotions. Other studies have also reported some success in classifying patterns of physiological responses to distinct emotions, which suggests that identifying physiological representations of basic emotions might currently be limited due to our current methodological repertoire rather than an absence of their existence (Scarantino & Griffiths, 2011). A machine learning study by Jang et al. (2013) used 27 features to demonstrate how particularly machine learning algorithms of Linear Discriminant Analysis were able to identify the common yet not basic emotions of boredom, pain, and surprise with a mean accuracy of 74.93% across the three emotion categories in a sample of 227 young adults. Features included emotion category-specific systematic variations in electrocardiogram, photoplethysmography, skin temperature and electrodermal activity responses. Contrarily, researchers have reported issues of accurate classification of emotions, due to large intra-individual differences (Picard, Vyzas, & Healey, 2001). For instance, algorithms struggled to correctly classify different instances of ‘anger’ across multiple measurements over a 30-day period, as physiological features can vary vastly within the same emotion category, yet great similarities can be reported between ‘distinct’ emotion categories, e.g. between ‘sadness’ and ‘anger’. These findings were based on electromyogram, blood volume pressure, skin conductivity and respiration data. Picard et al. (2001) assume successful emotion recognition requires low-level pattern recognition of physiological and behavioural features, as well as high-level reasoning of the context (e.g. the individual’s typical responses and the specific characteristics of the given situation. Therefore, it remains to be determined whether basic emotions do in fact exist and can be determined using more sophisticated methodological approaches.

Crucially, proponents of this approach assume certain inputs; i.e. internal or external stimuli, to always result in a particular outcome; i.e. emotion, and that these emotions are always expressed in the same way. For instance, experiences of threat are thought to always result in fear; however, this mechanistic view cannot account for variable responses to threat, such as anger or sadness. Further, Ekman and Friesen’s Facial Action Coding System proposes a set number of facial muscle movements which are combined in various formations to give rise to distinct facial expressions of basic emotions including anger, disgust, and sadness (Hamm, Kohler, Gur, & Verma, 2011), yet findings are often biased by presenting participants with a limited set of pre-selected emotion words which influences their judgements of stimuli presenting facial expressions (Barrett, Lindquist, & Gendron, 2007). Assuming basic emotions present with distinct physiological, behavioural and expressive responses, we can make use of physiological indicators, such as clammy hands, as a sign of increased perspiration when evaluating affective experiences of others. However, this example highlights how without providing a context for this affective reaction, the emotion we attribute to the other person, or indeed ourselves, is difficult to determine. The person might have clammy hands due to negative emotions, such as feeling anxious, or perhaps due to positive emotions of excitement. Basic emotion theorists are often criticised for attempting to classify emotions into neat and distinct categories based on physiological markers alone without considering the given context or each person’s idiosyncratic psychological response patterns (Barrett, Mesquita, Ochsner, & Gross, 2007; Barrett & Russell, 1999). Constructionist approaches in particular criticise basic emotion approaches for being inflexible (Barrett, 2013) and neuroimaging studies, struggling to identify distinct neural representations of basic emotions, raise doubts on the validity of inherent and immutable basic emotions (Clark-Polner, Johnson, & Barrett, 2017).

1.1.2. Appraisal Theories

Many approaches assume appraisals to be involved at some point within the emotion generative process, however, appraisal approaches assume emotions cannot arise at all without appraisals (Ellsworth, 2013; Moors, 2013). According to appraisal theorists, the individual evaluates changes in arousal and valence elicited by internal or external stimuli, using contextual information to make sense of their current experience. Information which is commonly thought to be processed during this appraisal period includes the extent to which the contextual information is relevant to the individual (Scherer, 2005), the extent to which the information is useful in the pursuit of one's current goal (Moors, 2014), the overall positive or negative valence of the event (Barrett & Bliss-Moreau, 2009), as well as how competent one feels in one's ability to manage the situational demands (Smith & Ellsworth, 1985). These theorists argue that different types of appraisals give rise to different emotions and that different appraisals influence the duration and intensity of one's emotional experience (Moors, 2013; Moors, Ellsworth, Scherer, & Frijda, 2013). Similar to constructionist approaches, appraisal theories offer flexible explanations for emotional variation. According to appraisal theorists, individual person-context interactions result in individuals experiencing different emotions in response to the same stimulus: focusing on different aspects of the stimulus or context leads to different appraisals which in turn generate different emotions. Contrarily, the same set of appraisals is thought to always lead to the same emotion. However, when appraisals, which are assumed to be antecedents to people's experiences of anger, were scrutinised, people described different appraisals leading to the same experience of anger (Kuppens, Van Mechelen, Smits, De Boeck, & Ceulemans, 2007).

Appraisal theories have been criticised for the importance they subscribe to cognitive processes in the emotion generative process (Frijda, 1993). As appraisals describe top-down information processing within the individual, they have been challenged in their ability to account for automatic emotional reactions, such as fear responses during acute experiences of threat. For instance, upon hearing a loud noise, a person's physiological arousal might heighten and behaviours of withdrawal from the situation might occur before the person completes the appraisal of the situation. According to appraisal theories, an emotional experience cannot be had without conscious appraisal, thus disregarding such automatic affective responses as emotions. Some appraisal theorists counteract this argument by assuming near-automaticity of the appraisal process (Moors, 2013). However, this raises questions over the extent to which such an automatic, and therefore somewhat deterministic process, can account for individual variation of emotional experiences. Further, the relationship between appraisals and emotions has been challenged, as appraisal theories are sometimes formulated in a circular fashion – some fail to specify whether appraisals are descriptive or causal explanations of emotions (Parkinson, 1997). The lack of clarity regarding whether appraisals are antecedents of emotions or an inherent component of the emotional response, results in a circular conceptualisation of this psychological construct. Thus, although appraisal theories exhibit some conceptual ambiguities that need to be addressed empirically in the future, they offer a little more flexibility in understanding inter-individual differences in emotional responding.

1.1.3. Constructionist Theories

At the centre of constructionist approaches lies their emphasis on the individuality of emotional experiences (Lindquist, 2013). Theorists assume that one's upbringing, previous experiences and the particular context in which the affective experience arises all contribute to the construction of these emotions (Barrett, 2006). Contrary to proponents of basic emotion theories, psychological constructionists emphasise the individual's idiosyncratic contributions towards the generation of emotions (Barrett, 2013). Although Barrett (2009) also contends that common language is used to describe categorical instances of affective experiences, e.g. 'fear', 'anger', 'sadness', they warn that these should not be considered evidence for the existence of basic emotion categories, but rather that these common terms are used to describe different instances of experiences we learn to articulate as 'fear', 'anger', 'sadness' and so on. Moreover, language is thought to primarily reflect the social value of communicating affective experiences with one another, although it might at times distort our understanding of what emotions are – i.e. they are not immutable, fixed categories, but rather flexible, dynamic and context-dependent psychological processes (Lindquist & Gendron, 2013). Crucially, they do not assume deterministic stimulus-response relationships. A particular stimulus, such as the sound of thunder, is not thought to necessarily lead to the same affective reaction across different individuals or contexts, but rather that previous occurrences of thunder and the particular context (e.g., being unsheltered outside versus safe indoors) influence what emotions we experience in any given situation (e.g., fear versus awe).

Interestingly, the importance of language emphasised by constructionist approaches eludes to the idea of emotions being integral to adaptive behaviour and successful social interactions (Lindquist, 2017), which is shared by theorists across disciplines including proponents of basic emotions (Ekman, 1999; Ekman, 2016) and appraisal theorists (Ellsworth, 2013; Moors, 2014). However, socio-constructionist theories go even further by proposing that emotions can *only* be constructed within social interactions (Boiger & Mesquita, 2012). Humans are inherently social and social constructionists assume all of our affective, as well as our cognitive and motivational functioning to have evolved to allow us to interact effectively with one another (Butler, 2017; Parkinson, 2012). Crucially, many social constructionist theorists argue that social contexts are necessary for emotions to be learned, which allows the individual to navigate their predominantly social world (Parkinson & Manstead, 2015). This view is often supported by developmental accounts of affective developments in infants who rely on their caregivers to regulate their emotions for their overall wellbeing (Cole, 2014). It is also argued that our abilities to decipher the emotional experiences of others and communicate our own emotional experiences to others are necessary for survival beyond childhood (Hollenstein, Tighe, & Lougheed, 2017; Vaish, Grossmann, & Woodward, 2008). For instance, the ability to communicate disgust after eating rotten food through one's facial expression can prevent others around us consuming perished foods. In line with this social constructionist view of emotions, emotion regulation across the lifespan can also be regarded as inherently social – children and adults rely on others to regulate their emotions (Carstensen, Fung, & Charles, 2003; Zaki & Williams, 2013), we regulate our emotions to suit the social contexts we find ourselves in (Liddell & Williams, 2019; Tsai, 2007), and our abilities to regulate our emotions effectively has been shown to have social consequences (English & Eldesouky, 2020; Gross, 2002).

1.1.4. The Somatic Marker Hypothesis

The somatic marker hypothesis of emotions (Bechara & Damasio, 2005) has been particularly popular within neuroscience paradigms (LeBlanc, McConnell, & Monteiro, 2015). According to the somatic marker hypothesis, emotions are defined as physiological and neural changes within the body following the perception of an actual or imagined external or internal event. Crucially, this hypothesis claims that changes in physiology (e.g., heart rate, pupil dilation or electrodermal activity), the endocrine system (e.g., the release of cortisol or adrenalin), and neural activations (e.g., engagement of cortical regions associated with the processing of valence and arousal, such as the amygdala, hippocampus or ventromedial prefrontal cortex) constitute body states which *are* the emotion itself (Bechara & Damasio, 2005). A key strength of the somatic marker hypothesis is its emphasis on these bodily representations or embodied cognitions, which avoid making distinctions between the body and mind. Contrarily, other approaches generally struggle to unequivocally define what constitutes the essence of an emotion, i.e. defining a property of the mind (Damasio, 2001). Within the brain, emotional representations are assumed to reside predominantly within the limbic system. The limbic system describes core neural nodes involved in emotional processing, which are primarily composed of subcortical structures, although emotional processing is now known to include cortical regions as well (Catani, Dell'Acqua, & De Schotten, 2013). The system comprises the amygdala, hippocampus, mammillary bodies of the hypothalamus, the thalamus, the ventral striatum, the orbitofrontal cortex and the cingulate. Neocortical regions, often considered as paralimbic regions, have also been discovered to play a crucial role in affective processing and are considered to be a part of the extended limbic system, including the olfactocentric paralimbic regions (i.e. the temporal pole, insula and posterior orbitofrontal cortex), as well as the hippocampocentric paralimbic regions (i.e. the parahippocampal gyrus, retrosplenial area, cingulate gyrus and subcallosal area; (Mesulam, 2000).

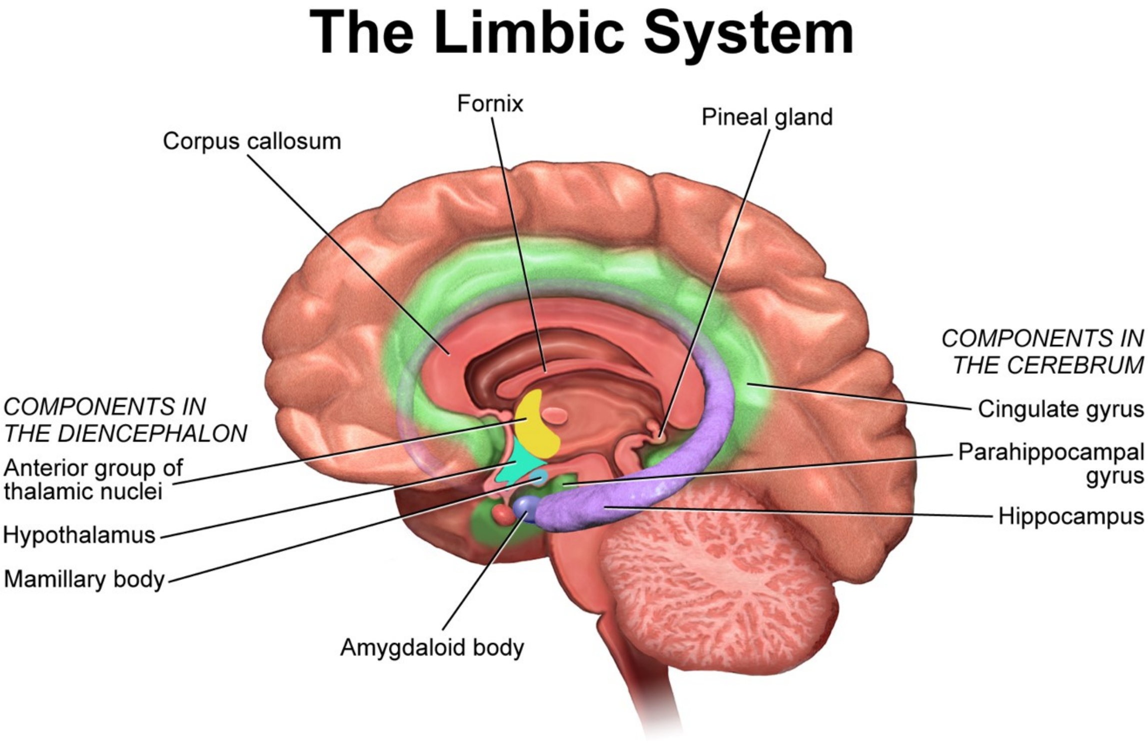


Figure 1.1.
Structures within the limbic system [Retrieved from en.wikipedia.org, Blausen.com staff (2014)].

As most nodes of the limbic system (see Figure 1.1) are found within subcortical regions, researchers initially considered affective processes to constitute primitive psychological functions primarily involved only in affective responses, such as fight-or-flight responses (LeBlanc et al., 2015). An inherent feature of emotional processing is the detection of novelty within one's environment (Weierich, Wright, Negreira, Dickerson, & Barrett, 2010). The amygdala has been associated extensively with both novelty detection in general (Blackford, Buckholtz, Avery, & Zald, 2010), as well as affective processes, such as emotion identification

(Todd & Anderson, 2009), emotion generation and subjective affective experiences (Inman et al., 2020), and emotion regulation (Lee, Heller, Van Reekum, Nelson, & Davidson, 2012; Linhartova et al., 2019). However, emotions not only enable adaptive and flexible responses to our environments (Ekman, 1992b; Gross & Feldman Barrett, 2011; Scarantino & Griffiths, 2011; Smith & Lazarus, 1990), emotion-cognition and emotion-behaviour interactions are also beginning to reveal the crucial influence of emotions on goal-directed and complex behaviours (Bieńkiewicz et al., 2021; Blair et al., 2007). Connectivity studies suggest that different structures within the limbic system form different neural networks, thereby allowing emotional influences on different higher-order cognitions (Catani et al., 2013). The temporo-amygdala-orbitofrontal network is involved in emotion-cognition and emotion-behaviour processing during which bodily representations – i.e. visceral and neural representations of emotion, are integrated to allow for complex cognitive and behavioural responses during decision-making (Garfinkel et al., 2016; Harlé, Chang, van't Wout, & Sanfey, 2012) or for co-ordinating joint actions with others (Bieńkiewicz et al., 2021). Thus, interactions between emotion and higher order cognitions, such as decision-making, have demonstrated the extensive role of emotions in adaptive cognitive and behavioural responding (Adolphs, Tranel, & Damasio, 1998; Bechara & Damasio, 2005).

Current neuroimaging studies are raising further doubts on the appropriateness of harsh distinctions between emotions and cognitions (Duncan & Barrett, 2007; Hoemann & Feldman Barrett, 2019). Moreover, numerous researchers question the clear distinction between emotion and cognition, as complex processes often involve a blend of both (Lindquist & Barrett, 2012), and it is likely that our complex everyday lives generally involve simultaneously occurring emotional and cognitive processing. In particular, neuroimaging studies highlight how brain regions previously associated with emotions, such as the amygdala and the ventral striatum, are engaged during tasks considered to be purely cognitive and brain regions associated with cognition, such as the dorsolateral prefrontal cortex, are often involved in emotional tasks (Blair et al., 2007; Pessoa, 2008). Thus, it can be useful to initially adopt a simplistic view of emotions and cognitions to understand these processes using paradigms with stricter experimental control. However, ecological validity – which includes scrutinising the intricate dynamic relationship between the two constructs, should be sought as our general understanding of each construct improves.

1.1.5. A Working Definition of Emotions

Although the various approaches might disagree on the antecedents of emotions or what they consider the essence of emotions to be, all approaches assume emotions to involve subjective experiences, physiological arousal and behaviour to some degree (Barrett & Bliss-Moreau, 2009; Barrett, Mesquita, et al., 2007; Ekman & Cordaro, 2011; Mesquita, Boiger, & De Leersnyder, 2016). For this thesis, emotions are broadly defined as multi-facetted constructs, which encompass dynamic, iterative processes enabling ever-changing subjective experiences, behavioural and physiological responses (Barrett, 2014; Kappas, 2011). Moreover, emotions are evaluative processes which support resource allocation; e.g. attention, necessary for the individual to detect novel stimuli within their environments (Weierich et al., 2010), and for them to respond to important internal and external stimuli, such as threats (Barrett, 2009). It is thus assumed that emotions allow for quick bottom-up responses to situational demands. Increases in physiological arousal mobilise metabolic and cognitive resources, particularly attention, to guide our interaction with the emotion-eliciting stimulus. Essentially, an individual's chances of survival increase if they can quickly identify and respond to threats within the environment. According to the Modal Model of Emotion (see Figure 1.2), emotions unfold over time via a sequential process during which an event is attended to and appraised in order to initiate an emotional response (Gross, 2015). These emotion-eliciting events can constitute an internal or external stimulus that is novel (Weierich et al., 2010), or of particular personal importance to the regulator (Fernández, Ros, Sánchez-Reolid, Ricarte, & Latorre, 2020), as well as stimuli which influence the probabilities of our survival (Öhman, 2005).

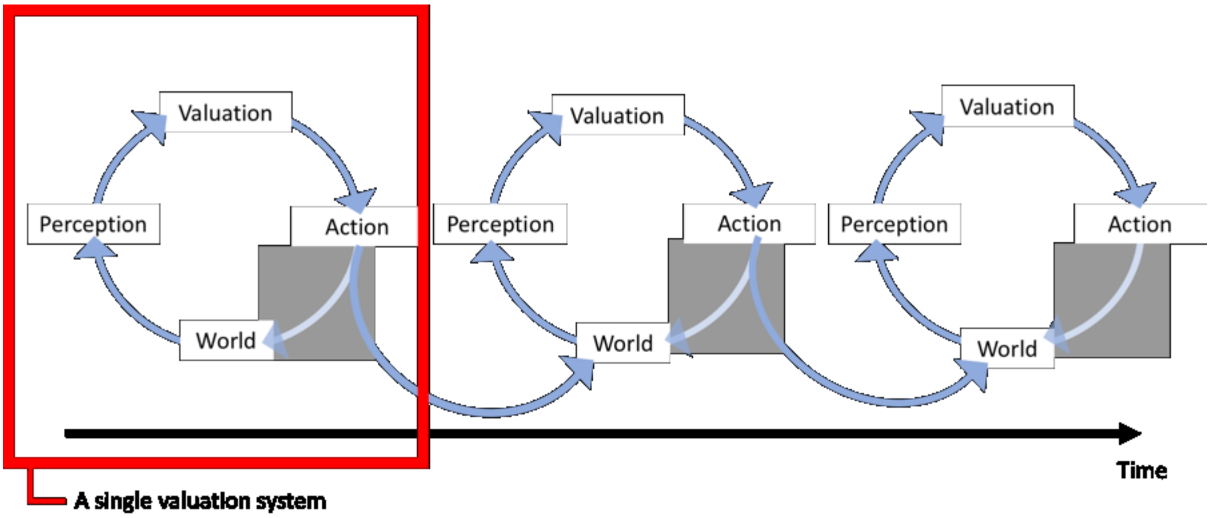


Figure 1.2. Schematic representation of emotions unfolding over time as described in the Modal Model of Emotion (adapted from Gross, 2015). The word 'World' describes internal and external events which are perceived and evaluated in order to initiate approach or withdrawal behaviours, or regulation.

Crucially, according to the Modal Model of Emotion, the emotion generative process is thought to involve cyclic changes in physiology, subjective experience, and/or behaviour which in turn modulate one's internal or external environment, thereby initiating a new appraisal within the emotion generative cycle. Therefore, it is difficult to determine the start and the end of an emotion (Hoemann & Feldman Barrett, 2019; Kappas, 2011). In fact, due to this ever-changing nature of the emotion generation process, emotion generation and regulation can be difficult to distinguish and, in some instances, researchers argue against the strict distinction between the two (Gross & Barrett, 2011; Kappas, 2011). This model is also in line with emotion theories which assume emotions to represent relatively brief, yet constantly changing affective processes (Kaufmann et al., 2020). Thus, this dynamic valuation process is iterated numerous times as we engage with our internal and external worlds, constantly responding to relevant or novel stimuli. Throughout our days, we are likely to experience several of these generative cycles sequentially or even in parallel, because different emotions can be experienced simultaneously as complex, mixed emotions (Grossmann & Ellsworth, 2017). We might also find ourselves in complex situations, e.g. group-settings, in which a different emotional response is elicited by different people.

1.2. Emotion Regulation

Emotions have been shown to guide behaviour (Weiss et al., 2015), as well as influence cognitions such as memory (Dillon, Ritchey, Johnson, & LaBar, 2007) and attention (LeBlanc et al., 2015). Indeed, the amygdala's vast connections to all but eight cortical regions, suggest the amygdala's crucial involvement in numerous perceptive, motor, language and cognitive processes (Pessoa, 2008). However, it is important to note that humans are not at the mercy of their emotions, as it was once assumed (Catani et al., 2013), and that emotion-cognition relationships are bidirectional (Blair et al., 2007). Within the bidirectional emotion-cognition relationship, the amygdala and hippocampus[1], commonly associated with affective processing, have been shown to exhibit more distributed connections to regions associated with cognition than they receive incoming projections from the neocortex, which suggests primacy of emotional over cognitive processing (Damasio, 1994; LeBlanc et al., 2015; Young, Scanneil, Burns, & Blakemore, 1994). Nonetheless, there are numerous ways in which emotions can be modified. People are able to alter their behavioural and cognitive responses in order to exert control on the emotion generative process. Studies on ideal affect look into why people aspire to feel specific emotions in certain contexts. In a study by Tamir and Ford (2012) participants were asked to prepare for an interaction with a tenant to resolve the issue with their unpaid rent. Participants preferred anger-inducing activities, such as listening to music that had been

---

[1] Note: Although the hippocampus is often included within the limbic system, there is extensive research to suggest the hippocampus is also commonly associated with cognition, including visuo-spatial processing and memory (Burgess, Maguire, & O'Keefe, 2002).

rated as angry in a previous pilot experiment, when asked to resolve the matter as quickly as possible within a confrontational condition. However, those participants assigned to a collaborative condition were asked to maintain a good relationship with the client and showed a preference for happy music prior to the interaction with the tenant. Thus, people are capable of regulating their emotions, and even occasionally choosing counter-hedonic emotions, in order to support behaviours congruent with their ultimate goals (Tamir, 2009; Tamir & Ford, 2012).

Emotional intelligence is often considered the ability to experience and recognise emotions, and to regulate our own and other's affective experiences in order to pursue flexible, adaptive goal-directed behaviours, particularly within social settings (Picard et al., 2001). When experiencing a particular emotion, we might behave in certain ways that modulates the emotional experience. For instance, when we feel happy we might share this news with others, which heightens our positive emotions further. Emotion regulation (ER) describes the process of altering the intensity, duration or overall quality of one's affective experience. Therefore, regulating an emotion often results in the generation of a new emotion, which further erodes the aforementioned distinction between emotion generation and regulation (Gross & Barrett, 2011; Thompson, 2011); indeed, one cannot be understood without the other. Various ER processes can be divided further into various forms (Gross, 1998) which include automatic versus controlled, intrinsic versus extrinsic, instructed versus uninstructed, or intra-personal versus inter-personal processes (see Figures 1.3. for a breakdown of ER processes). Effortful and conscious attempts of modulating emotions is considered controlled ER, whereas automatic ER occurs when our emotions change due to contextual factors not influenced by us, e.g. a friend's bad mood or the weather. When we are the target of our own effortful ER attempts, this is considered to be intrinsic ER and regulating someone else's emotions would be considered a form of extrinsic ER. Thus, intrinsic and extrinsic ER are sometimes used as synonyms for intra-personal and inter-personal ER, respectively (Zaki & Williams, 2013). Instructed ER describes the process of regulating emotions following specific guidance that has been given (e.g., telling someone to decrease negative emotions by imaging the upsetting documentary they are seeing is not real). When people are free to choose how they regulate their emotions or how they implement a certain ER strategy, this is considered to be an uninstructed form of ER.

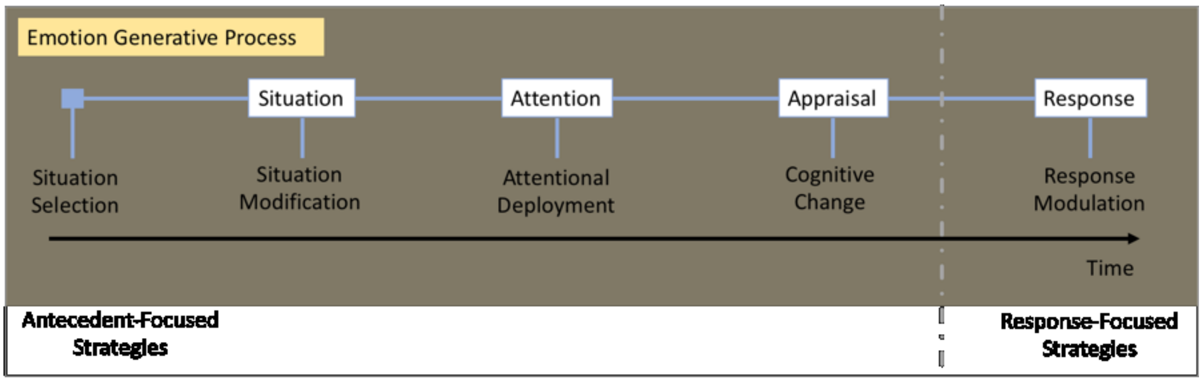


Figure 1.3.
The Process Model of Emotion Regulation (adapted from Gross, 2015) classifies emotion regulation strategies according to which point they interfere with the emotion generative cycle.

1.2.1. The Process Model of Emotion Regulation

Following from the Modal Model of Emotion, the Process Model of Emotion Regulation offers a useful procedural conceptualisation of ER strategies (Gross, 2015). As emotions are thought to unfold over time, the Process Model of Emotion Regulation assumes that ER can occur at any point during the emotion generative cycle. Depending on when ER is attempted, the ER strategy can be classed as either an antecedent- or response-focused ER strategy. Antecedent-focused strategies attempt to modulate the emotion generative process before the emotion has been fully generated. Critically, strategies interfering with early stages of the emotion generative process are thought to be the more effective than attempts to regulate fully generated emotions. Response-focused strategies attempt to modify outward expressions of emotions which have already been fully generated and are thus often referred to as response modulation. Classes of antecedent- and response-focused strategies are presented in Figure 3 and examples of commonly researched and specific strategies are provided in Table 1.1. Different strategies have been shown to have different physiological, psychological and social consequences. Gross (2002) discusses these various consequences dependent on the strategy that the person used. For instance, suppressing one's affective facial response increased physiological responses, such as cardiovascular activity, and was associated with less favourable social evaluations from others. Contrarily, reappraisal was associated with no changes in cardiovascular or electrodermal responses; however, participants reported subjective changes and were judged more favourably by others. Furthermore, poorer memory performance was observed in participants who had just engaged in suppression, whereas reappraisal did not affect memory performance. These findings highlight how the different components of an emotional experience (e.g., physiology and subjective experience) can occasionally diverge from one another (Brown et al., 2019; Dan-Glauser & Gross, 2013; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005).

Table 1.1.
Examples of widely researched ER strategies and a description of what the processes involve.

Strategy	Description
Cognitive Reappraisal	Attempts to actively change one's appraisal of a stimulus to elicit a different emotional experience.
	Example: Someone might tell themselves that what they are seeing is not real.
Disengagement	Disengagement is sometimes referred to as distraction and describes diverting one's attention from the emotion-eliciting stimulus, e.g. by thinking about something else or focusing on less emotion-eliciting aspects of the stimulus.
	Example: Whilst viewing a violent film, someone might focus their attention on the scenery in the background.
Expressive Suppression	Hiding current emotions by exhibiting neutral facial expressions.
	Example: Someone might keep a neutral expression, although they are feeling upset.
Rumination	Re-imagining the emotion-eliciting stimulus over and over again, to re-live and even heighten the emotional experience.
	Example: An athlete heightening feelings of euphoria by imagining over and over again how they felt when they won a medal.

1.2.2. Adaptive ER

It is also vital to note that ER strategies considered to be inherently adaptive are not always the most effective regulatory approach, and some strategies which are commonly regarded as maladaptive strategies have been found to be useful in certain contexts. When asked to prepare to defend one's own interests during an interaction with someone with conflicting goals, people prefer to up-regulate feelings of anger, which is generally regarded as a 'bad' emotion (Ford & Tamir, 2012). Thus, someone might choose to focus on an anger-inducing stimulus, such as an angry memory, and use rumination to heighten current emotional responses, although rumination is often considered to be maladaptive (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Kashdan & Rottenberg, 2010). Furthermore, unlike distraction, reappraisal requires some processing of the emotion-eliciting stimulus and therefore utilises more cognitive resources, such as attention and working memory (Strauss, Ossenfort, & Whearty, 2016). When cognitive resources need to be reserved for other important tasks, cognitive reappraisal, which is generally considered to be an adaptive strategy, might become cost-ineffective. Therefore, it appears that the ability to flexibly select and implement a strategy which is congruent to one's goal and appropriate for one's current situation is what determines whether a strategy is adaptive or not (Bonanno & Burton, 2013; Tamir, 2009). For instance, when people are asked to decrease their emotional responses to mildly arousing negative images, people prefer to reappraise, however, disengagement is preferred for highly arousing negative images (Shafir & Sheppes, 2020; Sheppes et al., 2014). Indeed, rigid emotion regulatory patterns that disregard the current goal or context are associated with greater prevalence rates of psychopathologies (Levy-Gigi et al., 2016; Lougheed & Hollenstein, 2012), even when participants possess a large repertoire of regulation strategies to choose from (Dixon-Gordon, Aldao, & De Los Reyes, 2015).

Regulating our emotions effectively does not only have consequences for the person engaging in regulation. Numerous studies on expressive suppression have demonstrated individual and social consequences of strategy use: It has been shown to have detrimental consequences for the individual, such as a poorer recollection of memories (Richards & Gross, 2000); however, most of the deleterious consequences concern its effect on social relationships. People who habitually suppress expressing their emotions were found to be less likely to share both positive or negative emotions with others, less likely to report using or having access to social support, and they were rated as less likeable by others (Gross & John, 2002). This suggests that habitually suppressing one's emotional response interferes with healthy social functioning (Gross, 2002). As detailed in previous sections above, within social contexts, emotions have signalling properties that help us make important evaluations about our environment (Öhman, 2005), and help us infer about the inner worlds of others (Jospe, Flöel, & Lavidor, 2018). Emotional expressions also allow for the bidirectional communication of important information within interactions (Chervonsky & Hunt, 2017). When someone we interact with habitually suppresses their emotional experiences, the other person can struggle to assess person characteristics about that person, including the degree to which they can be considered to be trustworthy or whether the other is pursuing competitive or collaborative goals. Expressive suppression has also been associated with reduced conflict resolution within couples and less relationship satisfaction (Thomson, Overall, Cameron, & Low, 2018). Another study by Tackman and Srivastava (2016) instructed participants to watch videos of an actor's face supposedly reacting to a film they were watching. The actor either expressed or suppressed amusement or sadness. Participants rated the actor who suppressed their emotions as more anxious and avoidant, and less extraverted and agreeable than emotionally expressive actors. Participants were also less interested in becoming acquainted with the actors who suppressed their emotional experiences, particularly when they suppressed positive emotions, e.g., amusement. Thus, expressive suppression does not only have detrimental effects on sustaining existing relationships, but it can interfere with the formation of new ones. Moreover, in a study by Butler et al. (2003), female dyads were tasked with viewing an upsetting war film prior to discussing the documentary with one another. Both the woman suppressing their emotional reactions and the other woman they interacted with exhibited heightened blood pressure in comparison with dyads in which one person was either asked to respond naturally or to reappraise their emotional response. These findings emphasise detrimental effects on social relationships and increased stress responses when affective signals are not communicated effectively during interactions with others.

1.3. Inter-Personal Emotion Regulation

Inter-personal ER has long been associated with children within the developmental psychology literature (Campos, Campos, & Barrett, 1989; López-Pérez & Pacella, 2019; Pacella & López-Pérez, 2018), however, the shift towards examining inter-personal ER in adults highlights the extent to which even in adulthood a lot of our ER attempts are influenced by others and the social context (Tamir, 2011; Zaki, 2020; Zaki & Williams, 2013). Moreover, until recently, ER research predominantly focused on intra-personal ER, however, researchers within the field are beginning to acknowledge the importance of social contexts and inter-personal ER processes in understanding real-life ER. Effective ER and socio-cognitive functioning is required for good physical and mental health, and difficulties in either domain is often associated with decreased functioning in the other domain (Beaudreau & O'Hara, 2008; Couette, Mouchabac, Bourla, Nuss, & Ferreri, 2020; Ladegaard, Larsen, Videbech, & Lysaker, 2014; Stevens & Jovanovic, 2019). Indeed, there are studies which suggest that social interactions offer protective properties against the influence of aversive stimuli. For instance, students asked to either hold a stress ball or the hand of another person, demonstrated poorer memory for negative but not positive information a week after testing (Flores Jr & Berenbaum, 2017). Thus, there may be processes which interfere with the consolidation of usually salient negative stimuli into long-term memory when we are surrounded by others (Norris, 2021). Social interactions might help dampen the effects of traumatic events and understanding the mechanisms underlying this social protective process can help harness these qualities in clinical interventions.

According to Social Baseline Theory (Beckes & Coan, 2011), the social presence of (close) others decreases physiological responses, such as cardiovascular activity; reduces the release of stress hormones, and diminishes neural activity associated with threat responses. Conversely, isolation and social rejection are associated with the opposite physiological activations resembling heightened stress responses. Importantly, as the name suggest, the Social Baseline Theory assumes a social context to be the baseline for human systems, such as the autonomic nervous system and the brain. Thus, when people are surrounded by others, their physiological and neural responses essentially resemble reduced activation patterns indicative of states of rest. This is supported by findings showing reduced physiological arousal in couples when they were in close proximity with their partners (Han et al., 2021), although these regulatory effects appear to be accompanied by decreased activation within emotion regulatory regions, such as the ventromedial prefrontal cortex (Beckes, Medina-DeVilliers, & Coan, 2021). Beckes and Coan (2011) assume the presence of others allows the individual to return to baseline, i.e. a state of rest, without relying exclusively on cognitively demanding top-down regulation of emotions, as is the case when we regulate our emotions independently. The authors go further to argue that the mechanisms underlying the beneficial effects of inter-personal ER might in fact not constitute goal-directed regulation per se, but rather that they represent a semi-automatic return to baseline rest.

The literature on ageing has also shed intriguing insights into the influence of social factors on affective processing. Older adults have been shown to exhibit a positivity bias (Barber, Opitz, Martins, Sakaki, & Mather, 2016) and report experiencing fewer negative emotions than younger adults (Charles, Reynolds, & Gatz, 2001). According to the socioemotional selectivity theory, older adults' awareness of their own mortality results in the re-organisation of their social circles (Carstensen et al., 2003). In a study by Lang, Staudinger, and Carstensen (1998), older adults were seen to have stronger emotional ties to each member of their smaller social circle. Contrarily, younger adults were likely to have bigger social circles with more acquaintances who provided less emotional support. The authors suggest that with increasing age, cultivating an emotionally supportive network of close others occurs when older adults focus on their emotional well-being (Liao & Carstensen, 2018).

1.3.1. The Role of Empathy and Embodiment

A personal characteristic that is likely to influence our abilities to successfully implement inter-personal ER is our ability to relate to others, i.e. empathy (Shamay-Tsoory, 2011). Empathy is often divided into cognitive empathy; sometimes referred to as Theory of Mind, and affective empathy (Schurz et al., 2021; Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). On the one hand, cognitive empathy describes our abilities to take on the other's perspective, understand what others are thinking and know that the beliefs that we hold of the world might differ from those held by others. On the other hand, affective empathy describes the ability to vicariously experience or simulate the other person's emotional experience. This distinction between cognitive and affective empathy is supported by studies with clinical populations demonstrating a double dissociation between the two. For instance, people with alexithymia display intact cognitive empathy, yet they exhibit poor affective empathy (Goerlich, 2018). Similarly, people with psychopathic personality disorder show diminished affective empathy despite typical cognitive empathy (Blair, 2005). The distinction between the two forms of empathy has been supported further by recent neuroimaging studies, highlighting the distinct neural networks engaged during tasks reliant purely on either cognitive *or* affective empathy (Schurz et al., 2021). Due to the inherently inter-personal nature of empathy, it is crucial to determine whether the ability to implement intrinsic inter-personal ER or to provide extrinsic inter-personal ER is dependent on our abilities to take on another's perspective or to simulate another person's affective experience.

Assuming that the observation of another person's affective experience elicits an affective experience within the observer, there are different affective responses the observer might have. The aforementioned argument for embodiment, assumes an affective empathic response in which the observer vicariously experiences the other person's emotions as their own (Jospe et al., 2018). However, people respond differently when seeing someone in distress and different categorisations have been proposed. An egocentric stress response following observing someone else's pain is often referred to as 'personal distress' and differs from an affective empathic (i.e. other-directed) response to the other's experience (López-Pérez, Carrera, Ambrona, & Oceja, 2014). Rather than experiencing the other's pain as one's own, one feels personally inflicted by the other's struggles. It is also possible to experience concern or sympathy for the other person in pain, rather than vicariously experiencing their pain – this is often described as 'empathic concern' (Lebowitz & Dovidio, 2015).

The mirror-neuron system is thought to support the mirroring of the other person's behaviours or emotions vie embodiment processes, which might allow us to understand their intentions and provide insights into their inner worlds, in order to predict their responses during social interactions (Hasson & Frith, 2016; Wilson-Mendenhall, 2017). Although mirror neurons have been identified in humans, it is important to note that the evidence is inconsistent and that human neuroimaging paradigms rarely involve investigations at the single-neuron level (Lamm & Majdandžić, 2015). Methodological constraints often hinder our ability to discern (1) whether these representational similarities between the observer and the observed reflect the same psychological process occurring, or (2) whether this similarity is somewhat biased by indirect measurements and averaging across multiple neurons (Lamm & Majdandžić, 2015). Multi-voxel pattern analysis (MVPA) describes the use of algorithms to classify patterns of neural activations to identify how information is represented within the brain across various voxels rather than individual voxels, as is typical for univariate neuroimaging analyses (Norman, Polyn, Detre, & Haxby, 2006). MVPA has provided one possibility to counteract some issues with multiple comparisons and thereby increase the power to detect signals within noisy neuroimaging data. Within empathy research, an MVPA study revealed that neural representations associated with imagining another person's bodily sensations and emotion-related actions resembled and could therefore be decoded using the participant's neural representations of their own bodily sensations and emotion-related actions (Oosterwijk, Snoek, Rotteveel, Barrett, & Scholte, 2017). This finding offers some support that we engage in a process of embodiment in order to empathise with the other person (Jospe et al., 2018).

1.4. Conceptualising Inter-Personal Emotion Regulation

Zaki & Williams (2013) proposed a conceptual framework for inter-personal ER. This framework is presented in Table 1.2. and highlights the key difficulties in examining dynamic interactions between two people. Inter-personal ER can be compromised if the individual who is attempting to regulate another's emotions (referred to herein as "Regulator" and "Target", respectively) is unable to identify when to commence and terminate regulation (Urry, 2009), choose an appropriate regulation strategy (Sheppes & Levin, 2013), assess the efficacy of this strategy and flexibly switch to a different strategy if needed (Niven, 2017). However, even an efficient Regulator's attempts may be affected by the Target's inability to implement the strategies, or if the Target refuses to regulate their emotions in the direction suggested by the Regulator. For instance, an angry person might not listen to guidance from those around them trying to calm them down. Thus, Regulator's intentions for ER and conflicting ER goals between the Regulator and Target can lead to unsuccessful inter-personal ER (Niven, Henkel, & Hanratty, 2019; Niven, Troth, & Holman, 2019).

Table 1.2.
Different Forms of Intra- and Inter-personal ER.

	Intra-personal		Inter-personal	
Intrinsic	The process of self-regulating one's own emotions.		The process of seeking another person to regulate one's emotions.	
	Implicit regulation occurs without the pursuit of explicit goals and might occur through habitual routines, e.g. including things in our daily routine that we enjoy and pursuing these automatically out of habit.	**Explicit regulation** requires someone to actively pursue the goal of up- or down-regulating their own current emotions, e.g. completing some breathing exercises when anxious.	**Implicit regulation** occurs when Targets are not pursuing a specific regulatory goal, but benefit from the presence of another person, e.g. a Target feeling better after spending time with their partner.	**Explicit regulation** is elicited by the Target who approaches the Regulator to up- or down-regulate the Target's emotions, e.g. attending an anger management class guided by a facilitator.
Extrinsic	-		The process of regulating someone else's emotions.	
	-	-	**Implicit regulation** can occur when either the Regulator and/or	**Explicit regulation** requires the Regulator to pursue a specific

			the Target are not actively pursuing specific regulatory goals to change the Target's emotions, e.g. attending a fitness class where the facilitator-guided physical exertion distracts the group from whatever they were worrying about.	regulatory goal for the Target – with or without the Target's awareness, e.g. asking the Target to join you for a walk to remove them from a stressful situation.

Although personal characteristics of the Regulator and the Target are crucial to the success of the inter-personal ER attempt (e.g., how close they feel to one another, or how effective the Regulator is in guiding the Targets' regulation), there are other factors which are likely to affect the regulatory process (see Figure 1.4. for factors which can influence each interactant or the dynamic between the two interactants). Inter-personal ER might also be impacted by situational determinants which have been found to influence intra-personal ER, such as displays of situation-incongruent affect (Greenaway & Kalokerinos, 2017), e.g. smiling and laughing at a funeral, or social stress (Jiang, Moreno, & Ng, 2022) – i.e. one's current experiences of stress in regards to relationships, school or work, and one's health. Importantly, these factors might affect one or both interactants directly, or they might exert an indirect influence by modulating the dynamic interactive process between interactants. Further complexities of inter-personal interactions are revealed when factors modulating dyadic interactions are considered (see Figure 4). An example of an individual response to different people crying can illustrate how various factors can influence inter-personal ER; when it is the person's young child crying, it might hurt them to see their child upset and they know how to and might therefore try to cheer up their child, whereas seeing their colleague crying at the office might make them feel uncomfortable and unsure of how to behave towards the other person (Clark & Finkel, 2005; Liu, Strube, & Thompson, 2021). Upon observing a stranger cry on the train, their behavioural response towards the other person is likely to be dependent on the context, e.g. are there other people there; the crying stranger's personal characteristic, such as whether this is a distressed young person or whether the person is male or female (Visser & Roelofs, 2011); or the crying stranger's response to the them (Dixon-Gordon, Bernecker, & Christensen, 2015).

Moreover, the efficacy of inter-personal ER has also been shown to be susceptible to modulation by the social proximity between the Regulator and Target. Emotion regulation between close dyads, such as mothers and daughters (Lougheed & Hollenstein, 2016; Lougheed, Koval, & Hollenstein, 2016) or couples (Coan et al., 2017; Levy-Gigi & Shamay-

Tsoory, 2017), and friends (Morawetz, Berboth, & Bode, 2021) has been shown to be highly effective, perhaps suggesting greater benefits of inter-personal ER over regulating our emotions ourselves. These differences in efficacy between inter- and intra-personal ER will be explored within this thesis. However, neural and physiological processes supporting the benefits of inter-personal ER and the mechanisms underlying this beneficial effect of inter- over intra-personal ER are not yet understood. Some faciliatory advantages of the mere presence of the (close) other being present, e.g., via social buffering might contribute towards the superiority of inter- over intra-personal ER (Beckes & Coan, 2011; Mulej Bratec et al., 2020). Nonetheless, findings suggest that these social advantages might be reduced slightly in dyads consisting of two strangers. Participants asked to regulate their emotions in the presence of a stranger compared with a trusted friend displayed amygdalar activations which were associated with fear, stress or threat processing (Morawetz et al., 2021), as well as increased physiological reactions akin to stress responses (Coan et al., 2017).

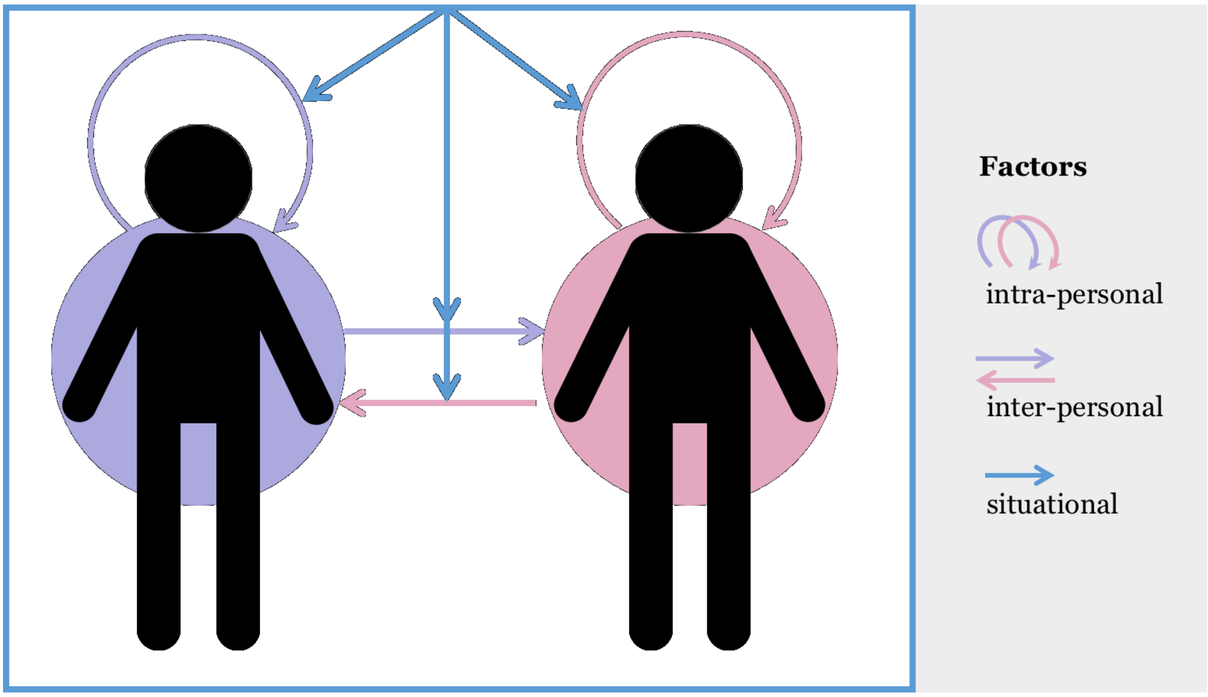
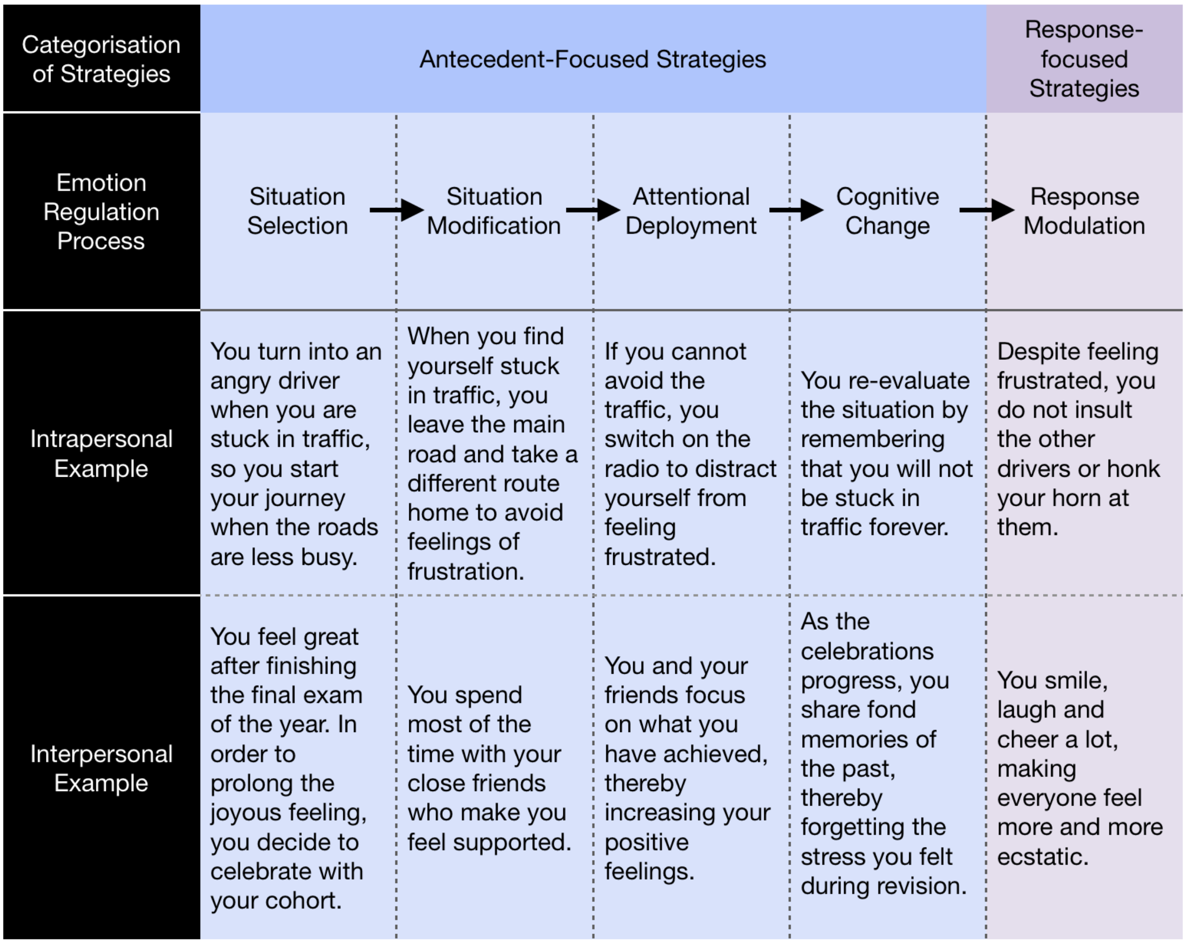


Figure 1.4.
Person- and Situation-Specific Influences on Dyadic Interactions.

Recently, there has been increased interest in inter-personal ER, as researchers acknowledge that most ER occurs within or due to our social surroundings. Although inter-personal ER was often restricted to developmental contexts, the consensus appeared to be that regulation was taught through emotion socialisation, with caregivers guiding the child's ER process, children emulating ER approaches they observe in those around them, and affective values to different behaviours and stimuli being communicated from parents to children (Kiel & Kalomiris, 2015). Interestingly, investigating adult inter-personal ER is beginning to gain more and more interest. For instance, couples have been seen to engage in joint ER, such as co-reappraisal. Couples engaging in co-reappraisal were less likely to exhibit adjustment difficulties, such as rumination, following a stressful event, whereas couples that engaged in co-brooding, i.e. joint rumination, often exhibited depressive symptoms and repetitive negative thoughts (Horn & Maercker, 2016). Married women undergoing functional magnetic resonance imaging (fMRI) scanning whilst either holding the hands of their husbands or the hand of a stranger when exposed to threats of electric stimulation, displayed attenuated neural response patterns to threat when holding their husband's hands (Coan, Schaefer, & Davidson, 2006). However, when holding the hand of the stranger, these women displayed greater amygdala responses akin to threat responses, which the authors assumed was due to not only the threat of electric shocks, but also the stranger being perceived as a threat. Nonetheless, it is important to note, that holding the hands of both stranger and husband was associated with lower amygdala activation compared with the women regulating alone. Another recent fMRI study offered further support for inter-personal effects being modulated by the closeness of the interactants. Participants asked to regulate their emotions with the help of a close friend or a stranger showed differential neural activation patterns during these two inter-personal ER conditions (Morawetz et al., 2021). Increased amygdala activation for strangers relative to friends was also regarded as participants perceiving the stranger as a stressor. Thus, these studies on social proximity offer some evidence to suggest factors beyond individual differences which have been shown to influence intra-personal ER, are likely to affect the efficacy of inter-personal ER.

1.4.1. The Process of Inter-Personal Emotion Regulation?



Categorisation of Strategies	Antecedent-Focused Strategies				Response-focused Strategies
Emotion Regulation Process	Situation Selection	Situation Modification	Attentional Deployment	Cognitive Change	Response Modulation
Intrapersonal Example	You turn into an angry driver when you are stuck in traffic, so you start your journey when the roads are less busy.	When you find yourself stuck in traffic, you leave the main road and take a different route home to avoid feelings of frustration.	If you cannot avoid the traffic, you switch on the radio to distract yourself from feeling frustrated.	You re-evaluate the situation by remembering that you will not be stuck in traffic forever.	Despite feeling frustrated, you do not insult the other drivers or honk your horn at them.
Interpersonal Example	You feel great after finishing the final exam of the year. In order to prolong the joyous feeling, you decide to celebrate with your cohort.	You spend most of the time with your close friends who make you feel supported.	You and your friends focus on what you have achieved, thereby increasing your positive feelings.	As the celebrations progress, you share fond memories of the past, thereby forgetting the stress you felt during revision.	You smile, laugh and cheer a lot, making everyone feel more and more ecstatic.

Figure 1.5.
Schematic Representation of the Emotion Regulation Process for Inter- and Intra-personal ER. *Note*: The emotion regulation processes are ordered according to the stage within the emotion generative process, that they would interfere with.

The aforementioned studies can be regarded as precursors for inter-personal ER studies as they examined inter-personal processes which are closely aligned with ER, but cannot be classed as effortful, and goal-directed ER (see Figure 1.5. for examples of effortful inter- and intra-personal ER). Some of these allied processes include emotional contagion and social buffering. Emotional contagion describes the automatic transference of an emotional experience from one person to another directly or via virtual platforms (Kramer, Guillory, & Hancock, 2014). It is believed that by simply observing someone's affective expressions that the observer can elicit the same physiological and subjective experiences (Dezecache, Jacob, & Grezes, 2015). However, the propensity for contagion is limited by various factors, such as the relationship between the interactants, or the emotion which is displayed – for instance displays of anger can elicit fear rather than anger in the observer (Wróbel & Imbir, 2019).

Social buffering describes the process of physiological responses, such as stress responses, being reduced by the mere presence of others (Gunnar & Hostinar, 2015). Social buffering has been reported to successfully reduce self-reported negative affect, which was associated with decreased neural activation within emotion generative regions, including the amygdala and the thalamus, and interestingly, reductions in emotion regulatory prefrontal cortices, such as the dorsolateral prefrontal cortex were also observed (Mulej Bratec et al., 2020). However, according to the Social Baseline Theory it has been argued that inter-personal ER does not necessarily require executive control functions of the prefrontal cortices to exert its regulatory effects (Beckes & Coan, 2011). Furthermore, social buffering is modulated by the relational closeness of the interactants. When participants were exposed to threats of painful stimulation, physiological stress responses were attenuated when they held the hand of their partner, however, the stress response was more pronounced when holding the hand of a stranger (Coan et al., 2017). Thus, dependent on the relational proximity, the presence of others can be sufficient to regulate one's affective experiences, even when no active, goal-directed and effortful attempt is made to modulate the affective experience directly. Crucially, although these studies and allied phenomena might offer some insights into the mechanisms underlying the efficacy of inter-personal ER, studies examining effortful ER attempts are needed to better understand top-down inter-personal ER.

1.5. The Present Study

Considering that most – if not all – ER occurs within social settings, the question arises as to whether inter- or intra-personal ER is more effective. Only a few researchers have examined both inter- and intra-personal ER within the same study. When couples were asked to decrease their emotional reactions to negatively valenced images, participants rated the images as less negative following ER guided by their partners compared with intra-personal ER attempts (Levy-Gigi & Shamay-Tsoory, 2017). Similarly, daughters guided by their mothers during inter-personal ER reported improved regulatory success during inter-personal ER compared with intra-personal ER (Lougheed et al., 2016). These rating responses offer preliminary evidence that inter-personal ER might in fact be more effective than intra-personal ER. However, it is unclear whether this beneficial effect of inter-personal ER also extends to other dimensions of the affective experience, such as physiological or even neural responses, which will be examined in this thesis. Moreover, this thesis probes whether different mechanisms underlie inter- and intra-personal ER (e.g., social buffering and cognitive control), and which factors might influence the efficacy of inter-personal ER (e.g., empathy).

Therefore, this thesis aims to better understand inter-personal ER by assessing the degree to which subjective and physiological differences between inter- and intra-personal ER account for the differences in efficacy previously reported between the two types of ER. Importantly, the thesis focuses on instructed ER, as this allows for greater experimental control and offers a foundation from which more naturalistic studies can examine the efficacy of inter-personal ER as it arises in everyday life. Further, findings from the wealth of studies on intra-personal ER will be used to compare intra- and inter-personal ER. This first chapter offered a general overview of emotions and our current understanding of ER in order to situate the following empirical investigations within the emerging field of inter-personal ER. Chapter 2 discusses the Methods which were employed to investigate inter-personal ER: it describes the choices of the visual stimuli and ER strategies, the inter-personal ER task structure and the various conditions, as well as the challenges of effective measurement of affective changes. The first empirical assessment of inter-personal ER is presented in Chapter 3. Electrodermal activity (EDA) measures were used to determine whether differences in efficacy between intrinsic inter- and intra-personal ER are evident not only in subjective self-ratings, but also using objective physiological measures. Physiological underpinnings of differences between inter- and intra-personal ER are scrutinised further by focusing on their neural underpinnings in Chapter 4. The second-person paradigm described within this chapter allowed for the exploration of (intrinsic) intra-personal ER, as well as intrinsic and extrinsic inter-personal ER in the person regulating their emotions (Targets) and those guiding the other person's ER efforts (Regulators), respectively. A general discussion is presented in Chapter 5.

References

Adolphs, R., Tranel, D., & Damasio, A. R. (1998). The human amygdala in social judgment. *Nature, 393*(6684), 470-474.

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review, 30*(2), 217-237. doi:10.1016/j.cpr.2009.11.004

Barber, S. J., Opitz, P. C., Martins, B., Sakaki, M., & Mather, M. (2016). Thinking about a limited future enhances the positivity of younger and older adults' recall: Support for socioemotional selectivity theory. *Memory & cognition, 44*(6), 869-882.

Barrett, L. F. (2006). Solving the Emotion Paradox: Categorization and the Experience of Emotion. *Personality and Social Psychology Review, 10*(1), 20-46. doi:10.1207/s15327957pspr1001_2

Barrett, L. F. (2009). Variety is the spice of life: A psychological construction approach to understanding variability in emotion. *Cognition & Emotion, 23*(7), 1284-1306. doi:10.1080/02699930902985894

Barrett, L. F. (2013). Psychological Construction: The Darwinian Approach to the Science of Emotion. *Emotion Review, 5*(4), 379-389. doi:10.1177/1754073913489753

Barrett, L. F. (2014). The Conceptual Act Theory: A Precis. *Emotion Review, 6*(4), 292-297. doi:10.1177/1754073914534479

Barrett, L. F., & Bliss-Moreau, E. (2009). AFFECT AS A PSYCHOLOGICAL PRIMITIVE. In M. P. Zanna (Ed.), *Advances in Experimental Social Psychology, Vol 41* (Vol. 41, pp. 167-218).

Barrett, L. F., Lindquist, K. A., & Gendron, M. (2007). Language as context for the perception of emotion. *Trends in Cognitive Sciences, 11*(8), 327-332. doi:10.1016/j.tics.2007.06.003

Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology, 58*, 373-403. doi:10.1146/annurev.psych.58.110405.085709

Barrett, L. F., & Russell, J. A. (1999). The structure of current affect: Controversies and emerging consensus. *Current Directions in Psychological Science, 8*(1), 10-14.

Beaudreau, S. A., & O'Hara, R. (2008). Late-life anxiety and cognitive impairment: A review. *American Journal of Geriatric Psychiatry, 16*(10), 790-803. doi:DOI 10.1097/JGP.0b013e31817945c3

Bechara, A., & Damasio, A. R. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and economic behavior, 52*(2), 336-372.

Beckes, L., & Coan, J. A. (2011). Social baseline theory: The role of social proximity in emotion and economy of action. *Social and Personality Psychology Compass, 5*(12), 976-988.

Beckes, L. A., Medina-DeVilliers, S. E., & Coan, J. A. (2021). The social regulation of emotion: Inconsistencies suggest no mediation through ventromedial prefrontal cortex. *Social neuroscience, 16*(1), 6-17.

Bermond, B., Bierman, D. J., Cladder, M. A., Moormann, P. P., & Vorst, H. C. (2010). The cognitive and affective alexithymia dimensions in the regulation of sympathetic responses. *International Journal of Psychophysiology, 75*(3), 227-233.

Bieńkiewicz, M., Smykovskyi, A., Olugbade, T., Janaqi, S., Camurri, A., Bianchi-Berthouze, N., . . . Bardy, B. G. (2021). Bridging the gap between emotion and joint action. *Neuroscience & Biobehavioral Reviews*.

Bird, G., & Cook, R. (2013). Mixed emotions: the contribution of alexithymia to the emotional symptoms of autism. *Translational psychiatry, 3*(7), e285-e285.

Bird, G., Silani, G., Brindley, R., White, S., Frith, U., & Singer, T. (2010). Empathic brain responses in insula are modulated by levels of alexithymia but not autism. *Brain, 133*(5), 1515-1525.

Blackford, J. U., Buckholtz, J. W., Avery, S. N., & Zald, D. H. (2010). A unique role for the human amygdala in novelty detection. *Neuroimage, 50*(3), 1188-1193.

Blair, K. S., Smith, B. W., Mitchell, D. G., Morton, J., Vythilingam, M., Pessoa, L., . . . Drevets, W. C. (2007). Modulation of emotion by cognition and cognition by emotion. *Neuroimage, 35*(1), 430-440.

Blair, R. J. R. (2005). Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric populations. *Consciousness and cognition, 14*(4), 698-718.

Blausen Medical. (2014). Medical gallery of Blausen medical 2014. WikiJournal of Medicine, 1(2), 1-79. doi: 10.15347/wjm/2014.010. ISSN 2002-4436.

Boiger, M., & Mesquita, B. (2012). The Construction of Emotion in Interactions, Relationships, and Cultures. *Emotion Review, 4*(3), 221-229. doi:10.1177/1754073912439765

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. doi:10.1177/1745691613504116

Brown, C. L., Van Doren, N., Ford, B. Q., Mauss, I. B., Sze, J. W., & Levenson, R. W. (2019). Coherence between subjective experience and physiology in emotion: Individual differences and implications for well-being. *Emotion*.

Burgess, N., Maguire, E. A., & O'Keefe, J. (2002). The human hippocampus and spatial and episodic memory. *Neuron, 35*(4), 625-641.

Butler, E. A. (2017). Emotions are temporal interpersonal systems. *Current Opinion in Psychology, 17*, 129-134. doi:10.1016/j.copsyc.2017.07.005

Butler, E. A., Egloff, B., Wlhelm, F. H., Smith, N. C., Erickson, E. A., & Gross, J. J. (2003). The social consequences of expressive suppression. *Emotion, 3*(1), 48.

Cai, R. Y., Richdale, A. L., Uljarević, M., Dissanayake, C., & Samson, A. C. (2018). Emotion regulation in autism spectrum disorder: Where we are and where we need to go. *Autism Research, 11*(7), 962-978.

Carstensen, L. L., Fung, H. H., & Charles, S. T. (2003). Socioemotional selectivity theory and the regulation of emotion in the second half of life. *Motivation and Emotion, 27*(2), 103-123. doi:Doi 10.1023/A:1024569803230

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: a theory of socioemotional selectivity. *American psychologist, 54*(3), 165.

Catani, M., Dell'Acqua, F., & De Schotten, M. T. (2013). A revised limbic system model for memory, emotion and behaviour. *Neuroscience & Biobehavioral Reviews, 37*(8), 1724-1737.

Charles, S. T., Reynolds, C. A., & Gatz, M. (2001). Age-related differences and change in positive and negative affect over 23 years. *Journal of Personality and Social Psychology, 80*(1), 136-151. doi:Doi 10.1037//0022-3514.80.1.136

Chervonsky, E., & Hunt, C. (2017). Suppression and Expression of Emotion in Social and Interpersonal Outcomes: A Meta-Analysis. *Emotion, 17*(4), 669-683. doi:10.1037/emo0000270

Christopher, G., & MacDonald, J. (2005). The impact of clinical depression on working memory. *Cognitive Neuropsychiatry, 10*(5), 379-399.

Clark, M. S., & Finkel, E. J. (2005). Willingness to express emotion: The impact of relationship type, communal orientation, and their interaction. *Personal Relationships, 12*(2), 169-180.

Clark-Polner, E., Johnson, T. D., & Barrett, L. F. (2017). Multivoxel pattern analysis does not provide evidence to support the existence of basic emotions. *Cerebral cortex, 27*(3), 1944-1948.

Coan, J. A., Beckes, L., Gonzalez, M. Z., Maresh, E. L., Brown, C. L., & Hasselmo, K. (2017). Relationship status and perceived support in the social regulation of neural responses to threat. *Social Cognitive and Affective Neuroscience, 12*(10), 1574-1583.

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological science, 17*(12), 1032-1039.

Cole, P. M. (2014). Moving ahead in the study of the development of emotion regulation. *International Journal of Behavioral Development, 38*(2), 203-207.

Couette, M., Mouchabac, S., Bourla, A., Nuss, P., & Ferreri, F. (2020). Social cognition in post-traumatic stress disorder: A systematic review. *British Journal of Clinical Psychology, 59*(2), 117-138.

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.

Damasio, A. (1994). Descartes' error: emotion, reason and the human brain. Picador. In: Avon Books, A Division of The Hearst Corporation, New York.

Damasio, A. R. (2001). Descartes error revisited. *Journal of the History of the Neurosciences, 10*(2), 192-194.

Dan-Glauser, E. S., & Gross, J. J. (2013). Emotion regulation and emotion coherence: evidence for strategy-specific effects. *Emotion, 13*(5), 832.

Dezecache, G., Jacob, P., & Grezes, J. (2015). Emotional contagion: its scope and limits. *Trends in Cognitive Sciences, 19*(6), 297-299.

Dillon, D. G., Ritchey, M., Johnson, B. D., & LaBar, K. S. (2007). Dissociable effects of conscious emotion regulation strategies on explicit and implicit memory. *Emotion, 7*(2), 354.

Dixon-Gordon, K. L., Aldao, A., & De Los Reyes, A. (2015). Repertoires of emotion regulation: A person-centered approach to assessing emotion regulation strategies and links to psychopathology. *Cognition & Emotion, 29*(7), 1314-1325. doi:10.1080/02699931.2014.983046

Dixon-Gordon, K. L., Bernecker, S. L., & Christensen, K. (2015). Recent innovations in the field of interpersonal emotion regulation. *Current Opinion in Psychology, 3*, 36-42.

Duncan, S., & Barrett, L. F. (2007). Affect is a form of cognition: A neurobiological analysis. *Cognition and emotion, 21*(6), 1184-1211.

Düsing, R., Radtke, E. L., Kuhl, J., Konrad, C., Vandekerckhove, M., & Quirin, M. (2021). Emotion regulation ability compensates for the depression-related negativity bias. *Acta Psychologica, 220*, 103414.

Ekman, P. (1992a). ARE THERE BASIC EMOTIONS. *Psychological Review, 99*(3), 550-553. doi:10.1037/0033-295x.99.3.550

Ekman, P. (1992b). AN ARGUMENT FOR BASIC EMOTIONS. *Cognition & Emotion, 6*(3-4), 169-200. doi:10.1080/02699939208411068

Ekman, P. (1999). *Basic emotions*.

Ekman, P. (2016). What Scientists Who Study Emotion Agree About. *Perspectives on Psychological Science, 11*(1), 31-34. doi:10.1177/1745691615596992

Ekman, P., & Cordaro, D. (2011). What is Meant by Calling Emotions Basic. *Emotion Review, 3*(4), 364-370. doi:10.1177/1754073911410740

Ellsworth, P. C. (2013). Appraisal Theory: Old and New Questions. *Emotion Review, 5*(2), 125-131. doi:10.1177/1754073912463617

English, T., & Eldesouky, L. (2020). We're not alone: Understanding the social consequences of intrinsic emotion regulation. *Emotion, 20*(1), 43.

Fernández, D., Ros, L., Sánchez-Reolid, R., Ricarte, J. J., & Latorre, J. M. (2020). Effectiveness of the level of personal relevance of visual autobiographical stimuli in the induction of positive emotions in young and older adults: pilot study protocol for a randomized controlled trial. *Trials, 21*(1), 1-16.

Fitzgerald, J. M., Kinney, K. L., Phan, K. L., & Klumpp, H. (2020). Distinct neural engagement during implicit and explicit regulation of negative stimuli. *Neuropsychologia, 145*, 106675.

Fletcher-Watson, S., & Bird, G. (2020). Autism and empathy: What are the real links? In: SAGE Publications Sage UK: London, England.

Flores Jr, L. E., & Berenbaum, H. (2017). The effect of the social regulation of emotion on emotional long-term memory. *Emotion, 17*(3), 547.

Ford, B. Q., & Tamir, M. (2012). When getting angry is smart: Emotional preferences and emotional intelligence. *Emotion, 12*(4), 685.

Frijda, N. H. (1993). Appraisal and beyond. *Cognition & Emotion, 7*(3-4), 225-231.

Garfinkel, S. N., Zorab, E., Navaratnam, N., Engels, M., Mallorquí-Bagué, N., Minati, L., . . . Critchley, H. D. (2016). Anger in brain and body: The neural and physiological perturbation of decision-making by emotion. *Social Cognitive and Affective Neuroscience, 11*(1), 150-158.

Goerlich, K. S. (2018). The Multifaceted Nature of Alexithymia - A Neuroscientific Perspective. *Frontiers in Psychology, 9*. doi:ARTN 1614
10.3389/fpsyg.2018.01614

Gollan, J. K., Connolly, M., Buchanan, A., Hoxha, D., Rosebrock, L., Cacioppo, J., . . . Wang, X. (2015). Neural substrates of negativity bias in women with and without major depression. *Biological Psychology, 109*, 184-191.

Greenaway, K. H., & Kalokerinos, E. K. (2017). Suppress for success? Exploring the contexts in which expressing positive emotion can have social costs. *European Review of Social Psychology, 28*(1), 134-174.

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. doi:10.1037/0022-3514.74.1.224

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*(3), 281-291. doi:10.1017/s0048577201393198

Gross, J. J. (2015). Emotion Regulation: Current Status and Future Prospects. *Psychological Inquiry, 26*(1), 1-26. doi:10.1080/1047840x.2014.940781

Gross, J. J., & Barrett, L. F. (2011). Emotion Generation and Emotion Regulation: One or Two Depends on Your Point of View. *Emotion Review, 3*(1), 8-16. doi:10.1177/1754073910380974

Gross, J. J., & Feldman Barrett, L. (2011). Emotion generation and emotion regulation: One or two depends on your point of view. *Emotion Review, 3*(1), 8-16.

Gross, J. J., & John, O. P. (2002). Wise emotion regulation. In *The wisdom in feeling: Psychological processes in emotional intelligence.* (pp. 297-319). New York, NY, US: The Guilford Press.

Grossmann, I., & Ellsworth, P. C. (2017). What are mixed emotions and what conditions foster them? Life-span experiences, culture and social awareness. *Current Opinion in Behavioral Sciences, 15*, 1-5. doi:10.1016/j.cobeha.2017.05.001

Grove, R., Baillie, A., Allison, C., Baron-Cohen, S., & Hoekstra, R. A. (2014). The latent structure of cognitive and emotional empathy in individuals with autism, first-degree relatives and typical individuals. *Molecular autism, 5*(1), 1-10.

Gunnar, M. R., & Hostinar, C. E. (2015). The social buffering of the hypothalamic–pituitary–adrenocortical axis in humans: Developmental and experiential determinants. *Social neuroscience, 10*(5), 479-488.

Hamm, J., Kohler, C. G., Gur, R. C., & Verma, R. (2011). Automated facial action coding system for dynamic analysis of facial expressions in neuropsychiatric disorders. *Journal of Neuroscience Methods, 200*(2), 237-256.

Han, S. C., Schacter, H. L., Timmons, A. C., Kim, Y., Sichko, S., Pettit, C., . . . Margolin, G. (2021). Romantic partner presence and physiological responses in daily life: Attachment style as a moderator. *Biological Psychology, 161*, 108082.

Harlé, K. M., Chang, L. J., van't Wout, M., & Sanfey, A. G. (2012). The neural mechanisms of affect infusion in social economic decision-making: a mediating role of the anterior insula. *Neuroimage, 61*(1), 32-40.

Hasson, U., & Frith, C. D. (2016). Mirroring and beyond: coupled dynamics as a generalized framework for modelling social interactions. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1693), 20150366.

Hoemann, K., & Feldman Barrett, L. (2019). Concepts dissolve artificial boundaries in the study of emotion and cognition, uniting body, brain, and mind. *Cognition and emotion, 33*(1), 67-76.

Hollenstein, T., Tighe, A. B., & Lougheed, J. P. (2017). Emotional development in the context of mother–child relationships. *Current Opinion in Psychology, 17,* 140-144.

Horn, A. B., & Maercker, A. (2016). Intra-and interpersonal emotion regulation and adjustment symptoms in couples: The role of co-brooding and co-reappraisal. *BMC psychology, 4*(1), 1-11.

Inman, C. S., Bijanki, K. R., Bass, D. I., Gross, R. E., Hamann, S., & Willie, J. T. (2020). Human amygdala stimulation effects on emotion physiology and emotional experience. *Neuropsychologia, 145*, 106722.

Jang, E.-H., Park, B.-J., Kim, S.-H., Chung, M.-A., Park, M.-S., & Sohn, J.-H. (2013). *Classification of human emotions from physiological signals using machine learning algorithms.* Paper presented at the Proc. Sixth Int'l Conf. Advances Computer-Human Interactions (ACHI 2013), Nice, France.

Jiang, X., Moreno, J., & Ng, Z. (2022). Examining the interplay of emotion regulation strategies, social stress, and gender in predicting life satisfaction of emerging adults. *Personality and Individual Differences, 185*, 111255.

Jospe, K., Flöel, A., & Lavidor, M. (2018). The interaction between embodiment and empathy in facial expression recognition. *Social Cognitive and Affective Neuroscience, 13*(2), 203-215.

Kappas, A. (2011). Emotion and Regulation are One! *Emotion Review, 3*(1), 17-25. doi:10.1177/1754073910380971

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review, 30*(7), 865-878.

Kaufmann, C., Agalawatta, N., Bell, E., & S Malhi, G. (2020). Getting emotional about affect and mood. *Australian & New Zealand Journal of Psychiatry, 54*(8), 850-852.

Kern, R. P., Libkuman, T. M., Otani, H., & Holmes, K. (2005). Emotional stimuli, divided attention, and memory. *Emotion, 5*(4), 408.

Kiel, E. J., & Kalomiris, A. E. (2015). Current themes in understanding children's emotion regulation as developing from within the parent–child relationship. *Current Opinion in Psychology, 3,* 11-16.

Kramer, A. D., Guillory, J. E., & Hancock, J. T. (2014). Experimental evidence of massive-scale emotional contagion through social networks. *Proceedings of the National Academy of Sciences, 111*(24), 8788-8790.

Kuppens, P., Van Mechelen, I., Smits, D. J., De Boeck, P., & Ceulemans, E. (2007). Individual differences in patterns of appraisal and anger experience. *Cognition and emotion, 21*(4), 689-713.

Ladegaard, N., Larsen, E. R., Videbech, P., & Lysaker, P. H. (2014). Higher-order social cognition in first-episode major depression. *Psychiatry Research, 216*(1), 37-43.

Lamm, C., & Majdandžić, J. (2015). The role of shared neural activations, mirror neurons, and morality in empathy–A critical comment. *Neuroscience Research, 90*, 15-24.

Lang, F. R., Staudinger, U. M., & Carstensen, L. L. (1998). Perspectives on socioemotional selectivity in late life: How personality and social context do (and do not) make a difference. *Journals of Gerontology Series B-Psychological Sciences and Social Sciences, 53*(1), P21-P30. doi:DOI 10.1093/geronb/53B.1.P21

LeBlanc, V. R., McConnell, M. M., & Monteiro, S. D. (2015). Predictable chaos: a review of the effects of emotions on attention, memory and decision making. *Advances in Health Sciences Education, 20*(1), 265-282.

Lebowitz, M. S., & Dovidio, J. F. (2015). Implications of emotion regulation strategies for empathic concern, social attitudes, and helping behavior. *Emotion, 15*(2), 187.

Lee, H., Heller, A. S., Van Reekum, C. M., Nelson, B., & Davidson, R. J. (2012). Amygdala–prefrontal coupling underlies individual differences in emotion regulation. *Neuroimage, 62*(3), 1575-1581.

Levy-Gigi, E., Bonanno, G. A., Shapiro, A. R., Richter-Levin, G., Keri, S., & Sheppes, G. (2016). Emotion Regulatory Flexibility Sheds Light on the Elusive Relationship Between Repeated Traumatic Exposure and Posttraumatic Stress Disorder Symptoms. *Clinical Psychological Science, 4*(1), 28-39. doi:10.1177/2167702615577783

Levy-Gigi, E., & Shamay-Tsoory, S. G. (2017). Help me if you can: Evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress. *Journal of Behavior Therapy and Experimental Psychiatry, 55,* 33-40. doi:10.1016/j.jbtep.2016.11.008

Liao, H.-W., & Carstensen, L. L. (2018). Future time perspective. *GeroPsych*.

Liao, H.-W., Shavit, Y. Z., & Carstensen, L. L. (2019). Selective narrowing of peripheral social networks predicts poor long-term cognition in old age. *Innovation in Aging, 3*(Supplement_1), S174-S175.

Liddell, B. J., & Williams, E. N. (2019). Cultural differences in interpersonal emotion regulation. *Frontiers in Psychology, 10,* 999.

Lindquist, K. A. (2013). Emotions emerge from more basic psychological ingredients: A modern psychological constructionist model. *Emotion Review, 5*(4), 356-368.

Lindquist, K. A. (2017). The role of language in emotion: Existing evidence and future directions. *Current Opinion in Psychology, 17,* 135-139.

Lindquist, K. A., & Barrett, L. F. (2012). A functional architecture of the human brain: emerging insights from the science of emotion. *Trends in Cognitive Sciences, 16*(11), 533-540. doi:10.1016/j.tics.2012.09.005

Lindquist, K. A., & Gendron, M. (2013). What's in a word? Language constructs emotion perception. *Emotion Review, 5*(1), 66-71.

Linhartova, P., Latalova, A., Kosa, B., Kasparek, T., Schmahl, C., & Paret, C. (2019). fMRI neurofeedback in emotion regulation: A literature review. *Neuroimage, 193,* 75-92. doi:10.1016/j.neuroimage.2019.03.011

Liu, D. Y., Strube, M. J., & Thompson, R. J. (2021). Interpersonal Emotion Regulation: an Experience Sampling Study. *Affective Science*, 1-16.

López-Pérez, B., Carrera, P., Ambrona, T., & Oceja, L. (2014). Testing the qualitative differences between empathy and personal distress: Measuring core affect and self-orientation. *The Social Science Journal, 51*(4), 676-680.

Lougheed, J. P., & Hollenstein, T. (2012). A Limited Repertoire of Emotion Regulation Strategies is Associated with Internalizing Problems in Adolescence. *Social Development, 21*(4), 704-721. doi:10.1111/j.1467-9507.2012.00663.x

Lougheed, J. P., & Hollenstein, T. (2016). Socioemotional Flexibility in Mother-Daughter Dyads: Riding the Emotional Rollercoaster Across Positive and Negative Contexts. *Emotion, 16*(5), 620-633. doi:10.1037/emo0000155

Lougheed, J. P., Koval, P., & Hollenstein, T. (2016). Sharing the burden: The interpersonal regulation of emotional arousal in mother– daughter dyads. *Emotion, 16*(1), 83.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion, 5*(2), 175.

Meeks, T. W., Vahia, I. V., Lavretsky, H., Kulkarni, G., & Jeste, D. V. (2011). A tune in "a minor" can "b major": A review of epidemiology, illness course, and public health implications of subthreshold depression in older adults. *Journal of Affective Disorders, 129*(1-3), 126-142. doi:10.1016/j.jad.2010.09.015

Mesquita, B., Boiger, M., & De Leersnyder, J. (2016). The cultural construction of emotions. *Current Opinion in Psychology, 8*, 31-36. doi:10.1016/j.copsyc.2015.09.015

Mesulam, M.-M. (2000). *Principles of behavioral and cognitive neurology*: Oxford University Press.

Moors, A. (2013). On the causal role of appraisal in emotion. *Emotion Review, 5*(2), 132-140.

Moors, A. (2014). Flavors of Appraisal Theories of Emotion. *Emotion Review, 6*(4), 303-307. doi:10.1177/1754073914534477

Moors, A., Ellsworth, P. C., Scherer, K. R., & Frijda, N. H. (2013). Appraisal theories of emotion: State of the art and future development. *Emotion Review, 5*(2), 119-124.

Morawetz, C., Berboth, S., & Bode, S. (2021). With a little help from my friends: the effect of social proximity on emotion regulation-related brain activity. *Neuroimage*, 117817.

Mulej Bratec, S., Bertram, T., Starke, G., Brandl, F., Xie, X., & Sorg, C. (2020). Your presence soothes me: a neural process model of aversive emotion regulation via social buffering. *Social Cognitive and Affective Neuroscience, 15*(5), 561-570.

Niven, K. (2017). The four key characteristics of interpersonal emotion regulation. *Current Opinion in Psychology, 17*, 89-93.

Niven, K., Henkel, A. P., & Hanratty, J. (2019). Prosocial versus instrumental motives for interpersonal emotion regulation. *Journal of Theoretical Social Psychology, 3*(2), 85-96.

Niven, K., Troth, A. C., & Holman, D. (2019). Do the effects of interpersonal emotion regulation depend on people's underlying motives? *Journal of Occupational and Organizational Psychology, 92*(4), 1020-1026.

Norman, K. A., Polyn, S. M., Detre, G. J., & Haxby, J. V. (2006). Beyond mind-reading: multi-voxel pattern analysis of fMRI data. *Trends in Cognitive Sciences, 10*(9), 424-430.

Norris, C. J. (2021). The negativity bias, revisited: Evidence from neuroscience measures and an individual differences approach. *Social neuroscience, 16*(1), 68-82.

Oakley, B. F., Brewer, R., Bird, G., & Catmur, C. (2016). Theory of mind is not theory of emotion: A cautionary note on the Reading the Mind in the Eyes Test. *Journal of abnormal psychology, 125*(6), 818.

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

Oosterwijk, S., Snoek, L., Rotteveel, M., Barrett, L. F., & Scholte, H. S. (2017). Shared states: using MVPA to test neural overlap between self-focused emotion imagery and other-focused emotion understanding. *Social Cognitive and Affective Neuroscience, 12*(7), 1025-1035.

Parkinson, B. (1997). Untangling the appraisal-emotion connection. *Personality and Social Psychology Review, 1*(1), 62-79.

Parkinson, B. (2012). Piecing together emotion: Sites and time-scales for social construction. *Emotion Review, 4*(3), 291-298.

Parkinson, B., & Manstead, A. S. R. (2015). Current Emotion Research in Social Psychology: Thinking About Emotions and Other People. *Emotion Review, 7*(4), 371-380. doi:10.1177/1754073915590624

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Reviews Neuroscience, 9*(2), 148-158.

Picard, R. W., Vyzas, E., & Healey, J. (2001). Toward machine emotional intelligence: Analysis of affective physiological state. *IEEE transactions on pattern analysis and machine intelligence, 23*(10), 1175-1191.

Pinquart, M., & Silbereisen, R. K. (2006). Socioemotional selectivity in cancer patients. *Psychology and Aging, 21*(2), 419.

Poquérusse, J., Pastore, L., Dellantonio, S., & Esposito, G. (2018). Alexithymia and autism spectrum disorder: a complex relationship. *Frontiers in Psychology, 9*, 1196.

Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and psychopathology, 17*(3), 715-734.

Predatu, R., David, D. O., & Maffei, A. (2019). Beliefs About Emotions, Negative Meta-emotions, and Perceived Emotional Control During an Emotionally Salient Situation in Individuals with Emotional Disorders. *Cognitive Therapy and Research*, 1-13.

Quinones, A. R., Markwardt, S., & Botoseneanu, A. (2016). Multimorbidity Combinations and Disability in Older Adults. *Journals of Gerontology Series a-Biological Sciences and Medical Sciences, 71*(6), 823-830. doi:10.1093/gerona/glw035

Ratcliffe, M. (2005). The feeling of being. *Journal of Consciousness Studies, 12*(8-9), 43-60.

Richards, J. M., & Gross, J. J. (2000). Emotion regulation and memory: the cognitive costs of keeping one's cool. *Journal of Personality and Social Psychology, 79*(3), 410.

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39*(6), 1161.

Samson, A. C., Phillips, J. M., Parker, K. J., Shah, S., Gross, J. J., & Hardan, A. Y. (2014). Emotion dysregulation and the core features of autism spectrum disorder. *Journal of Autism and Developmental Disorders, 44*(7), 1766-1772.

Scarantino, A., & Griffiths, P. (2011). Don't give up on basic emotions. *Emotion Review, 3*(4), 444-454.

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social science information, 44*(4), 695-729.

Schurz, M., Radua, J., Tholen, M. G., Maliske, L., Margulies, D. S., Mars, R. B., . . . Kanske, P. (2021). Toward a hierarchical model of social cognition: A neuroimaging meta-analysis and integrative review of empathy and theory of mind. *Psychological Bulletin, 147*(3), 293.

Shafir, R., & Sheppes, G. (2020). How anticipatory information shapes subsequent emotion regulation. *Emotion, 20*(1), 68.

Shamay-Tsoory, S. G. (2011). The neural bases for empathy. *The Neuroscientist, 17*(1), 18-24.

Shamay-Tsoory, S. G., Aharon-Peretz, J., & Perry, D. (2009). Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. *Brain, 132*(3), 617-627.

Sheppes, G., & Levin, Z. (2013). Emotion regulation choice: selecting between cognitive regulation strategies to control emotion. *Frontiers in Human Neuroscience, 7*, 179.

Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., & Gross, J. J. (2014). Emotion Regulation Choice: A Conceptual Framework and Supporting Evidence. *Journal of Experimental Psychology-General, 143*(1), 163-181. doi:10.1037/a0030831

Smidt, K. E., & Suvak, M. K. (2015). A brief, but nuanced, review of emotional granularity and emotion differentiation research. *Current Opinion in Psychology, 3*, 48-51.

Smith, A. (2009). The empathy imbalance hypothesis of autism: a theoretical approach to cognitive and emotional empathy in autistic development. *the Psychological record, 59*(3), 489-510.

Smith, C. A., & Ellsworth, P. C. (1985). PATTERNS OF COGNITIVE APPRAISAL IN EMOTION. *Journal of Personality and Social Psychology, 48*(4), 813-838. doi:10.1037/0022-3514.48.4.813

Smith, C. A., & Lazarus, R. S. (1990). Emotion and adaptation. *Handbook of personality: Theory and research*, 609-637.

Stephens, C. L., Christie, I. C., & Friedman, B. H. (2010). Autonomic specificity of basic emotions: Evidence from pattern classification and cluster analysis. *Biological Psychology, 84*(3), 463-473.

Stevens, J. S., & Jovanovic, T. (2019). Role of social cognition in post-traumatic stress disorder: A review and meta-analysis. *Genes, Brain and Behavior, 18*(1), e12518.

Strauss, G. P., Ossenfort, K. L., & Whearty, K. M. (2016). Reappraisal and distraction emotion regulation strategies are associated with distinct patterns of visual attention and differing levels of cognitive demand. *PloS one, 11*(11), e0162290.

Swart, M., Kortekaas, R., & Aleman, A. (2009). Dealing with feelings: characterization of trait alexithymia on emotion regulation strategies and cognitive-emotional processing. *PloS one, 4*(6).

Tackman, A. M., & Srivastava, S. (2016). Social responses to expressive suppression: The role of personality judgments. *Journal of Personality and Social Psychology, 110*(4), 574.

Tamir, M. (2009). What Do People Want to Feel and Why?: Pleasure and Utility in Emotion Regulation. *Current Directions in Psychological Science, 18*(2), 101-105. doi:10.1111/j.1467-8721.2009.01617.x

Tamir, M., & Ford, B. Q. (2012). When Feeling Bad Is Expected to Be Good: Emotion Regulation and Outcome Expectancies in Social Conflicts. *Emotion, 12*(4), 807-816. doi:10.1037/a0024443

Thompson, R. A. (2011). Emotion and Emotion Regulation: Two Sides of the Developing Coin. *Emotion Review, 3*(1), 53-61. doi:10.1177/1754073910380969

Thomson, R. A., Overall, N. C., Cameron, L. D., & Low, R. S. (2018). Perceived regard, expressive suppression during conflict, and conflict resolution. *Journal of Family Psychology, 32*(6), 722.

Todd, R. M., & Anderson, A. K. (2009). Six degrees of separation: the amygdala regulates social behavior and perception. *Nature neuroscience, 12*(10), 1217-1218.

Tsai, J. L. (2007). Ideal Affect Cultural Causes and Behavioral Consequences. *Perspectives on Psychological Science, 2*(3), 242-259. doi:10.1111/j.1745-6916.2007.00043.x

Urry, H. L. (2009). Using reappraisal to regulate unpleasant emotional episodes: Goals and timing matter. *Emotion, 9*(6), 782.

Vaish, A., Grossmann, T., & Woodward, A. (2008). Not all emotions are created equal: the negativity bias in social-emotional development. *Psychological Bulletin, 134*(3), 383.

Visser, M. S., & Roelofs, M. R. (2011). Heterogeneous preferences for altruism: Gender and personality, social status, giving and taking. *Experimental Economics, 14*(4), 490-506.

Vorst, H. C. M., & Bermond, B. (2001). Validity and reliability of the Bermond-Vorst Alexithymia Questionnaire. *Personality and Individual Differences, 30*(3), 413-434. doi:Doi 10.1016/S0191-8869(00)00033-7

Weierich, M. R., Wright, C. I., Negreira, A., Dickerson, B. C., & Barrett, L. F. (2010). Novelty as a dimension in the affective brain. *Neuroimage, 49*(3), 2871-2878.

Weightman, M. J., Air, T. M., & Baune, B. T. (2014). A review of the role of social cognition in major depressive disorder. *Frontiers in psychiatry, 5*, 179.

Weiss, N. H., Tull, M. T., Davis, L. T., Searcy, J., Williams, I., & Gratz, K. L. (2015). A Preliminary Experimental Investigation of Emotion Dysregulation and Impulsivity in Risky Behaviours. *Behaviour Change, 32*(2), 127-142. doi:10.1017/bec.2015.5

Wilson-Mendenhall, C. D. (2017). Constructing emotion through simulation. *Current Opinion in Psychology, 17*, 189-194.

Wróbel, M., & Imbir, K. K. (2019). Broadening the perspective on emotional contagion and emotional mimicry: The correction hypothesis. *Perspectives on Psychological Science, 14*(3), 437-451.

Young, M. P., Scanneil, J. W., Burns, G. A., & Blakemore, C. (1994). Analysis of connectivity: neural systems in the cerebral cortex. *Reviews in the Neurosciences, 5*(3), 227-250.

Zaki, J., & Williams, W. C. (2013). Interpersonal Emotion Regulation. *Emotion, 13*(5), 803-810. doi:10.1037/a0033839

Chapter 2 – Methodology

Rationale

In order to determine differences in the efficacy of inter- and intra-personal ER, one Inter-personal ER paradigm was employed for all empirical investigations presented in Chapters 3 and 4, and adapted to facilitate the acquisition of electrodermal activity (EDA) or functional magnetic resonance imaging (fMRI). This paradigm was based on four key considerations and presented within this chapter: (1) the joint measurement of subjective experiences and physiological responses, (2) a common approach to measuring affective changes, (3) aligning the inter- and intra-personal ER conditions to allow comparisons between the two, and (4) measuring factors likely to influence the efficacy of inter-personal ER.

2.1. The Inter-Personal Emotion Regulation Task

A similar paradigm was employed for all of the experiments presented within the empirical chapters 3 and 4 (see Figure 2.1.). This task was adapted from previous ER studies, which have investigated regulatory flexibility and choice behaviour in ER in order to examine more flexible and thus naturalistic regulation (Sheppes & Levin, 2013; Sheppes et al., 2014). This ER paradigm has recently also been applied to studies of inter-personal ER (Levy-Gigi & Shamay-Tsoory, 2017). The task required participants to view negatively valenced images taken from the International Affective Picture System (IAPS; Lang et al., 2008). In the ER condition trials, participants used one of two strategies – Disengagement or Reappraisal to reduce negative emotional reactions, with the strategy being self-selected by the participant during intra-personal ER trials, whereas this strategy was selected for them either by the experimenter (Chapter 3) or by the other participant they interacted with (Chapter 4) within the inter-personal ER condition. However, for the EDA experiment presented in Chapter 3, all participants were presented with the same pre-selected pseudo-random sequence of ER strategy recommendations, to ensure they were always recommended Disengagement for low and Reappraisal for high arousal images, and that they were never presented with the same strategy on more than three consecutive trials. Contrarily, both participants (i.e. the person engaging in intrinsic ER and the other providing extrinsic inter-personal ER) were free to choose any ER strategy for the second-person fMRI experiment. Due to previous findings on choice behaviour in ER suggesting a clear strategy preference for certain levels of arousal (Shafir, Schwartz, Blechert, & Sheppes, 2015; Sheppes et al., 2014), it was assumed that following the preferred pattern observed during intra-personal ER would allow for a comparable number of Disengagement and Reappraisal trials to compare the efficacy of these strategies when employed inter- or intra-personally. Especially as findings suggest that we recommend strategies we are likely to choose for ourselves to others, when regulating the emotions of others. For instance, children have been shown to recommend strategies to others based on what they would choose for themselves in that particular situation (López-Pérez & Pacella, 2019; Pacella & López-Pérez, 2018) and adults prefer distraction for the regulation of other's high intensity emotions (Pauw, Sauter, Van Kleef, & Fischer, 2019), which aligns with the preference to distract during the intra-personal regulation of highly arousing affect.

When using Disengagement, participants were asked to disengage from the image they were seeing by thinking about something that was unrelated to the image. For instance, the example given to participants in Chapter 3 was for them to think about their commute to work or what they had for breakfast. Importantly, participants were asked to think about mundane things, which do not elicit strong negative or positive emotional reactions, such as a fight with a loved one or a cherished childhood memory. Contrarily, when using Reappraisal, participants were asked to focus on the image and re-interpret its meaning in a way that makes them feel less negative about the image. For example, during the practice trials in Chapter 3, participants saw an image of a crying child to which they might imagine that the crying child's parent is on their way to soothe the child. Importantly, when applying the Process Model of Emotion Regulation to these strategies, which was introduced in Chapter 1, both Disengagement and Reappraisal can be understood as antecedent-focused ER strategies. Both strategies interfere with the emotion generative process to reduce the affective impact of the IAPS images before the emotion is fully generated. However, Disengagement interferes slightly earlier in the emotion generative process than Reappraisal does. Crucially, the conclusions drawn from the empirical investigations presented in Chapters 3 and 4 should tentatively only be applied to antecedent-focused strategies, and experiments focusing explicitly on response-focused studies are needed to understand how inter-personal ER influence emotions when they have already been generated. Nonetheless, previous investigations into response-focused strategies challenge their ability to evoke meaningful changes in affect. For instance, suppression has been shown to have detrimental social consequences, as those who suppress their emotions rather than displaying their emotional reactions were judged less favourably by other interactants (Butler et al., 2003). Furthermore, a recent study highlighted the minimal or even lack of regulatory influence exerted by response-focused strategies on subjective experiences, psychophysiological and cognitive processes, as well as behavioural reactions (Bahl & Ouimet, 2022).

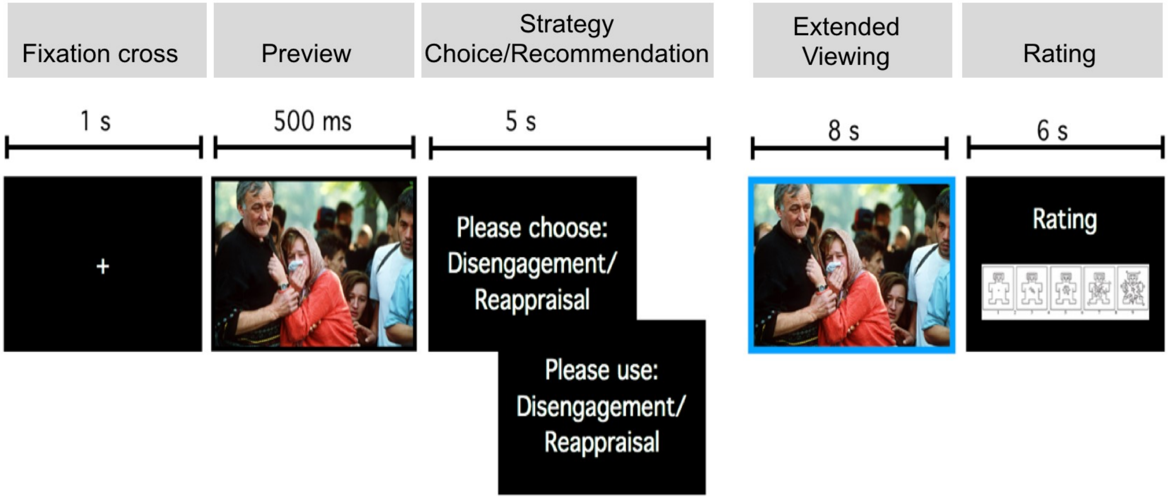


Figure 2.1..
Schematic Representation of a Trial Sequence for the ER Paradigm.

Participants completed an inter- and an intra-personal condition. During inter-personal ER trials, participants were informed of which ER strategy to use, based on what the experimenter had recommended to them (i.e. Disengagement for high and Reappraisal for low arousal trials), whereas they were presented with the other person's recommendation during the second-person fMRI experiment (see Figure 4 for a general schematic representation of the ER paradigm). The sequence was similar for the EDA and fMRI experiments; however, the fMRI experiment included a preparation phase after participants had selected/recommended a particular strategy. Thus, the exact timings and events for each study can be taken from their respective chapters. A "frame" control condition was chosen in favour of a traditional just-look baseline condition, the reasoning for this choice is discussed in greater detail below in section 2.1.2. Determining Appropriate Baseline or Control Conditions. When participants completed the inter-personal control condition, i.e. Frame trials, they would see the images in either a blue or green frame as it had been randomly selected by the experimenter (Chapter 3) or based on the decision of the other person within their dyad (Chapter 4). On the other hand, during intra-personal control trials, participants self-selected between a green or a blue frame during intra-personal Frame trials. Following the recommendation or self-selection of an ER strategy or Frame colour, participants down-regulated their emotions with the particular strategy or responded naturally to the viewing of the image within the coloured frame. At the end of each trial, participants rated their reactions using the Self-Assessment Manikin (SAM). Electrodermal and neural activity was captured throughout the trials, however, analyses focused on the 8s regulation or just-look window during each trial.

2.1.1. Affective Stimuli

According to the Affective Circumplex described in Chapter 1, emotions can be described based on valence and arousal (Barrett & Bliss-Moreau, 2009; Barrett & Russell, 1999). People have been shown to be influenced more strongly by negative relative to positive emotions, as they interfere more strongly with perception, memory, attention, and learning (Dolcos et al., 2020). It has been proposed that this might be due to evolutionary benefits of allowing the individual to gear up to face the aversive stimuli more quickly to avoid harm and increase chances of survival, for instance by detecting threats (Fox, Oler, Tromp, Fudge, & Kalin, 2015) and forming useful social relationships (Adolphs & Spezio, 2006; Gee, 2016). Furthermore, although excessive positive emotions are also associated with severely debilitating mental health disorders, for instance disorders characterised by increased risk taking (Dennison et al., 2015), or impulsivity, such as mania in bipolar disorder (Ramírez-Martín, Ramos-Martín, Mayoral-Cleries, Moreno-Küstner, & Guzman-Parra, 2020), most affective disorders are associated with heightened or long-lasting negative affect (Arlington & Association, 2013; Brown, Chorpita, & Barlow, 1998). Finding effective ways of down-regulating negative affect can have far-reaching positive clinical implications for people with affective disorders. Therefore, as negative emotions elicit greater physiological and neural responses and the benefits of successfully down-regulating negative emotions are far-reaching, the present experiments detailed within this thesis focus exclusively on down-regulating negative emotions.

In order to elicit emotional reactions, images from the International Affective Picture System (IAPS; Lang et al., 2008) were used for the studies presented in Chapters 3 and 4. IAPS images are commonly used in affective research and elicit affective responses reliably (Tracy, Klonsky, & Proudfit, 2014). Due to their extensive use in affective research, findings across numerous studies can be compared more easily across various affective paradigms. Some researchers advocate for the use of more dynamic stimuli to elicit affective responses, such as stories and film clips, which both provide contextual information which is absent from static images (Horvat, Kukolja, & Ivanec, 2015). Similarly, some researchers advocate for the use of emotion-eliciting stimuli with greater relevance to the regulating person, such as using autobiographical images or stories (Fernández et al., 2020). However, these dynamic stimuli extend the average trial length, thus limiting the total number of trials that can be presented to participants. Thus, in order to increase the number of trials, and due to the consideration that the use of IAPS images is well-established within various fields of affective science (Constantinescu, Wolters, Moore, & MacPherson, 2017), using IAPS images helps avoid lengthy testing and scanning times for participants.

A key consideration in affective research concerns habituation effects following repeated presentations of the same affective stimuli. People display the greatest affective response to novel stimuli and repeated exposure to the same stimulus is often associated with decreased physiological responding (Blackford, Buckholtz, Avery, & Zald, 2010; Kappas, 2011), as well as decreased neural activations, for instance evidenced by decreased activations within the amygdala which has been associated in a myriad of different affective processes (Inman et al., 2020; LeDoux, 2003; Phelps & LeDoux, 2005; Sergerie, Chochol, & Armony, 2008). The fMRI experiment in Chapter 4 included five different conditions which exposed participants to each image five times. To account for any gradual decreases in neural activations, supplementary analyses were carried out to determine which regions exhibit gradual decreases, e.g., linear decreases from the first to the fifth and final presentation of each image.

All images are associated with normative ratings for valence, arousal and dominance. Dominance scores refer to the degree to which participants feel controlled by, versus in control of, the stimulus presented to them (Mehrabian, 1996). Although valence, arousal and dominance are thought to correlate with one another, occasionally there are discrepancies between dominance and the other two dimensions, which often result in studies disregarding the normative dominance values when selecting their experimental stimuli (Constantinescu et al., 2017), thus dominance was not taken into consideration for the selection of images or the analysis of the subsequent experimental data. Only images with valence scores suggestive of negative emotions (i.e. scores below 5, see Figure 2.2) were used. Valence scores ranged between 1.0 and 4.0 for the psychophysiological study presented in Chapter 3, and between 1.78 and 3.85 for the fMRI study detailed in Chapter 4. Arousal refers to the intensity of the affective experience and represents the key dimension of interest within this thesis. Normative arousal ranged from 3.0 to 5.0 in the psychophysiological experiment, and between 3.95 and 7.26 – in the fMRI experiment. Moreover, median splits were applied to arousal ratings to classify the images as high or low arousal and participants were asked to rate their levels of arousal following ER. This distinction was particularly important, as previous studies on ER choice suggest that participants prefer reappraisal for low arousal images and disengagement for high arousal images (Sheppes et al., 2014). Thus, the experiments presented herein attempt to replicate this finding for intra-personal regulation and to determine whether participants report greater regulatory success following the use of reappraisal and disengagement for low and high arousal images, respectively, during *both* inter- and intra-personal ER.

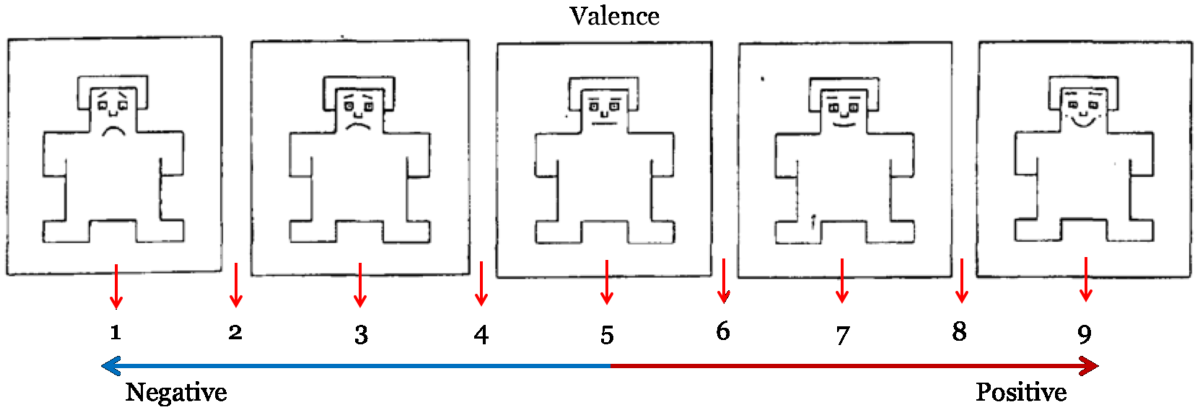


Figure 2.2.
Explanation of the positive and negative range of the Self-Assessment Manikin for valence.

2.1.2. Determining Appropriate Baseline or Control Conditions

Previous ER studies have used a baseline condition in which participants were asked to only look at the emotion eliciting stimulus without attempting to change how they feel (Goldin, McRae, Ramel, & Gross, 2008; Nakagawa, Gondo, Ishioka, & Masui, 2017; Strauss, Ossenfort, & Whearty, 2016). However, this just-look baseline condition was avoided within the experiments presented in this thesis for two main reasons. Firstly, it is unclear what participants are doing or thinking about during extensive passive response trials, thus limiting the number of passive response events within the experimental trial counteracts some of the ambiguity of the psychological processes unfolding during these intervals. Therefore, giving participants an alternative control task, which requires them to do something that does resemble the task within the experimental condition helps limit the possibility of different participants engaging in many different and therefore heterogenous processes, rendering the "baseline" conditions incomparable. To minimise the difference, and increase the comparability, between the EDA study in Chapter 3 and the fMRI study in Chapter 4, both studies forwent a just-look baseline condition.

Secondly, flexibility and choice behaviour were key aspects of the current studies presented in Chapters 3 and 4, thus a just-look baseline condition does not offer an adequate comparison to the ER trials during which participants were recommended or asked to select an ER strategy. Therefore, rather than using this just-look baseline condition, a control condition was used instead in which participants were presented with a green or a blue frame around the image. Following the choice or the recommendation of a coloured frame, participants were then asked to simply look at the image within the frame, without attempting to change their affective experience. Crucially, many studies which used a just-look baseline condition did not take choice behaviour into consideration (e.g. Thiruchselvam, Blechert, Sheppes, Rydstrom,

& Gross, 2011; Uusberg, Taxer, Yih, Uusberg, & Gross, 2019). These studies are primarily concerned with single or select ER strategies, such as reappraisal, and attempt to determine physiological effects of using reappraisal (Sheppes et al., 2009) or how the use of reappraisal can affect how we are perceived by others (English & Eldesouky, 2020; Gross, 2002). However, the importance of flexibility for general well-being and mental health has been lamented (Bonanno & Burton, 2013; Kashdan & Rottenberg, 2010; Levy-Gigi et al., 2016). The efficacy of inter-personal ER is likely to be limited by numerous factors, such as the regulatory ability or flexibility of the regulatory dyad. Thus, exploring flexibility can help distinguish between more or less effective regulators and help determine whether all or only more/less effective regulators benefit from inter-personal ER.

2.2. Comprehensive Measurements of Affective Changes

As described in Chapter 1, emotions encompass complex systems which, amongst other things, include subjective experiences, as well as physiological and behavioural responses (Barrett, 2006). It was previously assumed that emotional responses consist of congruent responses within all of these subsystems, however, there is extensive evidence to suggest the occasional divergence of these systems (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Moreover, ER studies in particular highlight the discrepancy between the sub-systems by demonstrating how particular ER strategies can influence one system but not another. For instance, a study by Sheppes, Catran, and Meiran (2009) revealed differential effects of reappraisal and disengagement on electrodermal responses, as only reappraisal was found to influence fluctuations in EDA. Therefore, in order to measure emotions accurately, various measures should be incorporated within the experiments which capture changes in these different sub-systems. There are a multitude of ways of capturing an individual's subjective experiences of emotional changes. For instance, open-ended questions in surveys or interviews are a way of collecting qualitatively rich portrayal of the individual's experience, however, these experiences are likely to vary considerably intra-individually within different situations, as well as inter-individually within similar to different situations (Jang et al., 2013). A slightly more objective way to capture subjective experiences can be made using Likert scales. This limits the dimensions on which the participant is asked to report, such as valence only, and provides some quantitative boundaries for their emotional response – for instance the Self-Assessment Manikin limits responses to magnitudes ranging from 1 to 9 (Bradley & Lang, 1994). Although this allows for easier comparison between people's responses, some variation in ability to identify and report emotional experiences accurately (Goerlich, 2018) and individual's overall emotional responsivity (Davidson, 2003) can be expected. Crucially, however, various inter-individual differences in responsivity are an integral aspect of emotional responding and influence all possible measures of emotion, including physiological responses. For example, age has been shown to influence EDA responses with older adults exhibiting lower skin potential responses and skin conductance levels than younger adults (Bari, Yacoob Aldosky, & Martinsen, 2020). Nonetheless, physiological responses are objective in the sense that they do not require conscious reporting from the participant. As emotions engage a plethora of physiological systems within the autonomic nervous systems, the measurement options are near endless and can include hormonal changes (Joseph, Jiang, & Zilioli, 2021), cardiac changes (Mather & Thayer, 2018), electrodermal activity (Sperduti et al., 2017), pupil dilation (Maier & Grueschow, 2021) or respiratory changes (Rompilla Jr, Hittner, Stephens, Mauss, & Haase, 2021).

The empirical investigations presented in Chapters 3 and 4 make use of self-reported ratings, EDA and fMRI measures to determine changes in emotional experiences, thus capturing subjective experiences as well as physiological changes. The rationale for the use of these three metrics and their respective strengths and limitations are considered below.

2.2.1. Self-Reported Ratings

The qualia of an emotion, or how the emotion feels like to the individual, has been regarded as the essence of all emotional experiences by some researchers (Barrett, Mesquita, Ochsner, & Gross, 2007; Cabanac, 2002; Denzin, 2017). As elaborated in Chapter 1, researchers and philosophers disagree on what an emotion *actually* is, however, the qualitative experience is often considered to be the fundamental characteristic of emotional processes (Ratcliffe, 2005), and the evaluation of our emotional experiences has been shown to be a strong predictor of behaviour (Benfer, Bardeen, & Clauss, 2018). What we think we feel or how in control we feel of our emotions or a particular situation determines our feelings and attitudes towards that experience and situation, and guides the way we engage with the emotion-eliciting stimulus. For example, a study by Midkiff, Lindsey, and Meadows (2018) highlighted the predictive ability of students' self-perceived ER capacities in their frequency to engage in non-suicidal self-injury. Similarly, participants who perceived that their ER self-efficacy was improved by giving them an alleged performance enhancing placebo drug, displayed reduced reactivity to stressful tasks, yet ER abilities were unperturbed when investigated using a behavioural task to measure how long participants persevere with a difficult, goal-congruent task when experiencing feedback for failed attempts (Benfer et al., 2018). Moreover, the importance of self-reports is stressed further by the fact that the only access into someone's subjective experience is via their introspection and subsequent report (Ratcliffe, 2005; Schooler & Schreiber, 2004). These reports can provide detailed information on someone's subjective experience, with interviews and open-ended questions allowing the exploration of detailed subjective accounts (Terpe, 2015), whereas rating scales are limited but sufficient to probe particular aspects of the affective experience, such as valence or arousal.

Despite the benefits of and the unique insight into subjective experiences offered by self-reports, they are also riddled by two fundamental limitations: biased introspection and inter-individual differences when comparing between participants. Introspection can be limited due to personal characteristics, such as the presence of alexithymic (Bornemann & Singer, 2017) or autistic traits (Silani et al., 2008), or situational factors limiting one's ability to process the internal or external affective stimuli, such as increased demands on working memory (Kobylińska & Kusev, 2019). Thus, there may be particular groups of people who are generally unable to provide accurate accounts of their affective experiences, whereas other people can be unable to determine their experiences accurately in specific situations. Thus, these situational and personal factors which can influence people's abilities to assess their affective experiences need to be taken into consideration and captured when ER efficacy is examined. Importantly, these factors have been shown to influence intra-personal ER, and it remains to be discovered how they influence inter-personal ER. For example, do less effective self-regulators benefit more from inter-personal ER, or to what extent must one be able to regulate one's own emotions in order to provide effective extrinsic inter-personal ER to others?

Some of these issues can be addressed using rating scales. Rating scales restrict participants' response options, which can often be associated with a numerical value denoting the magnitude of a particular property, such as arousal or valence. This represents a step towards the standardisation of subjective experiences, and allows the comparison between participants to a certain extent. Nonetheless, this standardisation is somewhat restricted, as rating scales do not eliminate the subjectivity of emotional experiences, as two people with a similar magnitude in emotional experience might score the emotion-eliciting stimulus very differently. Furthermore, it can be argued that a process such as an emotion, which can be considered partly or entirely subjective depending on one's theoretical viewpoint, can never be measured entirely objectively (Barrett, 2012). People generally rely on language categories or shared understandings of emotional experiences in an attempt to communicate one's emotional state to others (Barrett, 2009). Thus, when discussing the objectivity of measures used to evaluate emotional experiences, this essential property of emotions must not be forgotten. The issue with subjectivity and comparability across participants will be revisited in sections 2.2.2. and 2.2.3. for psychophysiology and functional MRI, respectively).

All empirical investigations within this thesis relied on IAPS images, and were used in conjugation with the Self-Assessment Manikin (SAM). The SAM is a 9-point Likert scale, used for three dimensions of the emotional experience – arousal, valence and dominance (Lang, Bradley, & Cuthbert, 2008). Although normative arousal and valence ratings were used to select images for participants, participants were only asked to report their level of arousal following each ER attempt. Valence ratings were considered in the selection of images to ensure participants only saw negatively valenced images, intended to elicit negative emotions. Again, although the SAM does not eliminate all subjectivity from participant's responses, it allows the comparison between participants and between studies. All studies discussed within this thesis used the SAM, thereby allowing for a more appropriate comparison between the findings presented in Chapters 3 and 4. Using the SAM also provides an indirect indication of the extent to which participants believe their regulatory attempt to have been successful following inter- and intra-personal regulation. Thus, the distinction between one's current level of arousal and one's estimation of regulatory success can be blurred.

There are three versions of the SAM which all represent a pictorial Likert scale ranging from 1 to 9. The SAM can either be used to measure valence (i.e. the degree to which the stimulus is experienced as positive or negative), arousal (i.e. the level of intensity associated with the emotional experience), or dominance (i.e. the extent to which the participant felt in control of their emotional reaction or controlled by the stimulus). All experiments discussed in this thesis used negatively valenced images exclusively and focused on the SAM scale which quantifies participants' experiences of arousal (see Figure 2.3.). Crucially, physiological and neural measures were acquired continuously throughout the trials, allowing the capture of responses during the regulatory section of the trial, whereas rating responses were only acquired at the end of each trial.

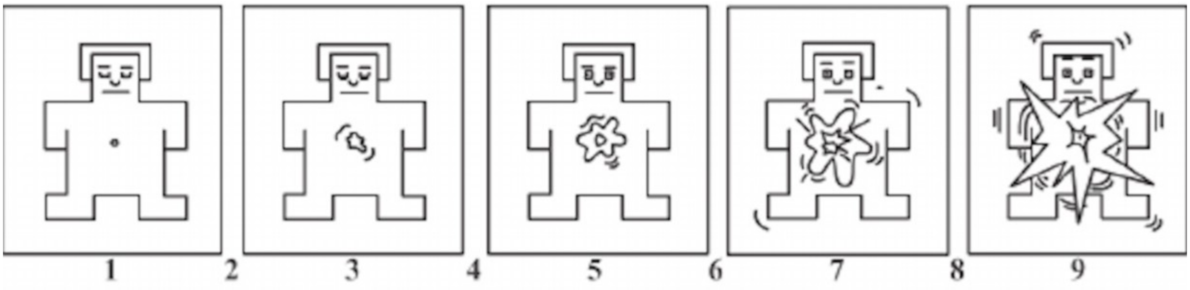


Figure 2.3.
The Self-Assessment Manikin used to Measure Arousal.

Moreover, as self-reported SAM scores were always collected alongside either electrodermal activity (EDA) or functional magnetic resonance imaging (fMRI) measures, the convergence between the measures could be determined. It is important to note that the different emotional subsystems do not always show changes in the same direction or with the same magnitude. For instance, when sadness is considered, greater feelings (i.e. subjective experiences) of sadness are associated with decreased arousal (Scherer, 2005). Likewise, emotion regulation does not always lead to congruent changes in subjective experience, physiological arousal and/or behavioural responses (Dan-Glauser & Gross, 2013; Gross, 1998; Mauss et al., 2005). This convergence provides insight into the extent to which inter- and intra-personal ER attempts can successfully alter subjective and physiological indices of emotions: divergent findings would challenge our abilities to accurately evaluate our emotional experiences and raises the question of how ER success should be measured – i.e. is one emotional subsystem more accurate in the assessment of emotional changes? Nonetheless, it should be noted, that inter-personal ER might only affect some and not all subsystems. Current findings suggest that inter-personal ER might be more effective in down-regulating negative emotions compared with intra-personal ER. Participants have been shown to report improved ER efficacy following inter- relative to intra-personal regulation with close friends (Sahi, Ninova, & Silvers, 2020) and romantic partners (Levy-Gigi & Shamay-Tsoory, 2017). Importantly, these findings are based on self-report measures and the inter-personal effects on physiology remain to be discovered. Therefore, SAM ratings and EDA measures were used to assess whether inter-personal ER can influence self-reported and physiological arousal in the experiments presented in Chapter 3. Determining the extent to which inter-personal ER can improve regulation, and thereby functioning, in interactive contexts can have significant implications for people's quality of life in various settings, such as clinical, occupational or developmental contexts.

Another key consideration concerns the measurement via self-report itself. In particular, it has been argued that requesting participants to assess their affective experience can alter the current affective experience, as merely thinking about an emotion is thought to elicit bodily reactions associated with the emotion itself (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005). Therefore, the timepoint at which these self-reports are captured are critical and they often occur at the end of the trial, when the emotion has already been generated and regulated. This is a key difference from physiological measures (including both EDA and fMRI), which can be obtained during the actual regulation process without distorting the signal via the measurement itself. Moreover, these self-reported ratings require complex operations during which participants are required to quickly condense their regulatory process, which unfolds over time, into a single score. Moreover, it should be noted that Likert scales represent ordinal level data although the underlying construct they aim to measure is continuous, e.g., arousal (Allen & Seaman, 2007; Jamieson, 2004). Whilst some researchers reject the use of parametric test on this ordinal level Likert scale data, it has been argued that this data can be treated as interval level data and that parametric tests are robust enough to handle the ordinal nature of Likert scale responses (Norman, 2010). Again, the physiological measures discussed below differ in this regard, as they can capture a range, thereby accounting for the entire regulatory process.

2.2.2. Objective Measures of Emotions

As described in the section above, emotions involve subjective feeling states, which are only accessible via introspection and self-reports. However, this is problematic when assessing emotional experiences in people who cannot access or report their emotional experiences accurately. There are numerous factors which can influence one's emotional processing abilities, however, the following focus will be set on alexithymia and autism, as these two characteristics are commonly associated with affective dysregulation and they were assessed in the studies presented herein. Alexithymia describes difficulties in identifying and verbalising one's internal emotional and mental states, as well as diminished abilities to fantasise or imagine things (Vorst & Bermond, 2001). Importantly, alexithymia has been shown to decrease people's abilities to regulate their emotions effectively (Swart, Kortekaas, & Aleman, 2009). Alexithymia is thought to be a stable personal characteristic and the construct can be divided further into affective and cognitive dimensions. The affective dimensions include diminished abilities to experience emotions, reduced abilities to verbalise one's emotions, and restricted emotional granularity or the difficulty to differentiate between differing emotional experiences. Furthermore, cognitive dimensions of alexithymia include reduced fantasising or an impoverished inner world, as well as difficulties analysing one's emotions (Bermond, Bierman, Cladder, Moormann, & Vorst, 2010).

Alexithymia is highly comorbid with autism spectrum disorder (ASD; Bird & Cook, 2013), and ASD has also been associated with poorer ER abilities (Samson et al., 2014). Children with autism are less likely to orient themselves to others, e.g., by making eye contact, and might therefore miss emotional cues expressed by those around them (Fletcher-Watson & Bird, 2020). The affective difficulties observed in ASD include reduced abilities to identify one's feelings, as well as regulate emotional experiences effectively and resemble key criteria for alexithymia (Poquérusse, Pastore, Dellantonio, & Esposito, 2018). Indeed, studies which do confirm both cognitive and affective empathy deficits in ASD, as well as their close relatives exhibiting sub-threshold, undiagnosed autism phenotypes, do not measure and therefore account for the influence of alexithymia within these populations (Grove, Baillie, Allison, Baron-Cohen, & Hoekstra, 2014). Thus, a growing number of studies suggest the emotional deficits which are commonly reported in people with autism are in fact likely due to alexithymia, rather than an inherent characteristic of ASD (Bird & Cook, 2013; Bird et al., 2010; Cai, Richdale, Uljarević, Dissanayake, & Samson, 2018; Poquérusse et al., 2018). In particular, cognitive empathy appears to be impaired in autism, yet affective empathy remains unchanged and in some cases is thought to be increased in people with ASD (Smith, 2009). This notion is supported by a study that demonstrated that after controlling for alexithymia, impaired cognitive empathy but intact affective empathy was observed in participants with autism, suggesting affective processing might not be impaired in autism per se (Oakley, Brewer, Bird, & Catmur, 2016). Thus, assessing the efficacy of ER can be hindered by people's abilities to introspect on their emotional experiences and can be counteracted using objective measures, such as physiological measurements.

2.2.2.1. Psychophysiology – Electrodermal Activity during ER

Psychophysiological processes broadly describe a myriad of processes of somatic, autonomic, neural, immunological and endocrinological systems (Cacioppo, Tassinary, & Berntson, 2007). Emotional experiences are associated with physiological changes which are initiated by activations within the autonomic nervous system (ANS). The ANS is thought to help mobilise the individual to engage with its environment by enabling approach and withdrawal behaviours. Importantly, as emotions are thought to primarily allow us to assess our environment and to prepare our bodies for the approach or avoidance of certain stimuli, it is unsurprising that affective changes are tightly coupled with ANS activations (Geršak, 2020). On the one hand, the ANS can be divided further into the sympathetic nervous system (SNS) which gears the body up for rapid responses, which for instance, are crucial when responding to threats. On the other hand, the parasympathetic nervous system (PNS) is associated with relaxation and decreases in arousal. Within social contexts, the presence of others has been shown to either elicit stress responses, particularly when we interact with strangers (Ravaja, 2009), or to have calming effects when we interact with close others whom we trust (Han et al., 2021). Examining inter-personal ER must therefore take the effects elicited by the mere presence of others, and the relational proximity of the interactants (i.e. close other versus stranger) into account when attempting to determine mechanisms underlying effective inter-personal ER.

Various physiological measures have previously been used to index emotional responses, such as the use of corrugator muscle activity to study facial displays of emotions (Schonfelder, Kanske, Heissler, & Wessa, 2014), heart rate variability to probe differences in regulatory abilities (Mather & Thayer, 2018), or EDA as a metric to assess effective ER in individuals within classroom (i.e. group) settings (Järvenoja et al., 2020). Some functions, including cardiovascular functions, are modulated by both sympathetic and parasympathetic activity, whereas eccrine sweat glands are only innervated by SNS nerve fibres (Posada-Quintero & Chon, 2020). Therefore, any changes in EDA can be attributed exclusively to changes in the SNS and EDA is a particularly good indicator of changes in arousal (Geršak, 2020). Moreover, electrodermal responses are considered to be automatic, as they are beyond conscious control in most cases, thereby counteracting issues of inaccurate measurements commonly encountered with self-report measures (Karvonen, Kykyri, Kaartinen, Penttonen, & Seikkula, 2016). Thus, EDA measures were selected to evaluate the efficacy of inter- and intra-personal ER in Chapter 3. Importantly, although neural responses also constitute physiological responses, the term "physiological responses" will be used selectively to refer to EDA measures within this thesis, whereas "neural responses" will be used to discuss fMRI findings.

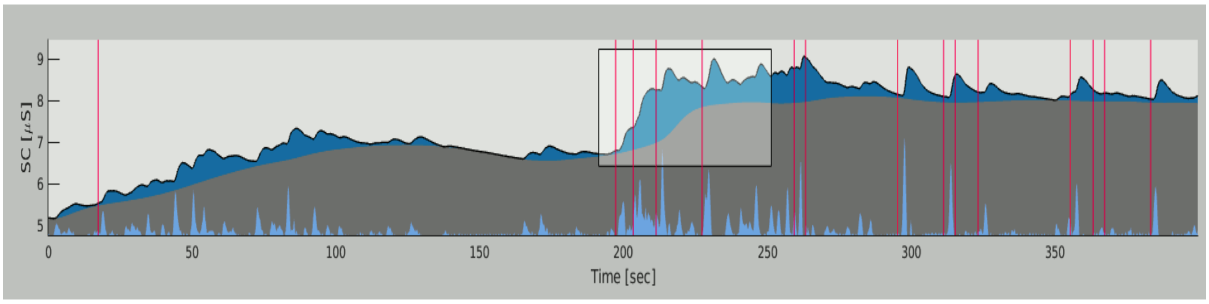


Figure 2.4.
Example of the EDA metrics used in Chapter 3 as displayed in the Ledalab GUI. *Note*. The vertical red lines signify trial events, such as the presentation of a fixation cross or an emotion-eliciting image. Tonic skin conductance levels are shaded in grey, whereas phasic skin conductance responses (SCRs) are shown in blue. All responses above 0.1 μS were considered significant responses and continuous decomposition analysis was used to distinguish between individual peaks of the SCRs and to calculate their sum of amplitudes.

Nonetheless, it should be noted that although EDA responses are particularly useful for the assessment of autonomic arousal, they are relatively slow and thus separate skin conductance responses (SCRs) generally overlap with each other. The number of SCRs is limited by the firing rate of the sudomotor nerve fibres, which have an estimated firing rate of 638ms. The number of SCRs is determined by the firing rate of sudomotor nerves, as one burst corresponds to a single SCR, whereas the amplitudes are restricted by the frequency of action potentials of the sudomotor nerves, as well as the number of sweat glands which are recruited for those particular responses (Benedek & Kaernbach, 2010). Decomposition approaches can be applied to the EDA signal to determine the number of SCRs constituting a particular signal, as well as the magnitude of these individual responses, which was elicited by a certain stimulus. Crucially, tonic skin conductance levels indicate someone's general psychophysiological state which describes stimulus-independent autonomic regulation, whereas phasic SCRs are particularly useful in evaluating the arousal elicited by internal (e.g. computing complex calculations) and external stimuli (e.g., responding to threats likely to cause bodily harm (Bari et al., 2020). When investigating inter-personal ER, the effects of relational proximity (i.e. friend versus stranger) are likely to be reflected in tonic skin conductance levels, whereas phasic responses can be expected in response to the emotion-eliciting images which change with every trial (Rudnicki, Declerck, De Backer, & Berth, 2019). The specific preprocessing pipeline used for the ER experiment is discussed in the Analysis section below. Due to the event-related nature of the study presented in Chapter 3, SCRs were preferred over tonic skin conductance levels. In order to assess participants' regulatory attempts, we investigated the number of SCRs recorded during regulation, and the sum of the amplitudes associated with these SCRs. Therefore, a greater number of SCRs as well as larger amplitudes denoted higher levels of arousal, i.e. less effective ER.

EDA measures are a particularly robust method of investigating miniscule changes in arousal, which might not be experienced consciously by the participant and might therefore be inaccessible to self-reports, yet they may be sufficient to influence cognition and behaviours (Cacioppo et al., 2007). People also differ in the overall magnitude of their electrodermal responses, for instance due to differences in the number of available sweat glands (Benedek & Kaernbach, 2010). There are numerous factors which can interfere with the accurate assessment of electrodermal changes in people. For instance, people with alexithymia who struggle with introspective processes and identifying bodily and psychological affective changes (Teixeira, Bermond, & Moormann, 2018). Moreover, estimations of the number of EDA non-responders varies between ranges of 5 – 25%, and mean estimates of 10% of people from the healthy population, who are considered to be non-responders, thus they do not display cyclic changes in eccrine responding which signifies changes in arousal (Braithwaite, Watson, Jones, & Rowe, 2013; Figner & Murphy, 2011; Geršak, 2020). Finally, age has been shown to influence EDA responses. A study by Bari et al. (2020) collected concurrent measurements of several EDA metrics on the same site in 60 participants and discovered that some of these metrics, such as skin conductance levels, are decreased in older adults, whereas others (e.g. the amplitudes of SCRs) do not differ significantly between younger and older adults. Thus, one way of combatting some of these restrictions of the use of EDA measures, is to choose appropriate EDA metrics for one's population of interest, for example when ageing questions are to be addressed. Further, following a power calculation to determine an appropriate sample size, one might choose to collect data from a slightly larger sample, so the probability of recording responses from non-responders is taken into consideration and this data can be removed. One key benefit of EDA measures is that they are non-invasive, relatively inexpensive to acquire and can be acquired in both controlled laboratory conditions and in ecologically valid settings, such as classrooms, thus allowing for paradigms to be expanded and tested in various settings with different levels of experimental control and ecological validity (Geršak, 2020; Järvenoja et al., 2020).

The difficulty of determining *what* constitutes an emotion was explored in Chapter 1 and this debate is likely to resurface when self-report and physiological measures diverge. There has been some evidence to challenge whether affective subsystems converge at all times. For instance, ER studies have highlighted how regulation strategies can have differential effects on reported affect and electrodermal measures. Sheppes et al. (2009) demonstrated how distraction reduced self-reported negative affect, although no changes in EDA were observed. Similarly, Mauss et al. (2005) found substantial coherence between self-reported affect and facial expressions when participants viewed either amusing or sad films, however, physiological indices of heart rate, finger pulse amplitude, blood volume and skin conductance levels diverged from both self-reports and facial expressions. Participants instructed to suppress visual displays of their emotional experiences, for example by maintaining a blank expression, report no significant differences when regulating or simply looking at emotional stimuli, however, heightened physiological responses emerge during suppression relative to just-look conditions (Gross & Levenson, 1993). It is difficult to determine whether ER attempts have been successful when this decision is based on self-reports or physiological responses alone, particularly when these two metrics diverge. Rather than arriving at a simplistic conclusion in favour of either metric, the particular context and supporting evidence including particularities of the paradigm or certain attributes of the sample, such as levels of alexithymia) should be scrutinised in order to derive a nuanced conclusion. Moreover, this divergence might not represent an anomaly but can give insights into how affective subsystems interact in different contexts and into the mechanisms underlying different emotion generative and regulatory processes (Gross, 1998). Indeed, it might not be possible or even useful to make such a clear distinction in favour of either self-reports reliant on introspection or automatic measures of physiological arousal. Therefore, it can be useful to understand emotions as embodied cognition to avoid the issue of Cartesian dualism, which proposes strict distinctions between the mind and body and fails to explain how the immaterial mind can influence the body and vice versa (Damasio, 2001). Embodied cognition emphasises the intricate interdependency between cognition and bodily states, and when applied to the affective domain, emotions can be understood as cognitive and bodily processes preparing an organism to evaluate and respond to one's ever-changing internal or external environment (Halberstadt, Winkielman, Niedenthal, & Dalle, 2009; Kiverstein & Miller, 2015). Importantly, divergence does not necessarily contradict this embodied cognitive perspective.

2.2.2.2. Functional MRI

The mechanisms underlying affective processing, emotion generation and regulation cannot be understood in their entirety without examining the brain – especially when emotions are conceptualised as examples of embodied cognition (Damasio, 2001). Thus, to understand how inter-personal ER works, one needs to understand how this regulation is represented within the brain. Previous ER studies have established associations between physiological changes and particular ER strategies. These studies, however, have predominantly focused on intra-personal regulation and it remains to be determined how the efficacy between inter- and intra-personal ER compares to one another, or whether inter- and intra-personal ER use similar or distinct mechanisms to elicit beneficial regulatory effects. Some researchers have proposed different mechanisms underlie inter- and intra-personal ER, with inter-personal ER recruiting less effortful control to elicit regulatory changes (Beckes & Sbarra, 2022). The challenges of assessing the efficacy of ER with both self-report and psychophysiological measures has been explored in the sections above, and the same issues apply when using fMRI. Thus, rating responses, as well as contrasts of blood-oxygen level dependent (BOLD) responses of several conditions were used for the fMRI experiment in Chapter 4 to derive a clearer picture of regulatory success – assuming the dependent measures converge. Furthermore, with fMRI research, determining successful ER definitively can be difficult, as ER is associated with complex activation patterns within widespread ER networks (these networks are discussed in greater detail in the following sections below). Nonetheless, these findings primarily describe brain regions associated with intra-personal ER and it remains to be determined (1) whether the same regions are engaged in inter-personal ER and (2) whether effective connectivity patterns within these regions are similar in inter- and intra-personal ER. The study presented in Chapter 4 utilises the localisation precision of MRI to provide some insights into the particular regions involved in inter-personal ER, which can then be used to address directional hypotheses of functional and/or effective connectivity in the future (Friston, 2011). Importantly, findings from these fMRI studies can be used in future studies on effective inter-personal ER in conjunction with magnetoencephalography and its improved temporal resolution to gain a better understanding of how these brain regions engage with one another (Tewarie et al., 2019) or transcranial magnetic stimulation to induce virtual lesions which perturb activations within specific regions-of-interests (ROIs) to determine causal relationships between these regions (Bestmann et al., 2008).

Like self-reported ratings and EDA measures, fMRI experiments are associated with their own advantages and challenges. Functional MRI experiments generally occur under highly controlled conditions which allow for the controlled empirical examination of inter-personal ER processes (Soares et al., 2016), which is advantageous for a nascent scientific field to identify potential processes underlying effective inter-personal ER. These processes can then be used to derive hypotheses and they can be subjected to further empirical testing (Popper, 2005). This level of experimental control will be particularly useful in determining to what extent inter- and intra-personal ER resemble one another, before more ecologically valid inter-personal ER can be scrutinised. For instance, studies on intra-personal ER have revealed reliable activations within the precuneus and the middle temporal gyrus, as well as three prefrontal regions – the inferior frontal gyrus, the superior frontal gyrus, and supplementary motor area, (Berboth, Windischberger, Kohn, & Morawetz, 2021). Another study by Moodie et al. (2020) confirmed strategies, such as attentional deployment and reappraisal, to engage similar brain regions and to be effortful by involving cognitive control regions. Interestingly, these regions were deployed differently for the various strategies and dependent on the level of arousal elicited by the stimulus. Moreover, real-time fMRI neurofeedback studies demonstrated improved ER following the participants learning how to modulate activity within their amygdala, anterior insula and anterior cingulate cortex – crucially, this benefit of neurofeedback involved the prefrontal cortex, yet benefits were absent when the prefrontal regions themselves were the target of up- or down-regulation with neurofeedback (Linhartova et al., 2019). These findings offer further support for the involvement of the prefrontal cortex in effortful intra-personal ER. However, more research on inter-personal ER is needed to determine whether or how these effects are modulated by interactions with others. Ecological validity might be limited, as unlike EDA measures, fMRI recordings of interacting individuals cannot be taken in various real-life settings, such as a clinician's therapy room (Paananen et al., 2018) or a classroom (Järvenoja et al., 2020). Nonetheless, ecological validity can somewhat be increased in future studies by using stimuli that are personal to the participant (Fernández, Ros, Sánchez-Reolid, Ricarte, & Latorre, 2020), such as family pictures, or by utilising second-person paradigms to examine neural activations during real-time interactions between two participants (Koike, Tanabe, & Sadato, 2015).

Different theories of how inter-personal processes elicit effective ER have been proposed, which can be tested by examining the brain regions engaged during inter-personal ER. In the sections that follow, various theories of potential neural processes underlying inter-personal ER will be examined. These theoretical considerations will form the basis of the predictions of the expected neural activation patterns during the inter-personal ER paradigm presented in Chapter 4.

2.2.2.2.1. Social Baseline Theory

According to the Social Baseline Theory proposed by Beckes and Coan (2011), humans interacting with others is the norm, whilst human processes occurring in isolation deviate from this norm and are associated with heightened stress responses. Therefore, the authors propose that regulatory processes which occur during interactions with others are primary driven by this return to baseline which is thought to occur with the mere presence of others. Crucially, it is assumed that resource-intensive involvement of the prefrontal cortex is diminished in the presence of others. Thus, in regards to affective processes, the presence of others is thought to re-establish one's physiological equilibrium; i.e. engaging with others aids our homeostasis. In fact, Gross and Medina-DeVilliers (2020) reviewed evidence of the widespread influence of social relations on various resource dependent cognitive processes, such as memory, vision and attention, emphasising how the resources associated with these cognitive processes can be reduced when tasks are completed in the presence of others. Similarly, Saxbe, Beckes, Stoycos, and Coan (2020) discuss the allostatic value of the quality of particular relationships, i.e. positive relationships are associated with decreased overall stress, better well-being and decreased risks for various diseases. Nonetheless, other theorists assume the prefrontal cortex to be heavily involved in inter-personal ER. For instance, Kohn et al. (2014) proposed a neural model of intra-personal ER by extending the Process Model of Emotion Regulation proposed by Gross (2015), which is explained in Chapter 1. Crucially, Kohn et al. (2014) argue that the ER cycle can be divided into various phases, which are supported by different brain regions. This model is described in more detail below. Similarly, Reeck, Ames, and Ochsner (2016) propose a neural model of inter-personal ER: the Social Regulation Cycle – the details of which are also presented below. However, it should be noted that unlike Kohn's intra-personal model, the Social Regulation Cycle is more speculative as there are insufficient inter-personal ER studies to draw definitive conclusions from, particularly regarding the neural mechanisms underlying extrinsic inter-personal ER. It is assumed that the prefrontal cortex is involved in both inter- and intra-personal ER, but that it engages differently with emotion generative and socio-cognitive regions during inter- relative to intra-personal ER. However, these assumed differences still need to be explored empirically. Support for the Social Baseline Theory can be assumed in the case of reduced activity within the prefrontal cortex, whereas theories of inter-personal ER advocating for the involvement of control processes can be supported with evidence of activation in the prefrontal cortex during inter-personal ER. Both of these theories will be assessed with the fMRI data presented in Chapter 4, which provides insights into brain regions involved in real-time and interactive, intrinsic and extrinsic inter-personal ER.

2.2.2.2.2. Kohn's Neural Model of Cognitive Emotion Regulation

Neural models of ER have extended findings and theories from behavioural and psychophysiological intra-personal ER. Complementing, Gross's Process Model of Emotion Regulation, Kohn et al. (2014) propose a neural model of cognitive ER, which divides the regulatory process into three distinct stages: emotion evaluation, regulation initiation and regulation implementation/maintenance. These three stages, which are thought to occur sequentially, are associated with activations in distinct neural structures across the limbic system, prefrontal cortex (PFC) and parietal brain regions. Kohn et al. (2014)'s meta-analysis assessed 23 fMRI studies to reveal consistent activations during the cognitive control of emotions regardless of the particular strategy or stimuli employed within the study. The findings suggest the lateral PFC to be consistently activated in ER paradigms involving the effortful control of emotions, which is in line with the PFC's involvement in higher level cognitions, such as executive functions (Menon & D'Esposito, 2022). Structural connectivity was also taken into consideration when modelling the direction of spreading activation between the identified neural regions. For instance, although the dlPFC is reliably involved in effortful ER (Ochsner & Gross, 2005; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008), due to severely limited direct connections between the dlPFC and the limbic system, e.g. the amygdala, it is unlikely that the dlPFC is directly involved in modulating emotional reactivity (Ray & Zald, 2012). Rather, the dlPFC is thought to initiate ER, e.g. by identifying the need to regulate and planning ways in which the current state can be modified to reach a desired goal state. Thus, the dlPFC's influence on emotion generative regions is thought to be mediated by the anterior middle cingulate cortex (aMCC)/dorsal ACC. The aMCC possesses direct connections to cortical regions including the dlPFC/MFG, precentral gyrus, SMA, superior parietal lobe, fusiform gyrus, as well as subcortical regions including the thalamus, putamen, pallidum, and reciprocal connections to the amygdala, thus providing a suitable pathway for the modulation of subcortical activity by the PFC (Kohn et al., 2014). Contrarily, the vlPFC has reciprocal bidirectional connections to the amygdala and is thought to process the salience of emotion-eliciting stimuli, thereby being involved in emotion generation and aiding the evaluation of the need to regulate one's emotions (Ray & Zald, 2012). The vlPFC is also anatomically connected to the dlPFC and pre-SMA and therefore thought to play a key role in encoding the need for action inhibition, though it is not directly involved in the inhibition (Kohn et al., 2014).

Critically, these insights have been taken from the extensive literature on the neural basis of intra-personal ER and a similar comprehensive meta-analytic investigation of inter-personal ER will require many more inter-personal ER experiments to be carried out. Currently, intra-personal ER studies can inform educated guesses on how these neural processes might vary slightly during interactions of a regulating dyad based on what is known about self -regulation. A tentative neural model of inter-personal ER, referred to as the Social Regulatory Cycle (SRC; Reeck et al., 2016) is discussed below, however, unlike the model proposed by Kohn, it has been derived from limited studies explicitly investigating inter-personal ER. Moreover, as inter-personal ER involves at least two people – one person providing extrinsic inter-personal ER and another person engaging in intrinsic inter-personal ER, empirical explorations of the neural process of both members of the dyad are required. Currently, the focus within the inter-personal ER literature lies on the person engaging in intrinsic inter-personal ER (Reeck et al., 2016; Zaki, 2020). This asymmetry in the focus of one person within the dyad can be avoided by utilising second-person paradigms, which are discussed in section 2.3. of this chapter.

2.2.2.2.3. The Social Regulatory Cycle

The proposed neural models of ER, such as the model proposed by Kohn and colleagues (2014) above, have been extended to consider the influence of social processes during inter-personal ER. Reeck et al. (2016) proposed a model of inter-personal ER based on findings from neuroimaging studies. The model is detailed in Table 1. The authors define three systems, which are thought to be differentially involved in Targets and Regulators. The cognitive control network (system I) is thought to influence sub-cortical emotion generative regions (system II) directly to up- and down-regulate affective experiences. System III is involved in processing social cues, such as inferring the intentions of one's interactant. According to Reeck et al. (2016)'s theory of the Social Regulatory Cycle (SRC), not all of the three systems are involved in both the person giving (i.e. the Regulator) as well as the person receiving (i.e. the Target) inter-personal ER, and the expected patterns of neural activations within the systems engaged during regulation are thought to differ depending on one's role within the dyad. For instance, no significant activation in the cognitive control system is assumed for Targets during intrinsic inter-personal ER, whereas Regulators engaging in extrinsic inter-personal ER are thought to employ the dorso- and ventro-lateral PFC, posterior medial PFC and the dorsal ACC. The opposite pattern is assumed for the emotion generative system, as Targets are thought to make use of their bilateral amygdalae and ventral striatum, whereas Regulators are not thought to involve these emotion generative regions when regulating someone else's emotions. Thus, the particular paradigm employed in Chapter 4 enables the examination of whether differential activations within the cognitive control and emotion generative systems persist for Regulators and Targets during inter-personal ER.

Table 2.1.

The Social Regulatory Cycle as a Neural Inter-Personal ER Network Proposed by Reeck et al. (2016).

	System I	System II	System III
Network	Cognitive control	Emotion generation	Social processing
ROIs	bilateral IFG, bilateral MFG, SMA	bilateral amygdala	bilateral supramarginal gyrus, left superior/middle frontal gyrus, left MTG

Importantly, the processes involved in successful inter-personal ER are thought to vary between Regulators and Targets. On the one hand, Regulators are hypothesised to rely on empathy to identify emotions and the need to regulate the emotions of the other person. Although the authors do not make any reference to embodied cognitions per se, Reeck et al. (2016) propose the amygdala, the mentalising network, including the dorsal medial PFC, precuneus and the temporoparietal junction, as well as motor regions, such as the premotor cortex, to be involved in processing affective reactions of others via “affective mimicry”. Previous studies on empathy in ER offer some initial support for the involvement of empathy in inter-personal ER (Zaki, 2020), however, this will be explored a little further in Chapter 4, and requires explicit empirical examinations for definitive conclusions to be drawn. On the other hand, Targets are expected to recruit less cognitive control when engaging in intrinsic inter-personal ER, as they may rely on the other person to identify their need to commence and terminate regulation, to select an appropriate ER strategy and to monitor their regulatory success. This assumption has been supported by studies on ER conducted in the presence of close others highlighting decreased activations within the lateral PFC, which is commonly associated with effortful cognitive control (Menon & D’Esposito, 2022; Opitz, Rauch, Terry, & Urry, 2012). Again, it should be noted, that these proposed Target-specific activations require formal empirical investigations in the future. This will aid in understanding how intrinsic inter-personal ER exerts its regulatory effects if cognitive control systems within the PFC are indeed reduced or bypassed.

2.3. Second-Person Paradigms

Many processes, including ER processes, occur within social settings and numerous psychologists are starting to argue for the assessment of psychological functions to occur within these inter-personal contexts (Lehmann, Maliske, Böckler, & Kanske, 2019; Schilbach et al., 2013; Shaw et al., 2018; Špiláková, Shaw, Czekóová, & Brázdil, 2019). Some argue that most social cognitive processes emerging from dynamic social situations, supersede individual cognitive processes which might be observed in people in isolated laboratory contexts (Satne, 2020). This is perhaps unsurprising considering the physiological and psychological effects exerted by the mere presence of others (Beckes & Coan, 2011; Kappas, 2011). Importantly, the replication crisis within Psychology has emphasised the need to interrogate these psychological effects more thoroughly using replication studies and more interactive paradigms (Redcay & Schilbach, 2019). For instance, rather than observing students regulate their emotions in isolation and extending the relevant findings to a hypothetical classroom, this ER study could be carried out in the classroom, or in the presence of a teacher or fellow students. Of course, these interactive, and more naturalistic paradigms are not without their challenges. Research conducted on dyads yields rich data on both participants individually, as well as the social process unfolding between them. Thus, these paradigms require effective analysis methods to disentangle these intricate individual and dyadic processes (Redcay & Schilbach, 2019).

There are various ways of investigating socio-cognitive processes, which can be divided into para-social and truly interactive social paradigms. First-person paradigms describe procedures during which the participant acts in a way that affects another person, such as a simulated other or avatar who, however, does not respond (Kircher et al., 2009); i.e. the interaction is unidirectional. Participants can also be asked to simply observe interactions between people with whom they cannot or do not interact with in third-person paradigms (Redcay & Schilbach, 2019; Schilbach et al., 2013). However, second-person paradigms involve active bi-directional interactions between at least two people, during which one person's behaviour serves as the input to trigger the other person's response, which in turn influences the first person's next response and so forth (Shamay-Tsoory & Mendelsohn, 2019). Importantly, it has been suggested that real-time social interactions might differ significantly from para-social paradigms and offer more ecologically valid insights into social processing during true inter-personal interactions (Schilbach et al., 2013; Shaw et al., 2018). For instance, spontaneous autonomic synchronisation of skin conductance responses or heart rate has been reported in couples engaging in a joint task (Palumbo et al., 2017). Beyond studies on neural synchrony, studies of neural coupling have shown how social interactions involve reciprocal influences between the interactants (Hasson & Frith, 2016). For instance, reciprocal choices of money allocations within an iterated Ultimatum Game were modelled using behavioural dynamic causal modelling (bDCM; Shaw et al., 2019). This bDCM model by Shaw et al. (2018) enabled the prediction of both players choices, in regards to whether they would propose fair divisions of the wins, and whether responders would accept the offer, with accuracies above 70%.

Traditionally, psychological studies of emotional processing have required participants to observe social scenarios, such as the viewing of films involving the actions of other, and to then make inferences about the other person's emotions (Satne, 2020). Thus, these studies are unable to assess psychological processes which emerge in interactive exchanges when the participant is actively engaging with at least one other person. Contrarily, second-person paradigms involve at least two interacting people, allowing for the measurement of real-time psychological responses. It is possible to measure responses of only one person within this dyad or to measure both interactants of the dyad. It is important to note that in line with this working definition, at least one person from the dyad needs to be aware of and actively attempt to change their own or the other's affective experience in order for this process to be considered goal-directed and intentional inter-personal ER. In the current inter-personal ER studies, there has been an increased focus on the person engaging in intrinsic inter-personal ER, to the detriment of our understanding of the person providing extrinsic inter-personal ER (Reeck et al., 2016). This bias was avoided in the fMRI study presented in Chapter 4, as neural activations were measured in both members of the dyad. Second-person paradigms can help elucidate phenomena occurring during real-time, dynamic social contexts, which do not arise in third-person social psychological paradigms (Redcay & Schilbach, 2019). For instance, a classroom study using portable EEG devices on 12 students and their teacher revealed how social processes influenced learning (Bevilacqua et al., 2019). The extent to which students reported feeling close to their teacher influenced the amount of material each student retained. Furthermore, brain-to-brain synchrony between a student and their teacher was positively correlated with the student's engagement and how much they reported liking the teacher. Similarly, second-person studies on couples in therapy have revealed couples seeking support from a therapist to exhibit reduced EDA synchrony (Karvonen et al., 2016), whereas interactions between harmonious couples are generally associated with increased EDA synchrony and high levels of empathy (Coutinho et al., 2019). These examples illustrate how second-person paradigms are beginning to offer rich insights into socio-cognitive processes which occur during real interactions between people.

2.4. Analyses

2.4.1. Key Effects of Interest

Due to the similar paradigms employed for the EDA and fMRI experiments, analogous main analyses could be carried out for both studies (see Figure 2.5.). Study-specific adjustments, such as alternative analyses to account for the differences in trial numbers introduced by the choice element of the paradigm, as well as paradigm-specific exploratory analyses are detailed within the respective chapters and depicted briefly in Figure 3. For both the EDA and the fMRI experiments, there were three main foci of the analyses – namely, (1) to explore any main effects of Condition (inter-personal, intra-personal) and (2) Arousal (low, high), as well as (3) Condition-by-Arousal interaction effects. Firstly, differences between the inter- and intra-personal condition were examined to assess differences in efficacy when participants engaged in intrinsic inter- and intra-personal ER. Contrasting neural activation within the two conditions also aided in answering the question of whether inter- and intra-personal ER engage a similar brain network. Secondly, exploring arousal effects provided some insights into whether the experimental manipulation had been successful in inducing affective arousal in the regulating participants, with higher levels of arousal being expected for highly arousing stimuli, as well as for ineffective ER. Thirdly, the Condition-by-Arousal interaction provided useful information on condition-specific differences based on the level of arousal elicited by the images. Indeed, this allows for initial investigations into contextual factors (i.e. the level of arousal) which might improve or dampen the efficacy of inter-personal ER.

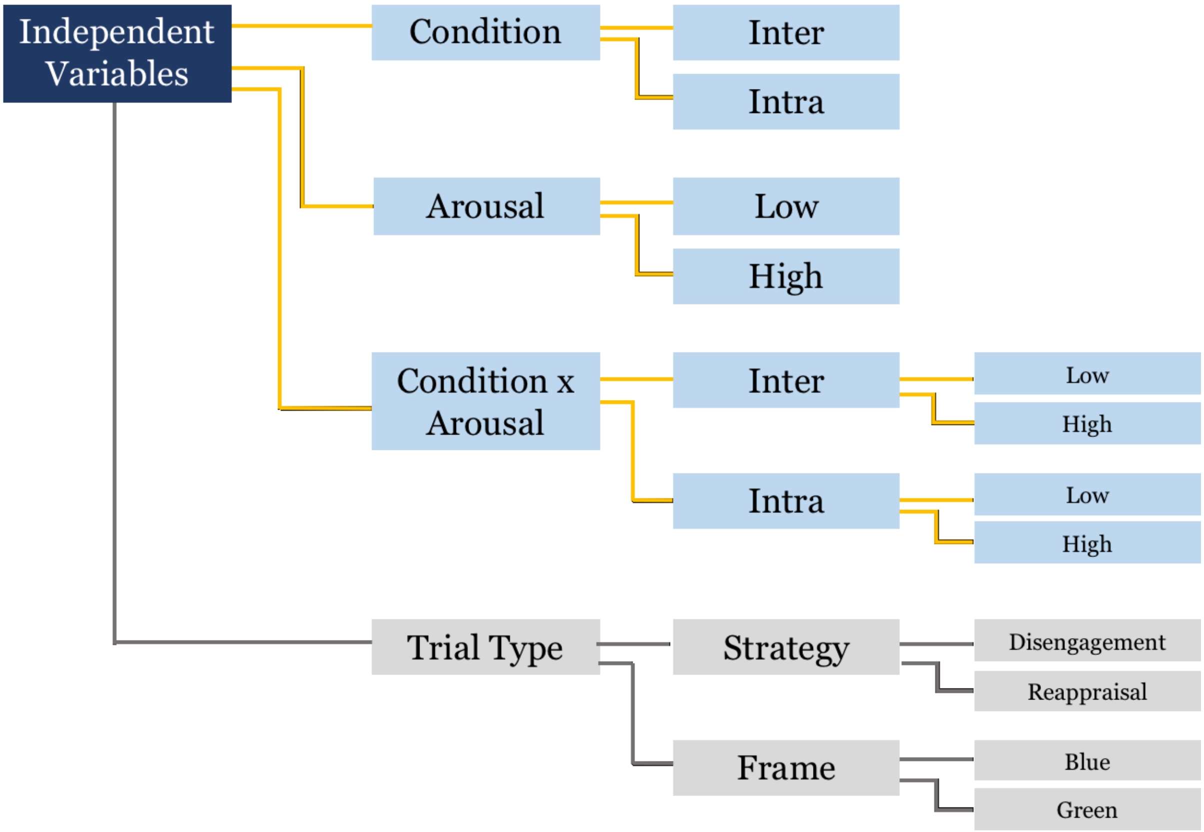


Figure 2.5.
Main and Interaction Effects Examined within the ER Paradigms. *Note*. Blue boxes represent the main analyses carried out for all rating, EDA responses and fMRI activations. Grey boxes include "flexible" analyses which involved the element of free choice and required modification dependent on participants' choices during the EDA and fMRI experiments.

In addition to the main analyses which were run across the EDA and fMRI experiments, some investigations into the effect of Trial Type were carried out. However, it should be noted that these analyses needed to be flexible to account for participants' choices, as this free choice resulted in unequal Disengagement and Reappraisal trial numbers for each participant (EDA experiment) or pair (fMRI experiment). By examining participants' choices of strategies, it could be ascertained which strategies participants favoured under particular conditions. The primary interest was in attempting to replicate findings reported by Sheppes et al. (2014) which showed a clear preference for Reappraisal under low and Disengagement under high arousal. Thus, to pre-empt this preference, participants were always recommended Reappraisal for low and Disengagement for high arousal trials in the EDA experiment detailed in Chapter 3. However, direct comparisons between the strategies under inter- or intra-personal conditions required there to be a similar number – or at least a sufficient number, of intra-personally selected Reappraisal trials under low and Disengagement trials under high arousal. Given the imbalanced number of trials in which participants chose each strategy in response to low- and high-arousal images during the two conditions in the experiments presented in Chapter 3 and 4, it was inappropriate to compare their effectiveness with the planned 2 (Condition: Intra-personal, Inter-personal) x 3 (Strategy: Disengagement, Reappraisal, Frame) x 2 (Arousal: Low, High) repeated-measures ANOVA. Instead, we compared the effectiveness of intra- and inter-personal ER directly by first performing linear mixed models (LMMs); specifically, we compared the two conditions by considering only those trials that were equivalent – low-arousal trials in which reappraisal was self-selected or recommended, and high-arousal trials in which disengagement was self-selected or recommended. A step-up approach was used to define the best-fitting model for each dependent measure: starting with a reference model containing only fixed main effects, improvements to model fit were assessed after introducing a random intercept, random main effects and fixed interactions sequentially. Furthermore, examining the choice of strategies offered some insights into how participants choose strategies for others, i.e. extrinsic inter-personal ER in the fMRI experiment (Chapter 4). In particular, the questions remaining to be answered concerned whether participants also prefer to recommend Reappraisal or Disengagement for low or high arousal trials, respectively; and more importantly, whether we choose similar strategies for others as we would choose for ourselves or they would choose for themselves.

2.5. Conclusion

The present ER task was adapted from an ER paradigm used in a recent investigation into inter-personal ER by Levy-Gigi and Shamay-Tsoory (2017). One crucial benefit of the task is that it can be used in within-subjects paradigm to allow for direct comparisons between inter- and intra-personal ER, if the conditions are constructed in a way which allows a direct comparison. A within-subject investigation is particularly useful as intra-personal ER has shown people to differ in their abilities to implement self-directed ER effectively (Compton, 2000; Düsing et al., 2021; Malooly, Genet, & Siemer, 2013). This direct comparison can help determine whether one's ability to engage in effective inter-personal ER is dependent on one's self-regulatory abilities, or whether person characteristics shown to influence intra-personal ER impact on inter-personal ER abilities in a similar manner. Moreover, the present paradigm can be used within a second-person setting, thereby enabling researchers to address questions of whether ER abilities differ when engaging in intrinsic intra- or inter-personal, as well as extrinsic inter-personal ER. Thus, the paradigm is flexible enough to be modified to explore various facets of inter-personal ER. Importantly, by using the same paradigm with slight modifications, the comparability of results between the EDA and fMRI experiments presented in Chapters 3 and 4, respectively, was increased. Another key benefit of the present paradigm is its ability to take choice behaviours into consideration. People tend to modify their regulatory approach according to their goals (English, Lee, John, & Gross, 2017), and one's ability to engage in flexible ER has been shown to have beneficial effects on mental health outcomes (Levy-Gigi et al., 2016). Therefore, in order to truly understand ER, these flexible choices must be considered in dynamic paradigms. The paradigm also allows for the investigation of various stages of the regulatory process, including the choice of a strategy, the actual implementation of the strategy and the assessment of one's regulatory attempt. By modifying the timings of each event, different segments of the trials can be subjected to further analyses – for instance, by extending the preview or ensuring a blank screen is presented following the preview rather than moving on directly to the choice period, EDA or fMRI responses during the initial presentation of the stimuli can be scrutinised in future studies to determine how this influences subsequent strategy choices.

The use of Frames ensured participants were required to make a choice during both the experimental condition, as well as the control condition. However, it could be argued that a true baseline during which participants simply look at the picture, which has been preferred in previous research (e.g. Goldin et al., 2008; Thiruchselvam et al., 2011) minimises any possible influences the coloured frames could have on regulatory processes. Thus, future studies could assess this by maintaining choices in the experimental and control condition which, however, would not influence the subsequent presentation of the image. For instance, during the control conditions participants could be asked to make a task-irrelevant choice, such as choosing a colour, however, no coloured frame would be presented around the image. Participants would then go on to view the images and asked to respond naturally after their choice.

Furthermore, in regards to flexible choice behaviour, Chapter 3 assumed healthy participants in the general population would be relatively effective regulators and replicate findings of preferred Disengagement use for high and Reappraisal use for low arousal images, thus the inter-personal condition was modelled to resemble this situation which was assumed to be most probable and to represent the "best case scenario". However, configuring an inter-personal condition to be equivalent to an intra-personal condition which involves free choice is quite challenging. For instance, using a random selection of Disengagement and Reappraisal recommendations for both low and high arousal could result in insufficient equivalent trial numbers between the inter- and intra-personal ER conditions. Blue and green frame trials were always collapsed into Frame trials, as no differences were expected between the two and no hypotheses were made regarding differential effects of the colours on regulation. More naturalistic forms of inter-personal ER should be preferred for future studies, for instance studies relying on a second-person paradigm similar to the one presented in Chapter 4. However, assessing efficacy in dyadic explorations of inter-personal ER is incredibly complex, as differences in efficacy can be due to a myriad of issues. The person receiving inter-personal ER might be an ineffective regulator regardless of whether they engage in intra- or inter-personal regulation. Alternatively, the person providing extrinsic inter-personal ER might not be able to choose an appropriate strategy or time at which to commence and terminate regulation, they may be unable to assess whether ER is effective in the other person or miscommunication and misalignment of regulatory goals within the dyad can hinder effective inter-personal ER. Despite all of these additional considerations which are pervasive in second-person ER studies, they provide a clearer picture of how interactive processes exert their modulatory effects on regulation.

Thus, the present ER paradigm offers countless ways in which it can be modified to address future questions. Moreover, the complex trial structure allows for a thorough assessment of various sequences within the regulatory cycle. The sequence of trial events can also be modified to shift the focus in line with the research question, thereby offering numerous avenues for future explorations. For instance, the choice element could be removed if one wanted to solely focus on the inter- and intra-personal differences of a single ER strategy. Moreover, a key issue of investigating social processes lies in the use of third- and second-person paradigms at the cost of increased ecological validity versus experimental control. The paradigm presented herein can be used for both third- and second-person paradigms, thereby offering some flexibility in commencing with third-person, highly controlled studies and moving on to more naturalistic second-person paradigms. Certain methodological restraints must also be considered. Particularly, the use of specific baseline or control conditions, and the conceptualisation of the inter-personal condition within third-person experiments require careful consideration. Nonetheless, this paradigm can yield insights into the differences and similarities between inter- and intra-personal ER which have wide-reaching implications for clinical populations, and within developmental or organisational settings.

This chapter explored the ER paradigm employed within the empirical investigations presented in Chapters 3 and 4. Although different methods were used to investigate inter-personal ER, i.e. EDA and fMRI, a similar paradigm was used to increase the comparability between these results. Three key methodological considerations addressed within the EDA and fMRI experiments are evaluated below. Firstly, the difficulty of an accurate and comprehensive assessment of ER efficacy is explored. This is a general problem in ER research and solutions involving multi-modal assessments are highlighted. Secondly, the strengths and the challenges of the paradigm employed across the present experiments are considered. In particular the advantages of using a unified approach – i.e. one paradigm, which can be modified to address specific questions, is detailed. Moreover, the complex trial structure allows the investigation of different aspects of the regulatory cycle and options for future adaptions were explored. Thirdly, the difficulties of conceptualising an inter-personal ER condition within a third-person, para-social setting, as well as the challenges of using second-person ER tasks were discussed. Inter-personal processes are inherently complex as there are near countless options of how each person's individual characteristics can affect and are affected by the other's characteristics and the given context, but are essential to understanding naturalistic ER as it unfolds within social interactions.

References

Adolphs, R., & Spezio, M. (2006). Role of the amygdala in processing visual social stimuli. *Progress in brain research, 156*, 363-378.

Arlington, V., & Association, A. P. (2013). Diagnostic and statistical manual of mental disorders. *American Psychiatric Association, 5*, 612-613.

Bahl, N., & Ouimet, A. J. (2022). Smiling won't necessarily make you feel better: Response-focused emotion regulation strategies have little impact on cognitive, behavioural, physiological, and subjective outcomes. *Journal of Behavior Therapy and Experimental Psychiatry, 74*, 101695.

Bari, D. S., Yacoob Aldosky, H. Y., & Martinsen, Ø. G. (2020). Simultaneous measurement of electrodermal activity components correlated with age-related differences. *Journal of Biological Physics, 46*, 177-188.

Barrett, L. F. (2006). Solving the Emotion Paradox: Categorization and the Experience of Emotion. *Personality and Social Psychology Review, 10*(1), 20-46. doi:10.1207/s15327957pspr1001_2

Barrett, L. F. (2009). Variety is the spice of life: A psychological construction approach to understanding variability in emotion. *Cognition & Emotion, 23*(7), 1284-1306. doi:10.1080/02699930902985894

Barrett, L. F. (2012). Emotions Are Real. *Emotion, 12*(3), 413-429. doi:10.1037/a0027555

Barrett, L. F., & Bliss-Moreau, E. (2009). AFFECT AS A PSYCHOLOGICAL PRIMITIVE. In M. P. Zanna (Ed.), *Advances in Experimental Social Psychology, Vol 41* (Vol. 41, pp. 167-218).

Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology, 58*, 373-403. doi:10.1146/annurev.psych.58.110405.085709

Barrett, L. F., & Russell, J. A. (1999). The structure of current affect: Controversies and emerging consensus. *Current Directions in Psychological Science, 8*(1), 10-14.

Beckes, L., & Coan, J. A. (2011). Social baseline theory: The role of social proximity in emotion and economy of action. *Social and Personality Psychology Compass, 5*(12), 976-988.

Beckes, L., & Sbarra, D. A. (2022). Social baseline theory: State of the science and new directions. *Current Opinion in Psychology, 43*, 36-41.

Benedek, M., & Kaernbach, C. (2010). Decomposition of skin conductance data by means of nonnegative deconvolution. *Psychophysiology, 47*(4), 647-658.

Benfer, N., Bardeen, J. R., & Clauss, K. (2018). Experimental manipulation of emotion regulation self-efficacy: Effects on emotion regulation ability, perceived effort in the service of regulation, and affective reactivity. *Journal of contextual behavioral science, 10*, 108-114.

Berboth, S., Windischberger, C., Kohn, N., & Morawetz, C. (2021). Test-retest reliability of emotion regulation networks using fMRI at ultra-high magnetic field. *Neuroimage, 232*, 117917.

Bestmann, S., Ruff, C. C., Blankenburg, F., Weiskopf, N., Driver, J., & Rothwell, J. C. (2008). Mapping causal interregional influences with concurrent TMS–fMRI. *Experimental brain research, 191*(4), 383.

Bevilacqua, D., Davidesco, I., Wan, L., Chaloner, K., Rowland, J., Ding, M., . . . Dikker, S. (2019). Brain-to-brain synchrony and learning outcomes vary by student–teacher dynamics: Evidence from a real-world classroom electroencephalography study. *Journal of Cognitive Neuroscience, 31*(3), 401-411.

Bhaganagarapu, K., Jackson, G. D., & Abbott, D. F. (2014). De-noising with a SOCK can improve the performance of event-related ICA. *Frontiers in neuroscience, 8*, 285.

Blackford, J. U., Buckholtz, J. W., Avery, S. N., & Zald, D. H. (2010). A unique role for the human amygdala in novelty detection. *Neuroimage, 50*(3), 1188-1193.

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. doi:10.1177/1745691613504116

Bornemann, B., & Singer, T. (2017). Taking time to feel our body: Steady increases in heartbeat perception accuracy and decreases in alexithymia over 9 months of contemplative mental training. *Psychophysiology, 54*(3), 469-482.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*(1), 49-59.

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

Brown, T. A., Chorpita, B. F., & Barlow, D. H. (1998). Structural relationships among dimensions of the DSM-IV anxiety and mood disorders and dimensions of negative affect, positive affect, and autonomic arousal. *Journal of abnormal psychology, 107*(2), 179.

Butler, E. A., Egloff, B., Wlhelm, F. H., Smith, N. C., Erickson, E. A., & Gross, J. J. (2003). The social consequences of expressive suppression. *Emotion, 3*(1), 48.

Cabanac, M. (2002). What is emotion? *Behavioural processes, 60*(2), 69-83.

Cacioppo, J. T., Tassinary, L. G., & Berntson, G. (2007). *Handbook of psychophysiology*: Cambridge university press.

Cai, R. Y., Richdale, A. L., Uljarević, M., Dissanayake, C., & Samson, A. C. (2018). Emotion regulation in autism spectrum disorder: Where we are and where we need to go. *Autism Research, 11*(7), 962-978.

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological science, 17*(12), 1032-1039.

Compton, R. J. (2000). Ability to disengage attention predicts negative affect. *Cognition & Emotion, 14*(3), 401-415.

Constantinescu, A. C., Wolters, M., Moore, A., & MacPherson, S. E. (2017). A cluster-based approach to selecting representative stimuli from the International Affective Picture System (IAPS) database. *Behavior research methods, 49*(3), 896-912.

Coutinho, J., Oliveira-Silva, P., Fernandes, E., Gonçalves, O. F., Correia, D., Perrone McGovern, K., & Tschacher, W. (2019). Psychophysiological synchrony during verbal interaction in romantic relationships. *Family process, 58*(3), 716-733.

Damasio, A. R. (2001). Descartes error revisited. *Journal of the History of the Neurosciences, 10*(2), 192-194.

Dan-Glauser, E. S., & Gross, J. J. (2013). Emotion regulation and emotion coherence: evidence for strategy-specific effects. *Emotion, 13*(5), 832.

Davidson, R. J. (2003). Affective neuroscience and psychophysiology: Toward a synthesis. *Psychophysiology, 40*(5), 655-665.

Dennison, M., Whittle, S., Yücel, M., Byrne, M. L., Schwartz, O., Simmons, J. G., & Allen, N. B. (2015). Trait positive affect is associated with hippocampal volume and change in caudate volume across adolescence. *Cognitive, Affective, & Behavioral Neuroscience, 15*(1), 80-94.

Denzin, N. K. (2017). *On understanding emotion*: Routledge.

Dolcos, F., Katsumi, Y., Moore, M., Berggren, N., de Gelder, B., Derakshan, N., . . . Okon-Singer, H. (2020). Neural correlates of emotion-attention interactions: From perception, learning, and memory to social cognition, individual differences, and training interventions. *Neuroscience & Biobehavioral Reviews, 108*, 559-601.

Düsing, R., Radtke, E. L., Kuhl, J., Konrad, C., Vandekerckhove, M., & Quirin, M. (2021). Emotion regulation ability compensates for the depression-related negativity bias. *Acta Psychologica, 220*, 103414.

English, T., & Eldesouky, L. (2020). We're not alone: Understanding the social consequences of intrinsic emotion regulation. *Emotion, 20*(1), 43.

English, T., Lee, I. A., John, O. P., & Gross, J. J. (2017). Emotion regulation strategy selection in daily life: The role of social context and goals. *Motivation and Emotion, 41*(2), 230-242.

Fernández, D., Ros, L., Sánchez-Reolid, R., Ricarte, J. J., & Latorre, J. M. (2020). Effectiveness of the level of personal relevance of visual autobiographical stimuli in the induction of positive emotions in young and older adults: pilot study protocol for a randomized controlled trial. *Trials, 21*(1), 1-16.

Figner, B., & Murphy, R. O. (2011). Using skin conductance in judgment and decision making research. *A handbook of process tracing methods for decision research*, 163-184.

Fox, A. S., Oler, J. A., Tromp, D. P., Fudge, J. L., & Kalin, N. H. (2015). Extending the amygdala in theories of threat processing. *Trends in neurosciences, 38*(5), 319-329.

Friston, K. J. (2011). Functional and effective connectivity: a review. *Brain connectivity, 1*(1), 13-36.

Gee, D. G. (2016). Sensitive periods of emotion regulation: influences of parental care on frontoamygdala circuitry and plasticity.

Geršak, G. (2020). Electrodermal activity-a beginner's guide. *Elektrotehniski Vestnik, 87*(4), 175-182.

Goerlich, K. S. (2018). The Multifaceted Nature of Alexithymia - A Neuroscientific Perspective. *Frontiers in Psychology, 9*. doi:ARTN 1614
10.3389/fpsyg.2018.01614

Goldin, P. R., McRae, K., Ramel, W., & Gross, J. J. (2008). The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. *Biological Psychiatry, 63*(6), 577-586. doi:10.1016/j.biopsych.2007.05.031

Gross, E. B., & Medina-DeVilliers, S. E. (2020). Cognitive processes unfold in a social context: a review and extension of social baseline theory. *Frontiers in Psychology, 11*, 378.

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. doi:10.1037/0022-3514.74.1.224

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*(3), 281-291. doi:10.1017/s0048577201393198

Gross, J. J. (2015). Emotion Regulation: Current Status and Future Prospects. *Psychological Inquiry, 26*(1), 1-26. doi:10.1080/1047840x.2014.940781

Gross, J. J., & Levenson, R. W. (1993). Emotional suppression: physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology, 64*(6), 970.

Halberstadt, J., Winkielman, P., Niedenthal, P. M., & Dalle, N. (2009). Emotional conception: How embodied emotion concepts guide perception and facial action. *Psychological science, 20*(10), 1254-1261.

Han, S. C., Schacter, H. L., Timmons, A. C., Kim, Y., Sichko, S., Pettit, C., . . . Margolin, G. (2021). Romantic partner presence and physiological responses in daily life: Attachment style as a moderator. *Biological Psychology, 161*, 108082.

Hasson, U., & Frith, C. D. (2016). Mirroring and beyond: coupled dynamics as a generalized framework for modelling social interactions. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1693), 20150366.

Horvat, M., Kukolja, D., & Ivanec, D. (2015). Comparing affective responses to standardized pictures and videos: A study report. *arXiv preprint arXiv:1505.07398*.

Inman, C. S., Bijanki, K. R., Bass, D. I., Gross, R. E., Hamann, S., & Willie, J. T. (2020). Human amygdala stimulation effects on emotion physiology and emotional experience. *Neuropsychologia, 145*, 106722.

Jang, E.-H., Park, B.-J., Kim, S.-H., Chung, M.-A., Park, M.-S., & Sohn, J.-H. (2013). *Classification of human emotions from physiological signals using machine learning algorithms*. Paper presented at the Proc. Sixth Int'l Conf. Advances Computer-Human Interactions (ACHI 2013), Nice, France.

Järvenoja, H., Malmberg, J., Törmänen, T., Mänty, K., Haataja, E., Ahola, S., & Järvelä, S. (2020). *A collaborative learning design for promoting and analyzing adaptive* *motivation and emotion regulation in the science classroom.* Paper presented at the Frontiers in Education.

Joseph, N. T., Jiang, Y., & Zilioli, S. (2021). Momentary emotions and salivary cortisol: A systematic review and meta-analysis of ecological momentary assessment studies. *Neuroscience & Biobehavioral Reviews*.

Kappas, A. (2011). Emotion and Regulation are One! *Emotion Review, 3*(1), 17-25. doi:10.1177/1754073910380971

Karvonen, A., Kykyri, V. L., Kaartinen, J., Penttonen, M., & Seikkula, J. (2016). Sympathetic nervous system synchrony in couple therapy. *Journal of marital and family therapy, 42*(3), 383-395.

Kircher, T., Blümel, I., Marjoram, D., Lataster, T., Krabbendam, L., Weber, J., . . . Krach, S. (2009). Online mentalising investigated with functional MRI. *Neuroscience letters, 454*(3), 176-181.

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review, 30*(7), 865-878.

Kiverstein, J., & Miller, M. (2015). The embodied brain: towards a radical embodied cognitive neuroscience. *Frontiers in Human Neuroscience, 9*, 237.

Kobylińska, D., & Kusev, P. (2019). Flexible emotion regulation: How situational demands and individual differences influence the effectiveness of regulatory strategies. *Frontiers in Psychology, 10*, 72.

Kohn, N., Eickhoff, S. B., Scheller, M., Laird, A. R., Fox, P. T., & Habel, U. (2014). Neural network of cognitive emotion regulation - An ALE meta-analysis and MACM analysis. *Neuroimage, 87*, 345-355. doi:10.1016/j.neuroimage.2013.11.001

Koike, T., Tanabe, H. C., & Sadato, N. (2015). Hyperscanning neuroimaging technique to reveal the “two-in-one” system in social interactions. *Neuroscience Research, 90*, 25-32.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International affective picture system (IAPS): affective ratings of pictures and instruction manual. University of Florida, Gainesville.* Retrieved from

LeDoux, J. (2003). The emotional brain, fear, and the amygdala. *Cellular and molecular neurobiology, 23*(4), 727-738.

Lee, T.-W., & Xue, S.-W. (2018). Does emotion regulation engage the same neural circuit as working memory? A meta-analytical comparison between cognitive reappraisal of negative emotion and 2-back working memory task. *PloS one, 13*(9), e0203753.

Lehmann, K., Maliske, L., Böckler, A., & Kanske, P. (2019). Social impairments in mental disorders: recent developments in studying the mechanisms of interactive behavior. *Clinical Psychology in Europe, 1*(2), 1-15.

Levy-Gigi, E., Bonanno, G. A., Shapiro, A. R., Richter-Levin, G., Keri, S., & Sheppes, G. (2016). Emotion Regulatory Flexibility Sheds Light on the Elusive Relationship Between Repeated Traumatic Exposure and Posttraumatic Stress Disorder Symptoms. *Clinical Psychological Science, 4*(1), 28-39. doi:10.1177/2167702615577783

Levy-Gigi, E., & Shamay-Tsoory, S. G. (2017). Help me if you can: Evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress. *Journal of Behavior Therapy and Experimental Psychiatry, 55*, 33-40. doi:10.1016/j.jbtep.2016.11.008

Linhartova, P., Latalova, A., Kosa, B., Kasparek, T., Schmahl, C., & Paret, C. (2019). fMRI neurofeedback in emotion regulation: A literature review. *Neuroimage, 193*, 75-92. doi:10.1016/j.neuroimage.2019.03.011

López-Pérez, B., & Pacella, D. (2019). Interpersonal emotion regulation in children: Age, gender, and cross-cultural differences using a serious game. *Emotion*.

Maier, S. U., & Grueschow, M. (2021). Pupil dilation predicts individual self-regulation success across domains. *Scientific reports, 11*(1), 1-18.

Malooly, A. M., Genet, J. J., & Siemer, M. (2013). Individual differences in reappraisal effectiveness: the role of affective flexibility. *Emotion, 13*(2), 302.

Mather, M., & Thayer, J. F. (2018). How heart rate variability affects emotion regulation brain networks. *Current Opinion in Behavioral Sciences, 19*, 98-104.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion, 5*(2), 175.

Mehrabian, A. (1996). Pleasure-arousal-dominance: A general framework for describing and measuring individual differences in temperament. *Current Psychology, 14*(4), 261-292.

Menon, V., & D'Esposito, M. (2022). The role of PFC networks in cognitive control and executive function. *Neuropsychopharmacology, 47*(1), 90-103.

Midkiff, M. F., Lindsey, C. R., & Meadows, E. A. (2018). The role of coping self-efficacy in emotion regulation and frequency of NSSI in young adult college students. *Cogent Psychology, 5*(1), 1520437.

Moodie, C. A., Suri, G., Goerlitz, D. S., Mateen, M. A., Sheppes, G., McRae, K., . . . Gross, J. J. (2020). The neural bases of cognitive emotion regulation: The roles of strategy and intensity. *Cognitive, Affective, & Behavioral Neuroscience*, 1-21.

Morawetz, C., Berboth, S., & Bode, S. (2021). With a little help from my friends: the effect of social proximity on emotion regulation-related brain activity. *Neuroimage*, 117817.

Morawetz, C., Bode, S., Derntl, B., & Heekeren, H. R. (2017). The effect of strategies, goals and stimulus material on the neural mechanisms of emotion regulation: a meta-analysis of fMRI studies. *Neuroscience & Biobehavioral Reviews, 72*, 111-128.

Nakagawa, T., Gondo, Y., Ishioka, Y., & Masui, Y. (2017). Age, Emotion Regulation, and Affect in Adulthood: The Mediating Role of Cognitive Reappraisal. *Japanese Psychological Research, 59*(4), 301-308. doi:10.1111/jpr.12159

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review, 9*(3), 184-211.

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

Opitz, P. C., Rauch, L. C., Terry, D. P., & Urry, H. L. (2012). Prefrontal mediation of age differences in cognitive reappraisal. *Neurobiology of Aging, 33*(4), 645-655. doi:10.1016/j.neurobiolaging.2010.06.004

Paananen, K., Vaununmaa, R., Holma, J., Karvonen, A., Kykyri, V.-L., Tsatsishvili, V., . . . Seikkula, J. (2018). Electrodermal activity in couple therapy for intimate partner violence. *Contemporary Family Therapy, 40*(2), 138-152.

Pacella, D., & López-Pérez, B. (2018). Assessing children's interpersonal emotion regulation with virtual agents: The serious game Emodiscovery. *Computers & Education, 123*, 1-12.

Palumbo, R. V., Marraccini, M. E., Weyandt, L. L., Wilder-Smith, O., McGee, H. A., Liu, S., & Goodwin, M. S. (2017). Interpersonal autonomic physiology: A systematic review of the literature. *Personality and Social Psychology Review, 21*(2), 99-141.

Pauw, L. S., Sauter, D. A., Van Kleef, G. A., & Fischer, A. H. (2019). Stop crying! The impact of situational demands on interpersonal emotion regulation. *Cognition and emotion, 33*(8), 1587-1598.

Phelps, E. A., & LeDoux, J. E. (2005). Contributions of the amygdala to emotion processing: from animal models to human behavior. *Neuron, 48*(2), 175-187.

Popper, K. (2005). *The logic of scientific discovery*: Routledge.

Posada-Quintero, H. F., & Chon, K. H. (2020). Innovations in electrodermal activity data collection and signal processing: A systematic review. *Sensors, 20*(2), 479.

Ramírez-Martín, A., Ramos-Martín, J., Mayoral-Cleries, F., Moreno-Küstner, B., & Guzman-Parra, J. (2020). Impulsivity, decision-making and risk-taking behaviour in bipolar disorder: a systematic review and meta-analysis. *Psychological medicine*, 1-13.

Ratcliffe, M. (2005). The feeling of being. *Journal of Consciousness Studies, 12*(8-9), 43-60.

Ravaja, N. (2009). The psychophysiology of digital gaming: The effect of a non co-located opponent. *Media Psychology, 12*(3), 268-294.

Ray, R. D., & Zald, D. H. (2012). Anatomical insights into the interaction of emotion and cognition in the prefrontal cortex. *Neuroscience & Biobehavioral Reviews, 36*(1), 479-501.

Redcay, E., & Schilbach, L. (2019). Using second-person neuroscience to elucidate the mechanisms of social interaction. *Nature Reviews Neuroscience, 20*(8), 495-505.

Reeck, C., Ames, D. R., & Ochsner, K. N. (2016). The social regulation of emotion: An integrative, cross-disciplinary model. *Trends in Cognitive Sciences, 20*(1), 47-63.

Rompilla Jr, D. B., Hittner, E. F., Stephens, J. E., Mauss, I., & Haase, C. M. (2021). Emotion regulation in the face of loss: How detachment, positive reappraisal, and acceptance shape experiences, physiology, and perceptions in late life. *Emotion.*

Rudnicki, K., Declerck, C., De Backer, C., & Berth, M. (2019). Physiological changes during first encounters and their role in determining the perceived interaction quality. *Interaction Studies, 20*(2), 275-306.

Sahi, R. S., Ninova, E., & Silvers, J. A. (2020). With a little help from my friends: Selective social potentiation of emotion regulation. *Journal of Experimental Psychology: General.*

Satne, G. (2020). Understanding others by doing things together: an enactive account. *Synthese, 198*(Supplement 1), 507-528.

Saxbe, D. E., Beckes, L., Stoycos, S. A., & Coan, J. A. (2020). Social allostasis and social allostatic load: a new model for research in social dynamics, stress, and health. *Perspectives on Psychological Science, 15*(2), 469-482.

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social science information, 44*(4), 695-729.

Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., & Vogeley, K. (2013). Toward a second-person neuroscience 1. *Behavioral and brain sciences, 36*(4), 393-414.

Schonfelder, S., Kanske, P., Heissler, J., & Wessa, M. (2014). Time course of emotion-related responding during distraction and reappraisal. *Social Cognitive and Affective Neuroscience, 9*(9), 1310-1319. doi:10.1093/scan/nst116

Schooler, J., & Schreiber, C. A. (2004). Experience, meta-consciousness, and the paradox of introspection. *Journal of Consciousness Studies, 11*(7-8), 17-39.

Sergerie, K., Chochol, C., & Armony, J. L. (2008). The role of the amygdala in emotional processing: a quantitative meta-analysis of functional neuroimaging studies. *Neuroscience & Biobehavioral Reviews, 32*(4), 811-830.

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.

Shamay-Tsoory, S. G., & Mendelsohn, A. (2019). Real-life neuroscience: an ecological approach to brain and behavior research. *Perspectives on Psychological Science, 14*(5), 841-859.

Shaw, D. J., Czekóová, K., Staněk, R., Mareček, R., Urbánek, T., Špalek, J., . . . Brázdil, M. (2018). A dual-fMRI investigation of the iterated Ultimatum Game reveals that reciprocal behaviour is associated with neural alignment. *Scientific reports, 8*(1), 1-13.

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., & Levin, Z. (2013). Emotion regulation choice: selecting between cognitive regulation strategies to control emotion. *Frontiers in Human Neuroscience, 7*, 179.

Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., & Gross, J. J. (2014). Emotion Regulation Choice: A Conceptual Framework and Supporting Evidence. *Journal of Experimental Psychology-General, 143*(1), 163-181. doi:10.1037/a0030831

Silani, G., Bird, G., Brindley, R., Singer, T., Frith, C., & Frith, U. (2008). Levels of emotional awareness and autism: an fMRI study. *Social neuroscience, 3*(2), 97-112.

Soares, J. M., Magalhães, R., Moreira, P. S., Sousa, A., Ganz, E., Sampaio, A., . . . Sousa, N. (2016). A hitchhiker's guide to functional magnetic resonance imaging. *Frontiers in neuroscience, 10*, 515.

Sperduti, M., Makowski, D., Arcangeli, M., Wantzen, P., Zalla, T., Lemaire, S., . . . Piolino, P. (2017). The distinctive role of executive functions in implicit emotion regulation. *Acta Psychologica, 173*, 13-20.

Špiláková, B., Shaw, D. J., Czekóová, K., & Brázdil, M. (2019). Dissecting social interaction: dual-fMRI reveals patterns of interpersonal brain-behavior relationships that dissociate among dimensions of social exchange. *Social Cognitive and Affective Neuroscience, 14*(2), 225-235.

Strauss, G. P., Ossenfort, K. L., & Whearty, K. M. (2016). Reappraisal and distraction emotion regulation strategies are associated with distinct patterns of visual attention and differing levels of cognitive demand. *PloS one, 11*(11), e0162290.

Teixeira, R. J., Bermond, B., & Moormann, P. P. (2018). *Current Developments in Alexithymia - a Cognitive and Affective Deficit*: Nova Science Publishers, Incorporated.

Terpe, S. (2015). Triangulation as data integration in emotion research. In *Methods of exploring emotions* (pp. 305-313): Routledge.

Tewarie, P., Liuzzi, L., O'Neill, G. C., Quinn, A. J., Griffa, A., Woolrich, M. W., . . . Brookes, M. J. (2019). Tracking dynamic brain networks using high temporal resolution MEG measures of functional connectivity. *Neuroimage, 200*, 38-50.

Thiruchselvam, R., Blechert, J., Sheppes, G., Rydstrom, A., & Gross, J. J. (2011). The temporal dynamics of emotion regulation: an EEG study of distraction and reappraisal. *Biol Psychol, 87*(1), 84-92. doi:10.1016/j.biopsycho.2011.02.009

Tracy, J. L., Klonsky, E. D., & Proudfit, G. H. (2014). How affective science can inform clinical science: An introduction to the special series on emotions and psychopathology. *Clinical Psychological Science, 2*(4), 371-386.

Uusberg, A., Taxer, J. L., Yih, J., Uusberg, H., & Gross, J. J. (2019). Reappraising reappraisal. *Emotion Review, 11*(4), 267-282.

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.

Woo, C.-W., Krishnan, A., & Wager, T. D. (2014). Cluster-extent based thresholding in fMRI analyses: pitfalls and recommendations. *Neuroimage, 91*, 412-419.

Zaki, J. (2020). Integrating empathy and interpersonal emotion regulation. *Annual Review of Psychology, 71*, 517-540.

Chapter 3 – Comparing Inter- and Intra-Personal Emotion Regulation using Electrodermal Activity Measures and Rating Responses

This chapter has been submitted for publication and is currently under review with the International Journal of Psychophysiology.

3.1. Introduction

Emotion regulation (ER) describes the volitional process through which an emotional experience is altered (Gross, 2015, Tamir et al., 2020, Gross, 1998b). Since humans are inherently social, ER is influenced enormously by those around us (English et al., 2017, Dixon-Gordon et al., 2015); just as we support others in regulating their emotions, we often follow guidance provided from those around us when regulating our own affective states (Nozaki and Mikolajczak, 2020). This is referred to as extrinsic and intrinsic forms of inter-personal ER, respectively, and illustrates how the regulation of emotions often involves a complex interplay between affective and social processes (English et al., 2017, Butler, 2017). This differs from *intra*-personal ER – that is, when individuals regulate their own emotions without any external (social) support (Zaki and Williams, 2013). Although a wealth of research has informed our understanding of both intra- and inter-personal intrinsic ER, such as the regulatory strategies we tend to choose for ourselves in different situations (Gross, 2001, Bonanno and Burton, 2013, Sheppes and Meiran, 2007, Demaree et al., 2004) and how we implement those instructed or recommended to us by others (Zaki and Williams, 2013, Bernat et al., 2011, Jackson et al., 2000, Gross, 1998a), few studies have compared their effectiveness directly. Given the potential therapeutic implications of effective inter-personal intrinsic ER (e.g., patient-clinician interactions), the present study performed a psychophysiological assessment of its efficacy relative to intra-personal ER, and sought to identify the characteristics of individuals who benefit from it maximally.

Inter-personal intrinsic ER is a goal-directed process, during which an individual interacts with one or more other people in an attempt to modify their own emotional state (Zaki, 2020, Zaki and Williams, 2013, Barthel et al., 2018). Preliminary findings from the few behavioural studies that have compared this interactive process with intra-personal ER indicate that the former has the potential to be more effective at regulating emotions: Levy-Gigi and Shamay-Tsoory (2017), for example, found that individuals reported less intense negative emotions when they implemented an ER strategy recommended to them by their romantic partner compared to one that they had self-selected intra-personally. Morawetz et al. (2021) report the same reduction in subjective ratings of emotional intensity when individuals were guided by a close friend in down-regulating their negative affective reactions relative to when they attempted ER by themselves. Large-scale questionnaire data have also been used to demonstrate the enhanced effects of inter- relative to intra-personal intrinsic ER on self-reported psychological outcomes among female friends (Christensen et al., 2020). Although Morawetz et al. (2021) identified a brain system that appeared to differentiate between intra- and interpersonal intrinsic ER, direct comparisons of their effectiveness have relied exclusively on self-report ratings of emotional experience. Such subjective impressions are likely to reflect large individual differences in identifying and evaluating our emotional states accurately, and can be highly susceptible to expectation biases (Swart et al., 2009, Gross and Jazaieri, 2014, Sheppes et al., 2015). Although other studies have observed reductions in physiological indices of affective reactions within social settings (e.g., Lougheed et al., 2016, Uchino et al., 1999, Lepore et al., 1993), such objective metrics have not been used to compare intra- with inter-personal intrinsic ER.

Emotions are multifaceted constructs, comprising subjective experiences of valence and arousal, physiological responses (e.g., electrodermal activity) and behavioural (e.g., facial) expressions (Barrett and Bliss-Moreau, 2009). While some scholars assume these subsystems to be aligned at all times (Rosenberg, 1997, Ekman, 1992, Camodeca and Nava, 2020), research findings challenge this assumption in at least three ways (Hot et al., 2005, Gross, 1998a, Cacioppo and Tassinary, 1990, Brown et al., 2019). First, the intensity of an emotion has been shown to moderate the degree of convergence among these subsystems; subjective experiences correlate positively with both behavioural and physiological responses during high-intensity emotional states (Rosenberg and Ekman, 1994, Brown et al., 2019), but such convergence is reduced or abolished completely for low-intensity emotions (Sze et al., 2010, Mauss et al., 2005). Second, different ER strategies influence the degree of alignment; while some strategies (e.g., expressive suppression) appear to modify physiological indices but not subjective ratings (Gross, 1998a, Dan-Glauser and Gross, 2013, Gross and Levenson, 1993), others have the reverse effect (Urry, 2009, Ray et al., 2010). Third, the direction of regulation also influences convergence among affective subsystems. For example, Urry (2009) reports that unpleasant images were rated less negatively when individuals were asked to decrease their emotional reactions, despite no observable changes in their facial electromyograph, heart rate or skin conductance; but when asked to increase their negative emotions, both subjective ratings and physiological responses increased in parallel. Given this potential disconnect between subjective experiences and physiological measures of emotional state, the current study compared intra- and inter-personal intrinsic ER by assessing both self-report ratings and skin-conductance responses.

In the present study, we adapted an experimental paradigm used elsewhere (Levy-Gigi and Shamay-Tsoory, 2017, Sheppes et al., 2014, Sheppes et al., 2011) such that individuals implemented an ER strategy they had self-selected or one that had been recommended to them by an experimenter within an interpersonal setting. Our adaptation was based upon current knowledge of intra-personal ER: First, different mechanisms appear to underpin the up- and down-regulation of positive and negative emotions (Kim and Hamann, 2007). Since negative emotions are associated with greater physiological responses compared to positive or neutral emotions (Cacioppo and Gardner, 1999), and given the detrimental effects on one's mental and physical health from their chronic *dys*regulation (Aldao et al., 2010, Gross and Jazaieri, 2014, Barlow et al., 2004, Beaudreau and O'Hara, 2008, Cludius et al., 2020), the present study compared intra- and inter-personal intrinsic ER in terms of their effectiveness in reducing negative emotional reactions. Second, we focused our attention on two ER strategies that have received the majority of experimental attention to date: participants were free to choose between *reappraisal* – whereby the meaning conveyed by a stimulus is altered so as to modify the emotion(s) it evokes, or *disengagement* – a strategy that involves thinking of something unrelated to the present stimulus as a means of avoiding any emotion(s) it elicits (Goldin et al., 2008, Scheibe et al., 2015, Sheppes and Meiran, 2007, Hughes et al., 2020, McRae and Gross, 2020). Third, and perhaps most importantly, research has shown that people exhibit a preference for reappraisal when down-regulating their emotional reactions to low-arousal stimuli but choose disengagement for high-arousal images (Sheppes et al., 2014, Shafir and Sheppes, 2020). Furthermore, people report greater difficulties in implementing reappraisal in response to high-arousal stimuli (Hajcak et al., 2010), and evidence suggests a reduced efficacy of reappraisal under high and disengagement under low arousal (Shafir et al., 2015, Raio et al., 2013). To maximise the comparability of inter-personal intrinsic ER to the expected pattern of choices during its intra-personal counterpart, permitting a more direct comparison, individuals always received recommendations to disengage in response to high- and reappraise in response to low-arousal stimuli.

Goal-directed ER involves identifying the need to regulate, selecting an appropriate strategy, implementing the strategy and then evaluating its effectiveness (Gross, 2015). Here, we focus specifically on the latter two phases of ER. To evaluate the relative efficacy of intrinsic ER performed intra- or inter-personally, we moved away from the traditional control condition in which participants are instructed typically to "just look" at the images passively. Specifically, we compared subjective and physiological indices of negative emotional reactions under both types of ER against those acquired when participants viewed the emotion-eliciting images surrounded by a self-selected or externally directed coloured frame. Whilst not providing a true baseline, these frame trials allowed us to isolate the effect of implementing

ER strategies under the intra- or inter-personal condition from those associated with decision-making processes or receiving external recommendations; the experimental and control trials were made equivalent except for the intrinsic ER element. Further, these frame trials allowed us to compare the effectiveness of self-selected or externally recommended top-down cognitive strategies (reappraisal and disengagement) against a more exogenous process; namely, the re-direction of attention away from the content of the emotion-eliciting stimulus and towards the coloured frame. Although such exogenous attentional (re-)allocation might serve as an ER strategy in its own right (e.g., MacLeod et al., 2002), this would occur earlier than the active cognitive control required for intrinsic ER; both are antecedent-focused strategies that serve to modulate emotional experiences before they are fully generated (Ochsner and Gross, 2005), but attentional shifts occur much earlier in the emotion generative process. As such, this offered a control condition against which the endogenous ER strategies implemented under the intra- and inter-personal conditions could be compared.

Finally, we sought to shed light on the mechanisms underlying the apparent superiority of inter- over intra-personal intrinsic ER. It is unclear whether the relative benefits of the former are due primarily to the inter-personal dynamic itself (English and Eldesouky, 2020) or if they are moderated by person characteristics known to influence the latter (e.g., Niven et al., 2019, Coan et al., 2006; for a related discussion see Hughes et al., 2020). To investigate this, the present study also explored relationships between individual differences in inter-personal intrinsic ER and those expressed in variables that impact upon intra-personal ER. This included individuals' age (Opitz et al., 2012, Urry and Gross, 2010), their mood state at the time of testing (Larcom and Isaacowitz, 2009), the flexibility they show in their own choices of ER strategy (Kashdan and Rottenberg, 2010, Malooly et al., 2013, Pruessner et al., 2020, Sheppes et al., 2014), their perceived self-efficacy in intrinsic ER (Colombo et al., 2020, Tamir and Mauss, 2011), and their expression of alexithymic (Swart et al., 2009) and autistic traits (Mazefsky et al., 2012, Samson et al., 2015). According to the socioemotional selectivity theory, older adults exhibit improved ER abilities because they prioritise affective experiences (Carstensen et al., 2003). However, studies that have examined differences in strategy preferences and the success of ER implementation between younger and older adults yield inconsistent findings (Livingstone and Isaacowitz, 2021). Negative mood, inflexible choices and a belief of self-inefficacy in ER has been shown to limit one's ability to access and implement ER strategies intra-personally (Salsman and Linehan, 2012, Midkiff et al., 2018, Tamir and Mauss, 2011, Bonanno and Burton, 2013). Alexithymia describes the lack of awareness or inability to verbalise one's emotional experiences (Bermond et al., 2010, Goerlich, 2018). As a result, high alexithymic traits can limit an individual's ability to process, evaluate and regulate their emotions effectively (Preece et al., 2018).

In light of the literature reviewed above, we hypothesised that negative emotions evoked by unpleasant stimuli would be more intense during intra- compared with inter-personal intrinsic ER, as indexed by higher subjective ratings and greater skin-conductance responses. Further, we hypothesised that lower ratings and electrodermal responses would be observed under both intra- and inter-personal conditions during endogenous ER compared with trials in which participants passively viewed emotion-eliciting images surrounded by coloured frames. We also predicted that, particularly for younger adults, a negative mood state, self-perceived ER inability, and high expressions of alexithymic and autistic traits would impede individuals' ability to down-regulate their own emotions – that is, we expected positive correlations between these characteristics and measures of affective reactions during both the intra- and inter-personal condition.

3.2. Experiment 1: Laboratory EDA Experiment

3.2.1. Methods

In the following sections we report all measures, manipulations and exclusions. All experimental scripts and materials are available at https://osf.io/stcr4.

3.2.2. Participants

A power analysis performed in G-Power (Faul et al., 2007) for a repeated-measures 2 (Condition: Intra-personal, Inter-personal) x 3 (Strategy: Reappraisal, Disengagement, Frames) ANOVA (Cohen's $f = .14$, $\beta = .95$) indicated that a sample of 134 participants was required. To account for potential data loss, 153 students and staff were recruited from Aston University. Data from seven of these individuals were omitted from any analyses due to poor physiological recordings, leaving a final sample of 146 participants (27 males; $M_{age} = 24.32$ [$SD_{age} = 7.88$; range = 18 - 63] years). The procedure was approved by the Research Ethics Committee of Aston University (ref: #1465) in accordance to the 1964 Declaration of Helsinki, and all participants gave their written informed consent prior to commencing the experiment. Upon completion, students were recompensed with course credits and staff with £10.

3.2.3. Procedure

The experimental procedure comprised one short experimental task to assess participants' mood, three questionnaires measuring different personality characteristics, and the Emotion Regulation Task. Each measure was administered with PsychoPy v1.90.1. (Peirce et al., 2019) in the order they are described below in section 2.3. Measures. Participants completed the procedure in a single session, in a shielded laboratory with an average temperature of 25°C (SE= .11). Once the recording equipment had been placed onto participants (see below; *2.4. Physiological Data Acquisition*), they first performed the assessment of their mood and then completed the three questionnaires. Physiological recordings commenced during this time (but were not evaluated) to allow the electrodes to calibrate for a minimum of 10 minutes. Participants then practiced implementing disengagement and reappraisal ER with the experimenter before starting the Emotion Regulation Task.

3.2.4. Measures

3.2.4.1. Mood

A computerised version of the Implicit Positive and Negative Affect Test (IPANAT; Quirin et al., 2009) was used as an implicit measure of participants' mood at the time of testing. This test has been shown to predict physiological metrics more accurately than self-report measures (Quirin and Bode, 2014), and achieves good test-retest reliability (> .072; van der Ploeg et al., 2016). Participants indicated how well three positive ("cheerful", "happy", and "energetic") and three negative adjectives ("inhibited", "tense", and "helpless") described six artificial words (e.g. "SUKOV", "BELNI") using a 4-point Likert scale ranging from 1 ("*Does not fit at all*") to 4 ("*Fits very well*"). The presentation order of all artificial words and adjectives were randomised for each participant. Ratings for positive affect and negative affect have shown acceptable internal consistency (Cronbach's α = .78 and .68, respectively).

3.2.4.2. Alexithymia

Alexithymia was measured using the 40-item Bermond-Vorst Alexithymia Questionnaire (BVAQ; Vorst and Bermond, 2001), which captures both cognitive and affective dimensions of alexithymic traits with five 8-item subscales: Verbalising, Fantasising, Identifying, Emotionalising and Analysing. Participants rated items on a 5-point Likert scale ranging from 1 ("*Definitely applies to me*") to 5 ("*In no way applies to me*"). Unlike the alternative Toronto Alexithymia Scale that is also used commonly (Taylor et al., 1992), the BVAQ captures the construct of alexithymia in its entirety by including the fantasising and emotionalising dimensions. It also exhibits superior psychometric properties, including counterbalancing and equal items in each subscale. Good construct validity and internal consistency has also been reported, with Cronbach's α between .75 and .83 for the subscales (de Vroege et al., 2018).

3.2.4.3.Autism

The 36-item Broad Autism Phenotype Questionnaire (BAPQ; Hurley et al., 2007) was used to measure traits resembling sub-clinical autistic characteristics, often found in non-diagnosed relatives of people with autism. Participants rated items on a 6-point Likert scale ranging from 1 ("*Very rarely*") to 6 ("*Very often*"). The BAPQ shows good reliability (Cronbach's α between .87 and .89) and good construct validity (Nishiyama et al., 2014). An alternative instrument used commonly – the Autism-Spectrum Quotient (Baron-Cohen et al., 2001), has been shown to have poorer internal consistency than the BAPQ (Nishiyama et al., 2014).

3.2.4.4. Self-efficacy in emotion regulation

Participants' self-estimation of their ER abilities was captured using the Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004). This 36-item instrument includes the subscales "Awareness", "Clarity", "Goals", "Impulse", "Non-acceptance" and "Strategies". Participants respond to each item using a 5-point Likert scale, ranging from 1 ("*Almost never*") to 5 ("*Almost always*"). The DERS is used widely in research and clinical settings, and shows good construct validity and internal consistency for all subscales (Cronbach's α between .82 and .92; Hallion et al., 2018).

Table 3.1 presents the distributions of responses and reliability estimates for each questionnaire.

Table 3.1.

Mean (±standard error) and Cronbach's Alpha for all self-report measures.

	Mean (±SE)	Cronbach's alpha
PA	2.06 (.04)	.78
NA	1.99 (.03)	.68
BVAQ	97.57 (1.49)	.86
BAPQ	2.78 (.05)	.89
DERS	88.93 (2.40)	.95

Note. PA and NA represent the positive and negative affect scales of the IPANAT, respectively. BVAQ= Bermond-Vorst Alexithymia Questionnaire; BAPQ= Broad Autism Phenotype Questionnaire; DERS= Difficulties in Emotion Regulation Scale.

3.2.4.5. Emotion Regulation Task

To assess participants' ability to regulate their emotions, we adapted an experimental procedure that has been validated elsewhere (Levy-Gigi and Shamay-Tsoory, 2017, Sheppes et al., 2014, Sheppes et al., 2011). This Emotion Regulation Task was performed in a within-subjects design; all participants viewed negatively valenced images under both an Intra- and Inter-personal condition, which were blocked and presented in a counterbalanced order to avoid any order effects. During the Intra-personal block, participants were asked to choose either one of two strategies to down-regulate their emotional response to the image (disengagement or reappraisal; Intra_{ER}) or a coloured frame to be presented around it (blue or green; $\text{Intra}_{\text{Frame}}$). In the Inter-personal condition, participants were instructed to implement the strategy or view the image surrounded by a frame colour chosen ostensibly by the experimenter (Inter_{ER} or $\text{Inter}_{\text{Frame}}$, respectively; see Figure 3.1. for an illustration of the protocol, and the full instructions given to participants are presented in 3.3.5.1. Instructions).

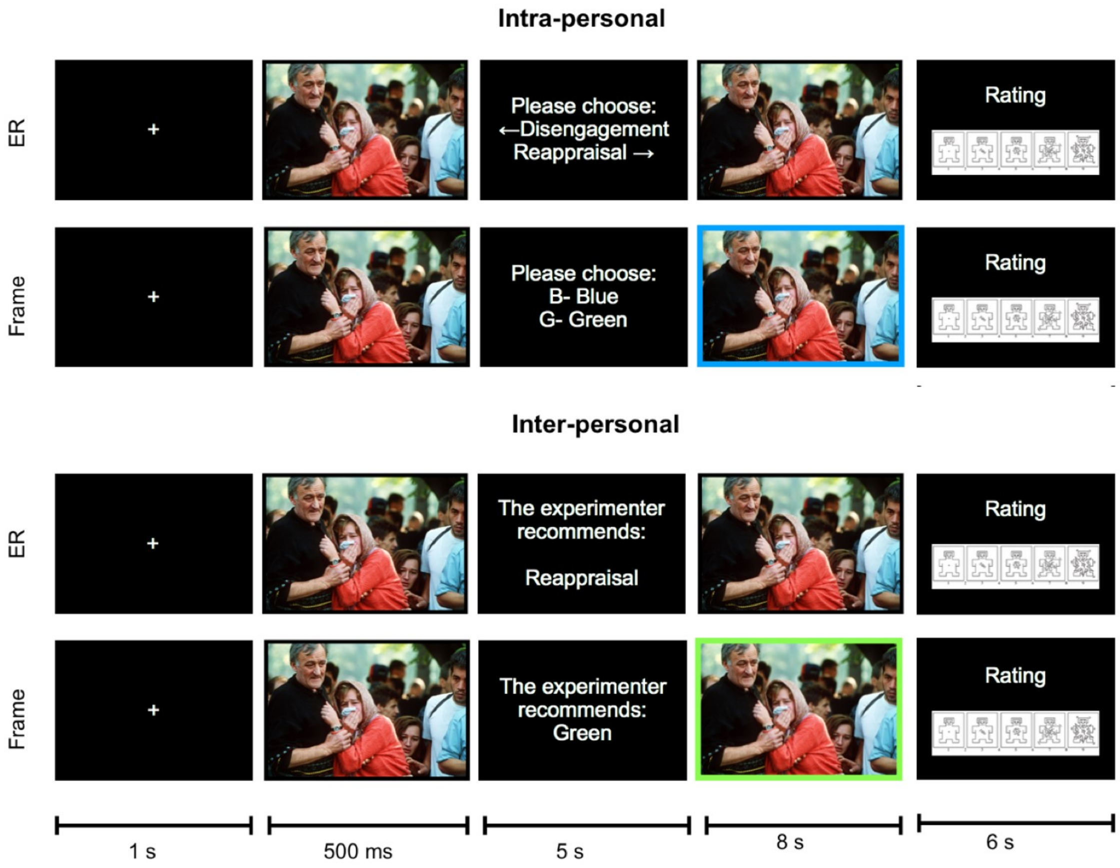


Figure 3.1.
Example trial sequences for the Intra- and Inter-personal condition.[2]

All trials begin with a 1000 ms fixation cross that was followed immediately by a 500 ms preview of a negative image with either high or low normative arousal ratings (see below). This brief preview allowed participants and, ostensibly, the experimenter to decide upon the most effective ER strategy to implement or recommend (Sheppes et al., 2011). Participants were then given 5000 ms to make one of two choices, or prepare to implement a recommendation made to them: During the Intra-personal condition, they were required to choose between disengagement or reappraisal (left or right arrow key, respectively) as a

---

[2] Image copyright - Mikhail Evstafiev © Wikipedia Creative Commons.

strategy for down-regulating their emotional reaction to a subsequent 8000 ms presentation of that same image (Intra_{ER} trials), or select either a blue or green frame to be presented around the image upon its subsequent presentation ('B' or 'G' key, respectively; $\text{Intra}_{\text{Frame}}$ trials). In the Inter-personal condition, they received an instruction on the ER strategy they should implement on the subsequent presentation of the image (Inter_{ER}; i.e. disengagement for high- and reappraisal for low-arousal trials), or they were told the frame colour they would see around the image ($\text{Inter}_{\text{Frame}}$). The experimenter sat with a laptop behind the participant throughout both conditions and participants were told that the recommendations presented to them during the Inter-personal condition were made by the experimenter. This positioning of the experimenter prevented any inadvertent social cues from confounding participants reactions to the stimuli. In the final 6000 ms trial segment, participants were asked to rate the intensity of their emotional response to the image on a 1 (low) to 9 (high) scale using the Self-Assessment Manikin (Bradley and Lang, 1994). These subjective ratings represent one of three dependent measures.

Table 3.2.

Practice Images and Examples Provided to Participants.

Practice Image	Example
	**Reappraisal:** You might think that these children got dirty playing in the park and are eating sweets.
	**Reappraisal:** You might think that this man is on his way to a shelter, so he will have a safe place to sleep tonight.

	**Disengagement:** You might ask yourself what kind of flowers the boy is holding.
	**Disengagement:** You could think about your commute this morning or the different models of the cars.

Before commencing the task, participants completed four trials to practice both ER strategies twice (examples of the images are provided in Table 3.2.). Four images were used for these practice trials – two low- and two high-arousal. Each practice trial followed the same sequence illustrated in Figure 1, but with an additional indefinite interval at the end for participants to verbalise their implementation of each strategy. Practice finished only if the experimenter was satisfied that the participant understood how to employ both regulation strategies. Following these practice trials, participants completed 120 experimental trials in total, split across an Intra- and Inter-personal block, each block consisting of 60 unique images – 30 low- and 30 high-arousal pictures, divided equally between Intra$_{\text{ER}}$/Inter$_{\text{ER}}$ and Intra$_{\text{Frame}}$/Inter$_{\text{Frame}}$ trials. The sequence of the two blocks was counterbalanced across participants.

The 124 images used across the practice and experimental trials were selected from the International Affective Picture System (IAPS; Lang et al., 2008). Following the requirements of the institutional review board, only images with normative valence ratings of 1-4 and arousal ratings of 3-5 were used; images with normative arousal ratings of 3.0-3.9 were classified as low arousal, and the remaining images were classed as high arousal.[3] Although different images were used in the Intra- and Inter-personal conditions, the two stimulus sets were matched closely on normative valence (M$_{\text{Inter}}$= 3.93, SD$_{\text{Inter}}$= .80; M$_{\text{Intra}}$= 4.08, SD$_{\text{Intra}}$=

---

[3] The images we label as 'high-arousal' might correspond more closely to the moderate-arousal images used in previous studies.

.72; $t_{[59]}$= -1.02, p= .314) and arousal ratings (M_{Inter}= 4.01, SD_{Inter}= .57; M_{Intra}= 3.87, SD_{Intra}= .74; $t_{[59]}$= 1.25, p= .215). The categorisation of these stimuli into high- and low-arousal was determined by mean normative arousal ratings (low = 3.39 [SD = .46], high = 4.49 [SD = .25]). In an event-related fashion, trials were presented in a pseudorandomised order such that neither ER nor Frame trials were presented successively on more than three occasions.

3.2.4.5.1. Instructions Given to Participants

The following instructions were given to participants for the laboratory experiment:

Instructions

The following instructions were given to participants before the practice trials:

> *"You are about to practice using the strategies DISENGAGEMENT and REAPPRAISAL to decrease negative emotions. You will see a brief preview of an image, before you are asked to use one of the two strategies.*
>
> *When you are asked to use DISENGAGEMENT, please look at the picture closely whilst thinking about something neutral.*
>
> *When asked to use REAPPRAISAL please look at the picture closely and try to give the picture a different meaning that helps you feel more positive about it.*
>
> *You will then be given 8 seconds to use the strategy whilst looking at the picture.*
>
> *At the end of each trial, you will be asked to give verbal feedback to the experimenter on your approach of the strategies."*

Instructions for the Intra-personal condition

> *"You are about to see some images intended to produce negative emotions. First, you will see a very brief preview of each picture. You will then be asked to either freely select a frame colour (BLUE or GREEN) or a strategy (DISENGAGEMENT or REAPPRAISAL) to help you decrease any negative emotions you might feel. Once you have made your choice, you will see the picture again for 8 seconds.*
>
> *If you were asked to select a coloured frame, the picture will reappear with your chosen frame colour. Please simply look at the image.*
>
> *If you were asked to select a strategy, please use your chosen strategy whilst viewing the image for 8 seconds.*

> *After each image you will be asked to rate how intense your emotional response was to the picture you just viewed on a scale from 1 (=low) to 9 (=high).”*

Instructions for the Inter-personal condition

> *“You will see a brief preview of each picture before an emotion regulation strategy is recommended to you. Either REAPPRAISAL or DISENGAGEMENT will be recommended to you to decrease your negative emotions. After a strategy has been recommended to you, you will see the image again for 8 seconds. Please use the strategy that you are recommended. You will then be asked to rate how intense your emotional response was to the picture on a scale of 1-9.”*

Inter-personal ER instructions were provided as follows:

“The experimenter recommends you use: REAPPRAISAL” or “The experimenter recommends you use: DISENGAGEMENT”

3.2.5. Physiological Data Acquisition

Electrodermal activity (EDA) was acquired with a Biopac MP36 system and Biopac Student Lab 4.0. Sampling was performed at 1kHz, with a low-pass filter of 66.5 sec, a quality factor of 0.5, and a gain of 2000. Two SS3LA transducers were treated with isotonic gel (Biopac Systems Inc.) and attached to the distal phalanges of participants’ left middle and index finger. Triggers signalling trial and image onsets were sent from the Biopac computer to the stimulus PC via a STP35A parallel port cable.

3.2.5.1. Physiological Data Processing

The pre-processing and analysis of EDA data was performed using Ledalab (Benedek and Kaernbach, 2010), a toolbox for MATLAB R2017a (Mathworks, 2017). First, a constant was applied to ensure that the signal minimum was equal to 1. This signal was then downsampled to 50Hz using a factor mean of 20, before being low-pass filtered with a first-order Butterworth filter (cut-off = 5Hz) and smoothed with an adaptive filter that convolved the signal with a Gaussian window (σ= 200ms). Once pre-processed, Continuous Decomposition Analysis was used to decompose skin conductance signals into tonic, slow-changing skin conductance levels and phasic skin conductance responses (SCRs). The skin conductance levels were identified as segments displaying increases of < 0.01 μS using peak detection analyses, and were subsequently subtracted from the overall signal. Participants' individual SCR shape was modelled using an impulse response function, which was estimated over four iterations to determine the best fit. For each participant, the response function was fitted four times prior to selecting the best-fitting response function. This is crucial, as people differ in their affective responsivity which is also referred to as someone's affective style (Davidson, 2003). In particular, these differences can be observed as differences in the required threshold to elicit an affective response, differences in magnitude of the elicited response, differences in the shape of the response function driven by differential rise and recovery times of the response, as well as differences in the overall duration of the affective response (Davidson, 1998). The number of SCRs (nSCR) above 0.01 μS occurring 1-4 secs following the onset of the 8 sec image presentation, and the sum of their amplitudes (AmpSum) were used as two separate dependent measures of EDA.

3.3. Results

Distributions of participants' subjective ratings, the number of skin-conductance responses (nSCRs) and the sum of their amplitudes (AmpSum) during each trial type are presented together in Figure 3.2. Although the number of skin conductance responses (nSCR) were distributed normally, subjective ratings and the sum of amplitudes (AmpSum) were skewed positively. These measures were therefore corrected using square root and logarithmic transformations, respectively, prior to any analyses. Due to the imbalanced sex distribution, whole-group *and* females-only analyses were conducted; however, since the results of the latter did not differ significantly to those for the former, only whole-group findings are reported (a whole-group and females-only comparison is provided in Table 3.4.).

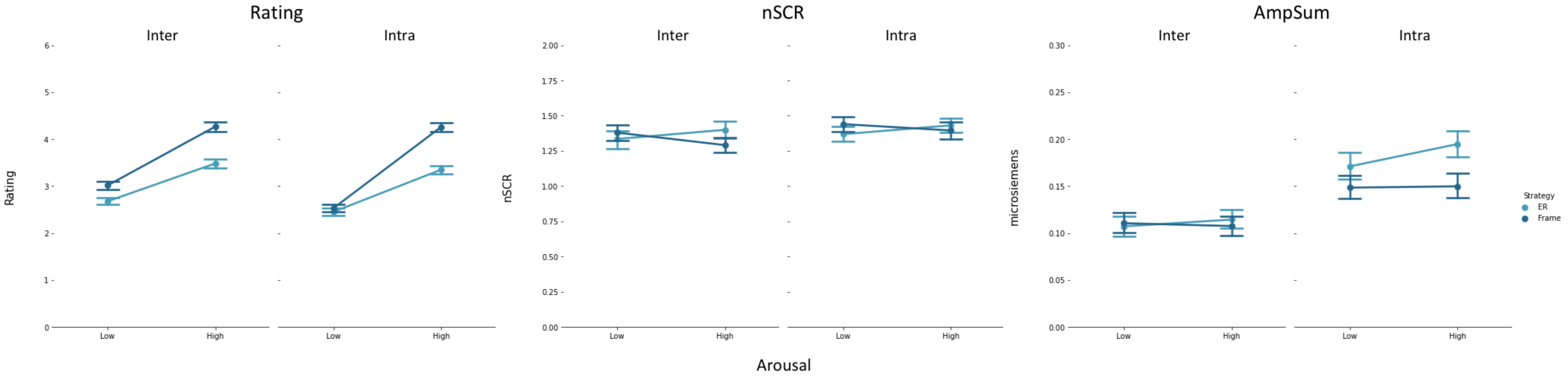


Figure 3.2.
Interaction effects between Condition (Inter, Intra), Strategy (ER, Frame) and Arousal (Low, High) for rating responses, nSCR and AmpSum in Experiment 1.
Note. ER trials consisted of reappraisal trials under low and disengagement trials under high arousal.

Table 3.3.

F-statistics for the main and interaction effects of the three-way ANOVA for the whole-sample (N= 140) and females-only analysis (N= 119).

	Whole sample			Females only		
Effect	Ratings	nSCR	AmpSum	Ratings	nSCR	AmpSum
Condition	21.01**	3.22	43.95**	10.84*	1.13	34.48**
Trial type	148.11**	.13	12.79**	128.28**	.13	21.98**
Arousal	409.59**	.25	5.85*	355.87**	.03	4.24*
Condition-by-Trial type	8.7*	1.02	7.26*	8.36*	1.01	9.91*
Condition-by-Arousal	16.0**	.10	1.31	12.0*	.02	1.16
Trial type-by-Arousal	50.82**	8.04*	8.94*	37.06**	6.95*	8.66*
Condition-by-Trial-by-Arousal	29.29**	.78	1.67	20.61**	1.07	1.49

Note: *p< .05 and **p< .001

3.3.1. Distribution of strategy choices

Unlike the Inter-personal condition, in which recommendations to disengage or reappraise were fixed according to the arousal level of images, participants were free to choose between these strategies during the Intra-personal condition. For this reason, we first checked if the expected preference for ER strategies according to arousal level (i.e. appraisal for low- and disengagement for high-arousal images), which was fixed in the Inter-personal condition, was indeed reflected in the distribution of choices on Intra$_{ER}$ trials. To assess this, a 2 (Strategy: Disengagement, Reappraisal) x 2 (Arousal: Low, High) repeated-measures ANOVA was performed on the frequency of self-selections made under the Intra-personal condition. No significant main effects of Strategy ($F_{[1, 145]}$= 3.76, p= .055, η_{ρ}^2= .03) or Arousal were observed ($F_{[1, 145]}$= 2.413, p= .122, η_{ρ}^2= .02). Moreover, the Strategy-by-Arousal interaction was not significant ($F_{[1, 145]}$= 1.331, p= .251, η_{ρ}^2= .01). Thus, participants showed no systematic preference for a particular strategy under different levels of arousal (see Figure 3.2.); while some self-selected reappraisal most frequently in response to high-arousal images, others appeared to prefer disengagement for the same images.

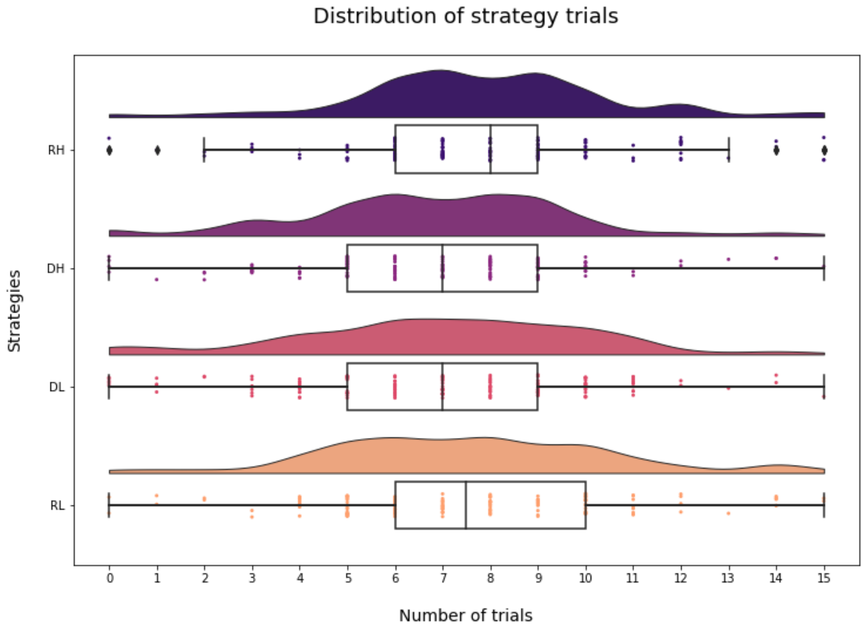


Figure 3.3.
Distribution of strategy choices during the Intra-personal condition across the entire sample. *Note*. Participants self-selected a strategy in response to 15 low- and 15 high-arousal images. DH and RH denote disengagement and reappraisal choices for high-arousal images, and DL and RL denote disengagement and reappraisal for low-arousal images, respectively.

3.3.2. Strategy effectiveness under self-selection or external recommendation

As discussed in the Methods Chapter 2, due to the imbalance of Reappraisal and Disengagement trials for each participant, Linear Mixed Modelling (LMM) was used to compare ER efficacy. The best-fitting LMM models for rating responses, nSCR and the sum of amplitudes are presented in equations 1-3 below.

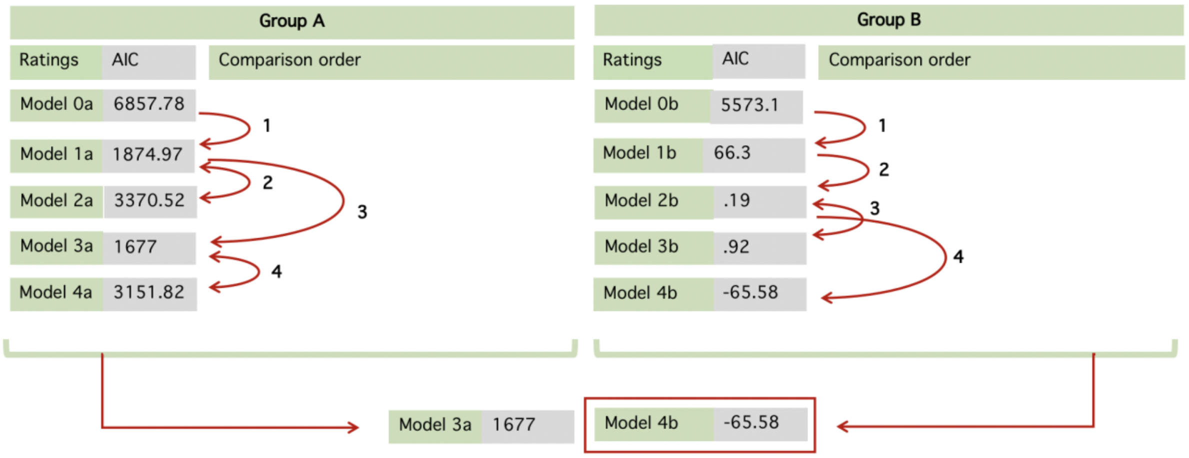


Figure 3.4.
Schematic representation of model selection exemplified using Rating responses. Models were separated into group A or B, in which either Strategy or Arousal was modelled as a predictor, respectively. Significant reductions in AIC were used as indices of model improvement (indicated by the red surround). *Note*. See Table 5 for model specifications.

Table 3.4.

Estimates (± standard error) of fixed and random effects for each dependent measure.

	Intercept (β_0)	Condition (β_1)	Strategy (β_{2j})		Arousal (β_{2j})	Condition x Strategy (β_3)		Condition x Arousal (β_3)
			Diseng.	Reappraisal		Diseng.	Reappraisal	
Ratings	.50 (.01)**	-.001 (.01)	-	-	-.21 (.01)**	-	-	.06 (.01)**
nSCR	1.41 (.05)**	-.06 (.02)*	.02 (.02)	-.001 (.02)	-	-	-	-
AmpSum	.27 (.01)**	-.05 (.01)**	.04 (.01)**	.03 (.01)*	-	-.03 (.01)*	-.04 (.01)**	-

Note. The sign of estimates represents the difference relative to a reference category. The reference for the Condition effect was the Intra-personal condition; negative estimates signify lower dependent measures under the Inter- compared with the Intra-personal condition. The reference for the Arousal effect was the high category; negative estimates signify lower dependent measures low-arousal images. The reference for Strategy were the Frame trials; positive values signify greater dependent measures during reappraisal and/or disengagement. *p <.05, ** p< .001.

In the Inter-personal condition, the effect of Strategy was confounded with Arousal; instructions to reappraise or disengage occurred only for low- and high-arousal images, respectively. Therefore, we compared two groups of models – the predictor for the first group was Strategy, whereas the second modelled Arousal as the predictor (see Figure 3.4. and Table 3.5.). Significant decreases in Akaike's Information Criteria (AIC; p< .05) were used to evaluate fit within each group of models, before comparing the best-fitting models of each group to one another. The following models achieved the best fit for each dependent measure, in which value *i* is estimated for each participant *j*:

(1) $$\boldsymbol{Rating_{ij}} = \beta_{0j} + \beta_1(Condition) + \beta_{2j}(Arousal) + \beta_3\,(Condition\ x\ Arousal) + e_{ij}$$

(2) $$\boldsymbol{nSCR_{ij}} = \beta_{0j} + \beta_1(Condition) + \beta_2(Strategy) + e_{ij}$$

(3) $$\boldsymbol{AmpSum_{ij}} = \beta_{0j} + \beta_1(Condition) + \beta_{2j}(Strategy) + \beta_3(Condition\ x\ Strategy) + e_{ij}$$

Results from these LMMs are presented in Table 3.3. For Ratings, there was no significant main effect of Condition (p=.832), but a significant main effect of Arousal (p<.001) confirmed that low-arousal images elicited significantly weaker subjective emotional reactions compared with high-arousal images. Pairwise comparisons for the significant Condition-by-Arousal interaction (p<.001) revealed that, in response to low-arousal images, subjective emotional reactions were significantly less intense under the Intra- compared with the Inter-personal condition (p< .001), yet no such difference existed for high-arousal images (p= .832). For nSCRs, a significant main effect of Condition (p= .001) revealed a significantly higher frequency of physiological responses under the Intra- compared with the Inter-personal condition, but there was no significant main effect of Strategy (p> .477). Significant main effects of Condition (p< .001) and Strategy (p< .001) were observed for AmpSum, with significantly higher amplitudes of physiological responses being recorded during the Intra- relative to the Inter-personal condition (p< .001) and lower amplitudes for Frame trials relative to those in which disengagement (p< .001) and reappraisal was implemented (p= .032). No significant difference was observed between disengagement and reappraisal on ER trials (p= .063). Post-hoc assessments of the significant Condition-by-Strategy interaction (p= .004) revealed significantly higher AmpSum for Frame and ER trials in which disengagement and reappraisal was implemented during the Intra- compared with the Inter-personal condition (p< .001). During the Intra-personal condition, there was no significant difference between ER trials in which disengagement or reappraisal was self-selected (p> .999); however, amplitudes were significantly lower for Frame relative to both disengagement (p< .001) and reappraisal ER trials (p< .001). Within the Inter-personal condition, however, there were no significant differences between Disengagement and Reappraisal (p= .056) or Disengagement and Frame (p= .277) trials, and no significant difference between Reappraisal and Frame trials (p= .876).

Table 3.5.

Equations for the linear mixed models.

Model number	Model specifications
0	$\boldsymbol{Rating_{ij}} = \beta_0 + \beta_1(Condition = Inter) + \beta_2(Arousal = Low) + e_{ij}$
1	$\boldsymbol{Rating_{ij}} = \beta_{0j} + \beta_1(Condition = Inter) + \beta_2(Arousal = Low) + e_{ij}$
2	$\boldsymbol{Rating_{ij}} = \beta_{0j} + \beta_1(Condition = Inter) + \beta_{2j}(Arousal = Low) + e_{ij}$
3	$\boldsymbol{Rating_{ij}} = \beta_{0j} + \beta_1(Condition = Inter) + \beta_2(Arousal = Low)$ $+ \beta_3(Condition = Inter\ x\ Arousal = Arousal) + e_{ij}$
4	$\boldsymbol{Rating_{ij}} = \beta_{0j} + \beta_1(Condition = Inter) + \beta_{2j}(Arousal = Low)$ $+ \beta_3(Condition = Inter\ x\ Arousal = Arousal) + e_{ij}$

Note: Model specifications are given for group A (Arousal). Equivalent models were computed for Group B (Strategy).

In summary, both physiological responses supported our initial hypothesis by demonstrating decreased arousal following inter- compared with intra-personal ER. However, a contradictory pattern emerged for subjective responses. Furthermore, the physiological indices suggested improved ER during Frame trials relative to those in which effortful regulation was implemented using a strategy.

3.3.3. Direct comparison between all inter- vs. intra-personal ER trials

The LMM analyses accounted for the unequal numbers of strategy trials by comparing only those that were equivalent between the Inter- and Intra-personal condition; i.e. low-arousal reappraisal and high-arousal disengagement trials. To perform a direct comparison of the conditions that included all the available trials, we collapsed across the disengagement and reappraisal trials in order to perform a 2 (Condition: Intra-personal, Inter-personal) x 2 (Trial type: ER, Frame) x 2 (Arousal: Low, High) repeated-measures ANOVA. In the following section, Greenhouse–Geisser corrections have been applied where necessary. Data distributions are presented in Figure 3.4.

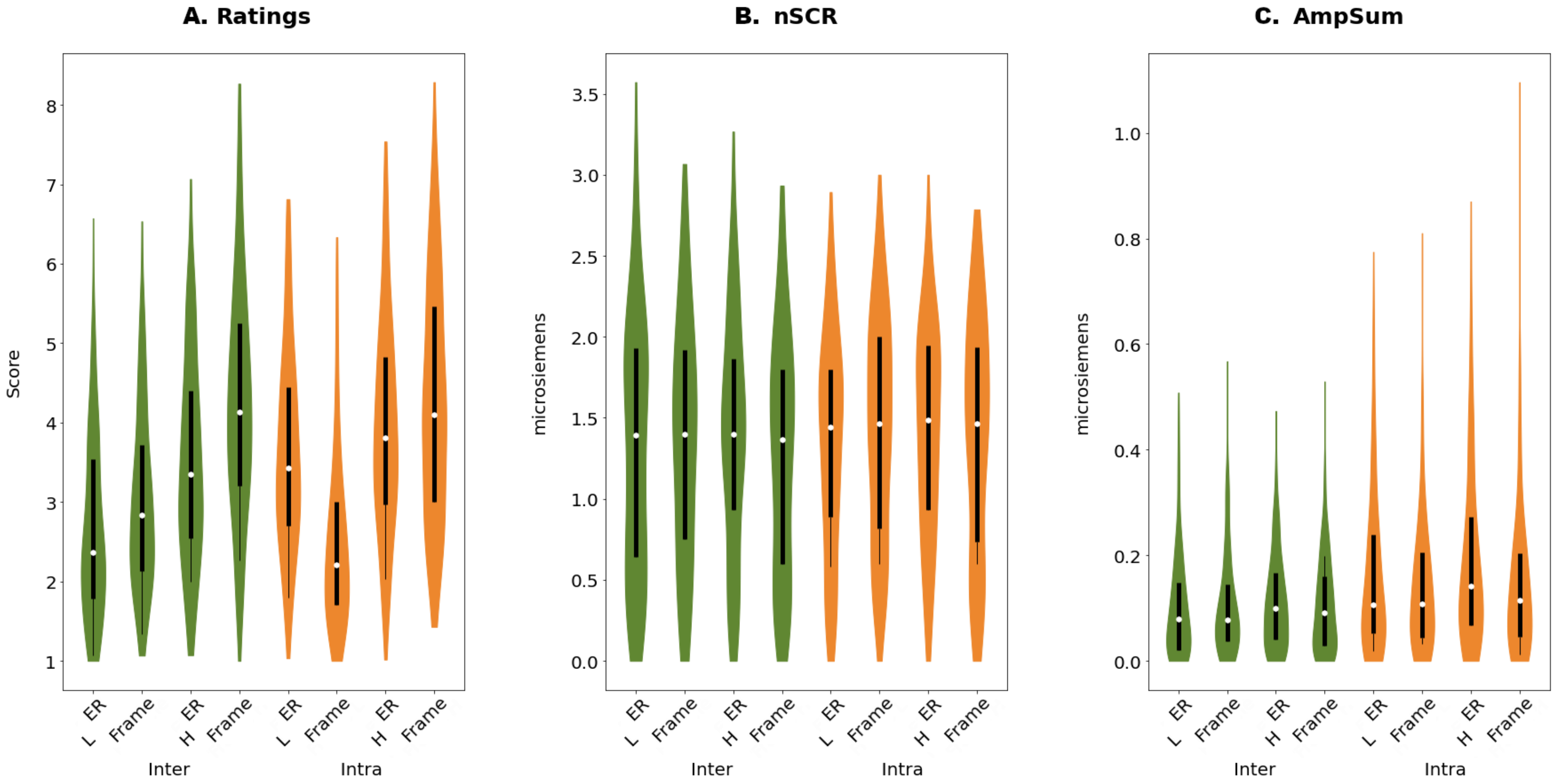


Figure 3.5.
Distributions of subjective ratings and electrodermal metrics across the Inter- and Intra-personal conditions under low- and high-arousal stimuli. *Note*: ER= emotion regulation, L= low arousal, H= high arousal; *N*=146 after list-wise deletion.

For ratings (Figure 3.4A), there were significant main effects of Condition ($F_{[1, 139]}$= 21.01, p< .001, η_ρ^2=.13), Trial type ($F_{[1, 139]}$= 148.11, p< .001, η_ρ^2=.52), and Arousal ($F_{[1, 139]}$= 409.59, p< .001, η_ρ^2=.75). Ratings were lower during the Intra- compared with the Inter-personal condition (p< .001), lower for ER compared with Frame trials (p< .001), and lower for low- compared with high-arousal trials (p< .001). This ANOVA also yielded a significant Condition-by-Trial type ($F_{[1, 139]}$= 8.7, p= .004, η_ρ^2=.06), Condition-by-Arousal ($F_{[1, 139]}$= 16.0, p< .001, η_ρ^2=.1), Trial Type-by-Arousal ($F_{[1, 139]}$= 50.82, p< .001, η_ρ^2=.27), and a three-way Condition-by-Trial type-by-Arousal interaction ($F_{[1, 139]}$= 29.29, p< .001, η_ρ^2=.17): Intra$_{\text{ER}}$ trials were rated significantly lower than Inter$_{\text{ER}}$ trials (p= .019), Intra$_{\text{Frame}}$ lower than Inter$_{\text{Frame}}$ trials (p< .001), Intra$_{\text{ER}}$ lower than Intra$_{\text{Frame}}$ trials (p< .001), and Inter$_{\text{ER}}$ lower than Inter$_{\text{Frame}}$ (p< .001). Lower ratings were also reported following low- relative to high-arousal trials within both the Intra- (p< .001) and Inter-personal conditions (p< .001). Further, low-arousal Intra-personal trials were rated lower than low-arousal Inter-personal trials (p< .001). Post-hoc comparisons of the significant Trial Type-by-Arousal interaction revealed significantly lower ratings for low relative to high ER (p< .001) and Frame trials (p< .001). Similarly, ER compared with Frame trials yielded significantly lower ratings under both low (p= .003), and high (p< .001) arousal. Post-hoc tests of the significant three-way interaction suggested significantly lower ratings for Intra$_{\text{ER}}$ relative to Inter$_{\text{ER}}$ only under high arousal (p= .009). In response to low-arousal images, lower ratings were reported for Intra$_{\text{Frame}}$ relative to Inter$_{\text{Frame}}$ (p< .001), and Inter$_{\text{ER}}$ relative to Inter$_{\text{Frame}}$ (p< .001). For high-arousal images, lower ratings were observed during Intra$_{\text{ER}}$ compared with Intra$_{\text{Frame}}$ (p< .001), and Inter$_{\text{ER}}$ compared with Inter$_{\text{Frame}}$ (p< .001). These results indicate that subjective ratings of emotional reactions to the images did not support our primary hypotheses; intra-personal ER was rated as more effective than inter-personal ER when disengagement and reappraisal were collapsed into ER trials.

Opposing patterns emerged for the EDA measures, however. Significant main effects of Condition ($F_{[1, 139]}$= 43.95, p< .001, η_ρ^2=.24), Trial type ($F_{[1, 139]}$= 12.79, p< .001, η_ρ^2=.08), and Arousal ($F_{[1, 139]}$= 5.85, p= .02, η_ρ^2=.04) were observed for AmpSum (Figure 4C): *higher* amplitudes were observed for the Intra- relative to the Inter-personal condition (p< .001), for ER compared with Frame trials (p< .001), and, as with ratings, high- compared with low-arousal trials (p= .017). Further, there was a significant Condition-by-Trial type interaction ($F_{[1, 139]}$= 7.26, p= .008, η_ρ^2=.05); this revealed significantly *higher* AmpSum for Intra$_{\text{ER}}$ compared with Inter$_{\text{ER}}$ (p< .001), Intra$_{\text{ER}}$ compared with Intra$_{\text{Frame}}$ (p< .001), and Intra$_{\text{Frame}}$ compared with Inter$_{\text{Frame}}$ (p< .001). There was also a significant Trial type-by-Arousal interaction ($F_{[1, 139]}$= 8.94, p= .003, η_ρ^2=.06), which revealed significantly lower amplitudes elicited during low- compared with high-arousal ER trials (p= .002), and higher amplitudes for high-arousal ER relative to Frame trials (p< .001). For nSCRs (Figure 3.4B), only a significant Trial type-by-Arousal interaction emerged ($F_{[1, 139]}$= 8.04, p= .005, η_{ρ}^{2}=.06); high-arousal ER trials elicited more nSCRs than high-arousal Frame trials (p= .025), and less nSCRs were observed for low- compared with high-arousal Frame trials (p= .004). In summary, our hypotheses were supported by physiological indices; amplitudes were reduced for inter- relative to intra-personal ER when all regulation trials were considered.

3.3.4. Relationships between behavioural phenotypes and emotion regulation

To assess the potential influence of participant characteristics on the effectiveness of self-selected or externally directed ER strategies, correlation analyses between the self-report measures and all dependent measures were performed. As shown in Table 3.6., only PA and BVAQ scores were associated with subjective ratings under the Intra-personal condition, only BVAQ and DERS scores were related to ratings under the Inter-personal condition, and none of the self-report measures correlated with nSCR or AmpSum. Interestingly, although subjective ratings were correlated strongly during the Intra- and Inter-personal conditions, as were both EDA metrics, ratings were not related to the physiological measures in either condition. Self-report measures were correlated mainly to one another.

The distribution of strategy choices under the Intra-personal condition indicated that participants self-select ER strategies with varying degrees of flexibility rather than showing any systematic preference. We therefore assessed the degree to which individual differences in such expressions of flexibility were related to the effectiveness of ER under each condition. To do so, we computed a single ratio measure for which greater values reflect greater flexibility under the Intra-personal condition:

$$Flexibility = \frac{N\ (Disengagement\ Trials)}{N\ (Disengagement\ Trials) + N\ (Reappraisal\ Trials)} \text{ x 100}$$

This index of choice flexibility was only mildly negatively correlated with positive affect. There were no significant associations between choice flexibility and any other self-report or electrodermal measures.

Table 3.6.

Pearson correlations among self-report instruments, subjective ratings and physiological measures.

	1	2	3	4	5	6	7	8	9	10	11	12
1.Age	-											
2. PA	-.01	-										
3. NA	.08	.23**	-									
4. BVAQ	-.02	-.01	.11	-								
5. BAPQ	-.13	.05	.14	.36**	-							
6. DERS	-.22**	-.01	.23**	.28**	.48**	-						
7. Flexibility	-.05	-.17*	-.01	.08	.002	.05	-					
8. nSCR$_{Inter}$	-.05	.09	.02	.05	.02	.06	-.02	-				
9. AmpSum$_{Inter}$	.007	.10	.07	.02	.004	-.01	.05	.72**	-			
10. Rating$_{Inter}$	.04	.13	.07	-.22**	.11	.16*	.10	-.13	-.07	-		
11. nSCR$_{Intra}$	-.11	.01	-.05	.06	.04	.05	.03	.79**	.62**	-.03	-	
12. AmpSum$_{Intra}$	-.04	.07	-.07	-.15*	-.004	-.01	-.13	.64**	.65**	.01	.61**	-
13. Rating$_{Intra}$	.02	.19*	-.02	-.22**	.09	.09	.10	-.16*	-.04	.88**	-.05	-.01

Note. The subscripts *Inter* and *Intra* denote disengagement, reappraisal and Frame trials of each condition. As suggested by Quirin et al. (2009), positive (PA) and negative affect (NA) scores from the IPANAT are presented separately. *Abbreviations*: ** p<.01 and * p<.05 (one-tailed); BVAQ = Bermond-Vorst Alexithymia Questionnaire; BAPQ = Broad Autism Phenotype Questionnaire; DERS = Difficulties in Emotion Regulation Scale. Correlations are not corrected for multiple comparisons.

3.4. Experiments 2 – 4: Online Experiments

The physiological measures in Experiment 1 suggested a beneficial effect of inter- over intra-personal ER in down-regulating negative affect. However, the paradigm included a specific schedule of ER strategy recommendations during inter-personal trials: reappraisal for low and disengagement for high arousal images. Thus, the question remained whether this schedule of recommendations rather than the inter-personal nature of the regulation underlay the superiority of inter-personal ER. Further studies were carried out using the same, a reverse and a balanced strategy recommendation schedule, respectively, to examine whether inter-relative to intra-personal ER continued to be more effective regardless of the recommendation patterns. Three preliminary online studies have been performed via Prolific (www.prolific.co/) to begin to investigate the optimal conditions for inter-personal intrinsic emotion regulation (ER). Each experiment was performed on an independent sample using the exact same Emotional Regulation Task: All participants completed the Intra-personal and Inter-personal condition in a counter-balanced manner, during which they implemented one of two ER strategies that they had selected themselves or that had been recommended to them. Unlike the main experiment, however, these subsequent preliminary investigations were all performed online rather than under controlled laboratory settings, no physiological data was measured, and participants were instructed that the strategies recommended to them in the Inter-personal condition had been "pre-selected".

3.4.1. Methods

The first supplementary experiment (Exp. 2) used an identical ER recommendation schedule as the lab experiment reported in the main paper to assess whether the pattern of subjective ratings could be reproduced when the task was delivered online; participants were instructed to reappraise for low- and disengage for high-arousal images. For the second online experiment (Exp. 3), participants received a recommendation to disengage for low- and reappraise for high-arousal images. The fourth (Exp. 4) online experiment, participants were recommended to implement disengagement for 50% of low- and 50% of high-arousal images, and reappraisal for the other half of the stimuli.

Power analyses for a 3 (Strategy: Disengagement, Reappraisal, Frame) x 2 (Arousal: Low, High) repeated-measures ANOVA with a moderate effect size suggested a sample of 57 participants were required to detect a significant difference between the conditions for each experiment. Exp. 2 comprised 63 (31 male, AgeM= 25.21 years, AgeSD= 6.03); Exp. 3 62 (32 males; Age_M= 26.06 years, Age_{SD}= 6.8); and Exp. 4 comprised 60 participants (30 male;

Age$_M$= 24.05 years, Age$_{SD}$= 4.62). All participants were reimbursed with £5 for their time. All experiments were approved by Aston University's Research Ethics Committee.

3.4.2. Results

The same analysis approach taken in the main experiment was used to assess differences in subjective ratings for Exp. 2 – 4. Disengagement and reappraisal trials were combined into ER trials for a 2 (Condition: Inter, Intra) x 2 (Trial Type: ER, Frame) x 2 (Arousal: Low, High) repeated measures ANOVA was used (see Figure 3.6.). ANOVAs were supplemented with LMM for strategy-level comparisons. Similar to the pattern of results emerging from Exp. 1 when rating responses were considered, there was no evidence of increased efficacy for inter- over intra-personal ER in these subsequent experiments; in Exp. 2 – 4, subjective ratings were significantly lower for the Intra- relative to the Inter-personal condition (see Table 3.7.).

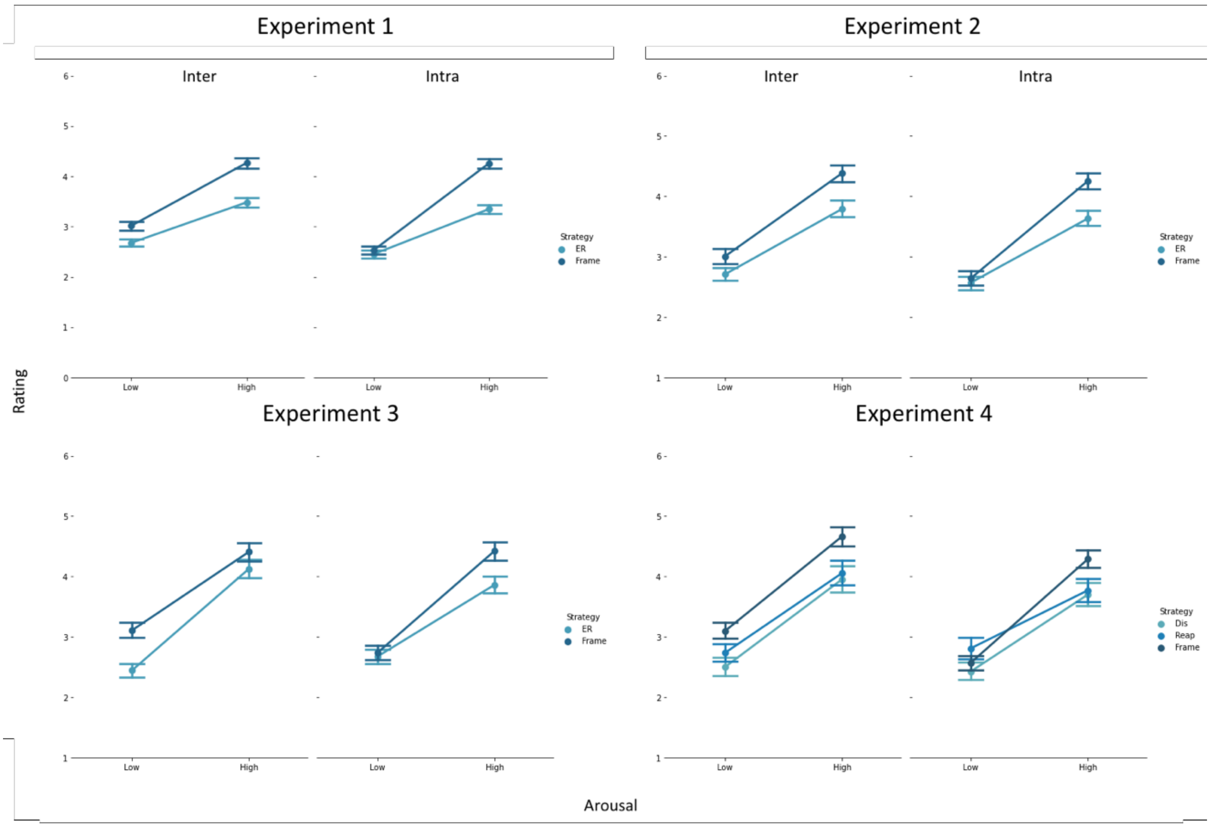


Figure 3.6.
Comparison of interaction effects between Condition (Inter, Intra), Strategy (ER, Frame) and Arousal (Low, High) for rating responses in the laboratory and online Experiments 1 – 4. *Note*. In Experiments 1 – 3, reappraisal and disengagement trials were combined into ER trials, as strategies were confounded with the level of arousal.

Table 3.7.

Estimates (± standard error) of fixed and random effects for the lab-based (Experiments 1) and online studies (Experiments 2-4).

		Intercept (β_0)	Condition (β_1)	Strategy (β_{2j})		Arousal (β_{2j})	Condition x Strategy (β_3)		Condition x Arousal (β_3)
				Disengagement	Reappraisal		Disengagement	Reappraisal	
1	Ratings	.50 (.01)**	-.001 (.01)	-		-.21 (.01)**	-		.06 (.01)**
	nSCR	1.41 (.05)**	-.06 (.02)*	.02 (.02)	-.001 (.02)	-	-		-
	AmpSum	.27 (.01)**	-.05 (.01)**	.04 (.01)**	.03 (.01)*	-	-.03 (.01)*	-.04 (.01)**	-
2	Ratings	3.97 (.15)**	.13 (.05)*	-		-1.34 (.09)**	-		.11 (.07)
3	Ratings	4.15 (.16)**	.13 (.06)*	-		-1.44 (.10)**	-		-.06 (.08)
4	Ratings	4.01 (.16)**	.33 (.06)**	-		-1.43 (.12)**	-		-.05 (.08)

Note. The sign of estimates represents the difference relative to a reference category. The reference for the Condition effect was the Intra-personal condition; negative estimates signify lower dependent measures under the Inter- compared with the Intra-personal condition. The reference for the Arousal effect was the high category; negative estimates signify lower dependent measures for low-arousal images. The reference for Strategy were the Frame trials; positive values signify greater dependent measures during reappraisal and/or disengagement. *p <.05, ** p< .001.

3.5. Discussion

The present study performed a comparison of emotion regulation (ER) effectiveness when we are free to choose between two regulatory strategies without any prior external guidance (intra-personal) and under instruction from another person (inter-personal). To do so comprehensively, we assessed both subjective ratings and electrodermal activity (EDA) as indices of emotional reactions while a large sample of individuals down-regulated their negative emotional reactions intra- or inter-personally. Driven by prior research, we hypothesised that higher ratings and elevated EDA would be observed during intra- compared with inter-personal intrinsic ER. We also predicted that certain person characteristics would influence the capacity for ER under external guidance, given their purported influence on intra-personal ER. Contrary to our predictions, when focusing only on trials in which the same ER strategies were implemented in response to low- or high-arousal images under both conditions, our data show decreased subjective ratings under intra- compared with inter-personal ER, but only in response to low-arousal stimuli. The physiological indices showed a different pattern, however; in support of our hypothesis, both the number and amplitude of skin-conductance responses (SCRs) were significantly *higher* under intra- relative to inter-personal ER, demonstrating the superior effectiveness of the latter in down-regulating affective responses. When collapsing across strategies, ratings were again unexpectedly lower under intra- compared with inter-personal ER, but the amplitude of SCRs remained significantly lower when implementing ER strategies directed by the experimenter inter-personally compared to those self-selected intra-personally. Contrary to our second prediction, few self-reported person characteristics were associated with participants' subjective ratings during the task, and there were no relationships between these characteristics and physiological indices.

3.5.1. Comparing inter- and intra-personal intrinsic emotion regulation

Previous studies on inter-personal ER have focused predominantly on the type of ER strategies we recommend to others extrinsically (Pacella and López-Pérez, 2018, Netzer et al., 2015, Pauw et al., 2019), or the strategies we choose to implement ourselves during inter-personal contexts (see Lindsey, 2020). The few studies that have compared directly the efficacy of intra- relative to inter-personal intrinsic ER report the beneficial effects of the latter over the former (Lougheed et al., 2016, Morawetz et al., 2021, Levy-Gigi and Shamay-Tsoory, 2017). These earlier findings are based exclusively on individuals' subjective experiences of their affective reactions, however, which reflect only those aspects of emotions that are accessible to introspective evaluation. Although we observed no difference in subjective ratings between the conditions when they were equivalent in terms of the strategies implemented and arousal level of the stimuli, physiological indices of affective reactions were consistently lower during inter- compared with intra-personal ER. This serves to extend these earlier findings by demonstrating the enhanced effectiveness of ER when directed by another individual in an interpersonal setting. When collapsing across the strategies implemented, however, although physiological metrics remained higher during intra- compared to inter-personal intrinsic ER, subjective ratings were *lower* during the former. We propose that this discrepancy between our observations and those reported elsewhere (Levy-Gigi and Shamay-Tsoory, 2017, Morawetz et al., 2021) reflect large differences in sample size and/or subtle variations in experimental paradigms. Furthermore, ER can be divided into an identification, selection and implementation phase; individuals first become aware of the need to regulate, select an ER strategy that they feel is most appropriate, and then implement the chosen strategy (Gross, 2015). The current study focused specifically on the entire implementation phase of inter-personal ER, whereas previous investigations completed some of the implementation for the participant by providing predetermined examples of how to use each strategy (e.g. "Imagine this is not real"; Morawetz et al., 2021, Xie et al., 2016, Hallam et al., 2014). Future research should explore whether the relative benefit of inter- over intra-personal intrinsic ER is restricted to specific stages of the regulatory process.

The task now is to identify the mechanisms through which inter-personal ER exerts this superiority, at least in physiological metrics of affective reactions. One study might offer a clue in this respect: Lougheed et al. (2016) suggest that reduced physiological indices of emotional distress in daughters coupled with their mothers reflects load sharing – that is, the inter-personal distribution of burden associated with a challenging situation. Perhaps, then, an implicit agreement about the perceived appropriateness of an ER strategy between the person recommending it and the one implementing it serves to reduce any uncertainty about its efficacy, thereby increasing its effectiveness. Interestingly, inter-personal intrinsic ER appears to be supported by brain systems implicated in self-referential processing and social cognition (Morawetz et al., 2021), perhaps revealing neurophysiological mechanisms through which such convergence in self- and other-selected strategies increases the effectiveness of ER. Future studies might investigate this further by comparing the effectiveness of inter-personal ER under different levels of agreement between the advisor and the target of their recommendations.

At this point it is important to stress that a fixed strategy of recommendations was followed during inter-personal ER in this laboratory-based experiment; participants always received an instruction to reappraise for low- and disengage for high-arousal images, ostensibly from the experimenter who was present in the room. Unlike previous studies (e.g., Shafir et al., 2015, Shafir and Sheppes, 2020, Sheppes et al., 2014), this schedule did not reflect self-selected choices during intra-personal ER in the current sample. This leads us to question whether the increased effectiveness of inter- over intra-personal ER that we have observed is due solely to this particular recommendation schedule or to the interpersonal dynamic itself. Preliminary data that we have acquired online using the exact same experimental task indicate that intra-personal ER continues to be rated *subjectively* as more effective than inter-personal ER even when different schedules of recommendations are made (e.g., reappraisal for high-arousal images; see Supplementary Material). However, since these data were acquired online during the global pandemic and, therefore, without the physical presence of a recommending individual, further research is needed to determine whether or not the perceived superiority of intra- over inter-personal ER holds across different schedules recommended within a more naturalistic interpersonal (social) setting.

3.5.2. Associations among emotion subsystems

A key finding to emerge from this study was the discrepancy between self-report ratings and physiological responses. After accounting for the number of trials during which participants self-selected reappraisal for low- and disengagement for high-arousal stimuli, rating responses did not differ significantly during intra- and inter-personal ER. However, when collapsing across strategies, our results suggest greater self-perceived efficacy in decreasing negative emotions for intra- relative to inter-personal ER. Interestingly, inter- compared with intra-personal ER resulted in significantly, and consistently, *reduced* EDA responses. Similar disconnects between rating and EDA responses were observed when ER and Frame trials were compared: Frames were more effective in reducing physiological responses to negative images than endogenous ER strategies, particularly in response to high-arousal images, yet participants reported the opposite – lower ratings were given following the active use of an ER strategy compared with the passive viewing of images with coloured Frames.

Such discrepancies might reflect genuine differential effects of ER strategies on experiential and physiological indices of emotional reactions (Gross, 1998a). Few of the studies reporting convergence between subjective experiences and physiological responses have investigated the differential influence of specific ER strategies on this relationship, let alone strategies implemented within inter- and intra-personal settings (Robinson and Demaree, 2009, Dan-Glauser and Gross, 2013, Hubert and de Jong-Meyer, 1990, Driscoll et al., 2009). Two studies report that reappraisal reduces ratings to negative stimuli whilst having no influence on electrodermal activity (Urry, 2009, Urry, 2010). Specific ER strategies might therefore utilise different mechanisms to regulate emotions, which can modulate experiential and physiological systems independently. In this light, disconnects between intra- and inter-personal ER may reflect the different mechanisms through which they exert their regulatory influence.

Alternatively, disconnects between subjective and physiological measures might simply reflect methodological factors. For instance, we acquired physiological measurements *during* the implementation of ER strategies, whereas subjective ratings were acquired retrospectively after the emotion-eliciting stimulus had disappeared – that is, during the evaluation phase. While this is entirely consistent with the approach taken elsewhere (Hot et al., 2005, Driscoll et al., 2009, Sheppes and Meiran, 2007, Dan-Glauser and Gross, 2013, Troy et al., 2018), the timing of ER initiation has been shown to modulate the degree of convergence between measures; no changes are observed in skin-conductance responses to negative images when individuals are instructed to regulate their emotions *before* viewing the stimuli, but these physiological responses are increased when ER is recommended during the viewing of the stimuli (Sheppes et al., 2009, Sheppes and Meiran, 2007).

On the other hand, these discrepancies might indicate that subjective ratings reflect processes independent of the physiological affective response; they may capture an individual's evaluation of their implementation of an ER strategy, rather than their actual experience of the resultant affective state (Hot et al., 2005, Wiens, 2005). We interpret the strongest divergence between measures on Frame trials to support this notion. An individual's ER ability is influenced by their self-perceived efficacy (Colombo et al., 2020, Tamir and Mauss, 2011) and beliefs about the controllability of their emotions (Ford and Gross, 2019, De Castella et al., 2013, De Castella et al., 2015). Our sample scored relatively low on the Difficulties in Emotion Regulation Scale, and so they appeared to perceive themselves as fairly effective regulators. Perhaps, then, the frames recommended to them, which they might not have chosen themselves, were evaluated subjectively as inefficacious. Simultaneously, however, these frames may have been sufficiently salient to elicit exogenous shifts of attention away from the images themselves, thereby serving as an implicit form of antecedent-focused ER that reduced the depth of their processing and any resultant physiological response (Gyurak et al., 2011, Steptoe and Vögele, 1986). Indeed, a substantial body of research demonstrates the powerful influence of exogenous cues in re-directing attention (Berger et al., 2005, Chica et al., 2013, Theeuwes, 1991, Bowling et al., 2020) and the processing of emotional content (Brosch et al., 2011), which forms the basis of attention training in the context of affective disorders (MacLeod et al., 2002, Amir et al., 2009, Papageorgiou and Wells, 2000).

3.5.3. Individual differences and emotion regulation

Only positive affect measured implicitly and alexithymic traits assessed explicitly were associated with participants' ratings during intra- and inter-personal intrinsic ER; specifically, people higher in positivity reported stronger emotional reactions during intra-personal ER, and those with higher alexithymic traits reported greater decreases in self-reported emotional intensity. It appears, therefore, that people reporting higher alexithymic characteristics assessed their regulation attempts as more successful. This was not corroborated by their physiological responses, however, which might reflect inaccurate interoception. Interestingly, then, higher levels of alexithymic traits were associated with greater scores on the Difficulties in Emotion Regulation Scale (DERS).

Self-reported ER ability measured on the DERS also related positively to autistic phenotypes. While this aligns with previous research reporting that autism is associated with poorer ER abilities (Mazefsky et al., 2012, Poquérusse et al., 2018, Samson et al., 2015), this self-reported characteristic did not correlate significantly with ER performance. It is important to stress that the present sample reported relatively low scores on both the DERS (Giromini et al., 2017) and the Broad Autism Phenotype Questionnaire (BAPQ; see Sasson et al., 2013). Future studies in populations with affective disorders, high levels of alexithymia and/or more pronounced autistic phenotypes are needed to achieve a more accurate estimation of the influences of these characteristics on inter-personal intrinsic ER and its therapeutic potential.

3.5.4. Implications and Future Directions

The superiority of ER under external guidance has potential implications for the treatment of affective disorders, which focus currently on altering the patient's cognition and behaviours (Aldao et al., 2014, Asnaani et al., 2020), their awareness and acceptance of emotional processes (Ford et al., 2018, Lindsay and Creswell, 2019), or a combination of both (Troy et al., 2018, Fassbinder et al., 2016). However, in light of growing evidence for the beneficial effect of inter-personal intrinsic ER, alternative treatments involving inter-personal dynamics among friends and family might prove more effective in reducing emotion dysregulation and preventing relapse. In particular, further research on pre-generative influences on emotion is needed to assess the efficacy of the regulator's strategy choice for others with maladaptive strategy preferences, such as a chronic use expressive suppression and rumination, which have been linked to psychopathology (Aldao et al., 2010, Chervonsky and Hunt, 2017). This requires a much more precise understanding of the conditions under which inter-personal ER is optimised, however, and this, in turn, requires future research to address some of the potential limitations of the present study.

Firstly, the control condition we have employed appears to have been effective in regulating emotions implicitly. To further quantify the beneficial effects of inter-personal intrinsic ER, future studies might compare both intra- and inter-personal ER against a baseline that captures spontaneous emotional reactivity in the absence of any intrinsic regulation. Alternatively, future studies could evaluate the effectiveness of other exogenous distractors as implicit ER strategies, or the manner in which they serve to attenuate emotional reactions. For example, it is likely that the effectiveness of exogenous distractions in down-regulating negative reactions applies only during their presentation, and does not persist into the evaluative period in which the ratings were made (post-presentation). Secondly, future studies are needed to establish whether the superior effectiveness of inter- over intra-personal ER at down-regulating physiological reactions remains when a reversed schedule of recommendations is made – that is, reappraisal for high- and disengagement for low-arousal images. Due to current restrictions imposed by the global pandemic, we were unable to complement our preliminary online data with EDA measurements. It remains to be seen, therefore, whether the convergence in subjective ratings acquired in our laboratory study and those from the preliminary online data holds also for physiological metrics. Future studies under controlled laboratory conditions are needed to determine whether electrodermal responses continue to demonstrate a benefit of inter- over intra-personal ER when the inter-personal recommendations follow a reversed schedule. This would shed more light on the degree to which inter-personal ER relies upon the social dynamic.

References

ALDAO, A., JAZAIERI, H., GOLDIN, P. R. & GROSS, J. J. 2014. Adaptive and maladaptive emotion regulation strategies: Interactive effects during CBT for social anxiety disorder. *Journal of anxiety disorders,* 28, 382-389.

ALDAO, A., NOLEN-HOEKSEMA, S. & SCHWEIZER, S. 2010. Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review,* 30, 217-237.

ALLEN, I. E., & SEAMAN, C. A. (2007). Likert scales and data analyses. *Quality progress, 40*(7), 64-65.

AMIR, N., BEARD, C., TAYLOR, C. T., KLUMPP, H., ELIAS, J., BURNS, M. & CHEN, X. 2009. Attention training in individuals with generalized social phobia: A randomized controlled trial. *Journal of consulting and clinical psychology,* 77, 961.

ASNAANI, A., TYLER, J., MCCANN, J., BROWN, L. & ZANG, Y. 2020. Anxiety sensitivity and emotion regulation as mechanisms of successful CBT outcome for anxiety-related disorders in a naturalistic treatment setting. *Journal of Affective Disorders,* 267, 86-95.

BARLOW, D. H., ALLEN, L. B. & CHOATE, M. L. 2004. Toward a unified treatment for emotional disorders. *Behavior Therapy,* 35, 205-230.

BARON-COHEN, S., WHEELWRIGHT, S., SKINNER, R., MARTIN, J. & CLUBLEY, E. 2001. The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, malesand females, scientists and mathematicians. *Journal of autism and developmental disorders,* 31, 5-17.

BARRETT, L. F. & BLISS-MOREAU, E. 2009. AFFECT AS A PSYCHOLOGICAL PRIMITIVE. *In:* ZANNA, M. P. (ed.) *Advances in Experimental Social Psychology, Vol 41.*

BARTHEL, A. L., HAY, A., DOAN, S. N. & HOFMANN, S. G. 2018. Interpersonal emotion regulation: A review of social and developmental components. *Behaviour Change,* 35, 203-216.

BEAUDREAU, S. A. & O'HARA, R. 2008. Late-life anxiety and cognitive impairment: A review. *American Journal of Geriatric Psychiatry,* 16, 790-803.

BENEDEK, M. & KAERNBACH, C. 2010. A continuous measure of phasic electrodermal activity. *Journal of Neuroscience Methods,* 190, 80-91.

BERGER, A., HENIK, A. & RAFAL, R. 2005. Competition between endogenous and exogenous orienting of visual attention. *Journal of Experimental Psychology: General,* 134, 207.

BERMOND, B., BIERMAN, D. J., CLADDER, M. A., MOORMANN, P. P. & VORST, H. C. 2010. The cognitive and affective alexithymia dimensions in the regulation of sympathetic responses. *International Journal of Psychophysiology,* 75, 227-233.

BERNAT, E. M., CADWALLADER, M., SEO, D., VIZUETA, N. & PATRICK, C. J. 2011. Effects of instructed emotion regulation on valence, arousal, and attentional measures of affective processing. *Developmental Neuropsychology,* 36, 493-518.

BONANNO, G. A. & BURTON, C. L. 2013. Regulatory Flexibility: An Individual Differences Perspective on Coping and Emotion Regulation. *Perspectives on Psychological Science,* 8, 591-612.

BOWLING, J. T., FRISTON, K. J. & HOPFINGER, J. B. 2020. Top-down versus bottom-up attention differentially modulate frontal–parietal connectivity. *Human brain mapping,* 41, 928-942.

BRADLEY, M. M. & LANG, P. J. 1994. Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry,* 25, 49-59.

BROSCH, T., POURTOIS, G., SANDER, D. & VUILLEUMIER, P. 2011. Additive effects of emotional, endogenous, and exogenous attention: behavioral and electrophysiological evidence. *Neuropsychologia,* 49, 1779-1787.

BROWN, C. L., VAN DOREN, N., FORD, B. Q., MAUSS, I. B., SZE, J. W. & LEVENSON, R. W. 2019. Coherence between subjective experience and physiology in emotion: Individual differences and implications for well-being. *Emotion*.

BUTLER, E. A. 2017. Emotions are temporal interpersonal systems. *Current Opinion in Psychology,* 17**,** 129-134.

CACIOPPO, J. T. & GARDNER, W. L. 1999. Emotion. *Annual review of psychology,* 50**,** 191-214.

CACIOPPO, J. T. & TASSINARY, L. G. 1990. Inferring psychological significance from physiological signals. *American psychologist,* 45**,** 16.

CAMODECA, M. & NAVA, E. 2020. The Long-Term Effects of Bullying, Victimization, and Bystander Behavior on Emotion Regulation and Its Physiological Correlates. *Journal of Interpersonal Violence***,** 0886260520934438.

CARSTENSEN, L. L., FUNG, H. H. & CHARLES, S. T. 2003. Socioemotional selectivity theory and the regulation of emotion in the second half of life. *Motivation and Emotion,* 27**,** 103-123.

CHERVONSKY, E. & HUNT, C. 2017. Suppression and Expression of Emotion in Social and Interpersonal Outcomes: A Meta-Analysis. *Emotion,* 17**,** 669-683.

CHICA, A. B., BARTOLOMEO, P. & LUPIÁÑEZ, J. 2013. Two cognitive and neural systems for endogenous and exogenous spatial attention. *Behavioural brain research,* 237**,** 107-123.

CHRISTENSEN, K. A., VAN DYK, I. S., NELSON, S. V. & VASEY, M. W. 2020. Using multilevel modeling to characterize interpersonal emotion regulation strategies and psychopathology in female friends. *Personality and Individual Differences,* 165**,** 110156.

CLUDIUS, B., MENNIN, D. & EHRING, T. 2020. Emotion regulation as a transdiagnostic process. *Emotion,* 20**,** 37.

COAN, J. A., SCHAEFER, H. S. & DAVIDSON, R. J. 2006. Lending a hand: Social regulation of the neural response to threat. *Psychological science,* 17**,** 1032-1039.

COLOMBO, D., FERNÁNDEZ-ÁLVAREZ, J., SUSO-RIBERA, C., CIPRESSO, P., VALEV, H., LEUFKENS, T., SAS, C., GARCIA-PALACIOS, A., RIVA, G. & BOTELLA, C. 2020. The need for change: Understanding emotion regulation antecedents and consequences using ecological momentary assessment. *Emotion,* 20**,** 30.

COUETTE, M., MOUCHABAC, S., BOURLA, A., NUSS, P., & FERRERI, F. (2020). Social cognition in post-traumatic stress disorder: A systematic review. *British Journal of Clinical Psychology, 59*(2), 117-138.

DAN-GLAUSER, E. S. & GROSS, J. J. 2013. Emotion regulation and emotion coherence: evidence for strategy-specific effects. *Emotion,* 13**,** 832.

DAVIDSON, R. J. (1998). Affective style and affective disorders: Perspectives from affective neuroscience. *Cognition & Emotion, 12*(3), 307-330.

DAVIDSON, R. J. (2003). Affective neuroscience and psychophysiology: Toward a synthesis. *Psychophysiology, 40*(5), 655-665.

DE CASTELLA, K., GOLDIN, P., JAZAIERI, H., HEIMBERG, R. G., DWECK, C. S. & GROSS, J. J. 2015. Emotion beliefs and cognitive behavioural therapy for social anxiety disorder. *Cognitive behaviour therapy,* 44**,** 128-141.

DE CASTELLA, K., GOLDIN, P., JAZAIERI, H., ZIV, M., DWECK, C. S. & GROSS, J. J. 2013. Beliefs about emotion: Links to emotion regulation, well-being, and psychological distress. *Basic and Applied Social Psychology,* 35**,** 497-505.

DE VROEGE, L., EMONS, W. H., SIJTSMA, K. & VAN DER FELTZ-CORNELIS, C. M. 2018. Psychometric Properties of the Bermond–Vorst alexithymia Questionnaire (BVaQ) in the general Population and a clinical Population. *Frontiers in psychiatry,* 9**,** 111.

DEMAREE, H., SCHMEICHEL, B., ROBINSON, J. & EVERHART, D. E. 2004. Behavioural, affective, and physiological effects of negative and positive emotional exaggeration. *Cognition & Emotion,* 18**,** 1079-1097.

DIXON-GORDON, K. L., BERNECKER, S. L. & CHRISTENSEN, K. 2015. Recent innovations in the field of interpersonal emotion regulation. *Current Opinion in Psychology,* 3, 36-42.

DRISCOLL, D., TRANEL, D. & ANDERSON, S. W. 2009. The effects of voluntary regulation of positive and negative emotion on psychophysiological responsiveness. *International Journal of Psychophysiology,* 72, 61-66.

EKMAN, P. 1992. AN ARGUMENT FOR BASIC EMOTIONS. *Cognition & Emotion,* 6, 169-200.

ENGLISH, T. & ELDESOUKY, L. 2020. We're not alone: Understanding the social consequences of intrinsic emotion regulation. *Emotion,* 20, 43.

ENGLISH, T., LEE, I. A., JOHN, O. P. & GROSS, J. J. 2017. Emotion regulation strategy selection in daily life: The role of social context and goals. *Motivation and Emotion,* 41, 230-242.

FASSBINDER, E., SCHWEIGER, U., MARTIUS, D., BRAND-DE WILDE, O. & ARNTZ, A. 2016. Emotion regulation in schema therapy and dialectical behavior therapy. *Frontiers in psychology,* 7, 1373.

FAUL, F., ERDFELDER, E., LANG, A.-G. & BUCHNER, A. 2007. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior research methods,* 39, 175-191.

FORD, B. Q. & GROSS, J. J. 2019. Why beliefs about emotion matter: An emotion-regulation perspective. *Current Directions in Psychological Science,* 28, 74-81.

FORD, B. Q., LAM, P., JOHN, O. P. & MAUSS, I. B. 2018. The psychological health benefits of accepting negative emotions and thoughts: Laboratory, diary, and longitudinal evidence. *Journal of personality and social psychology,* 115, 1075.

GIROMINI, L., ALES, F., DE CAMPORA, G., ZENNARO, A. & PIGNOLO, C. 2017. Developing age and gender adjusted normative reference values for the difficulties in emotion regulation scale (DERS). *Journal of Psychopathology and Behavioral Assessment,* 39, 705-714.

GOERLICH, K. S. 2018. The Multifaceted Nature of Alexithymia - A Neuroscientific Perspective. *Frontiers in Psychology,* 9.

GOLDIN, P. R., MCRAE, K., RAMEL, W. & GROSS, J. J. 2008. The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. *Biological Psychiatry,* 63, 577-586.

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, 41-54.

GROSS, J. J. 1998a. Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology,* 74, 224-237.

GROSS, J. J. 1998b. The emerging field of emotion regulation: An integrative review. *Review of general psychology,* 2, 271-299.

GROSS, J. J. 2001. Emotion regulation in adulthood: Timing is everything. *Current Directions in Psychological Science,* 10, 214-219.

GROSS, J. J. 2015. Emotion Regulation: Current Status and Future Prospects. *Psychological Inquiry,* 26, 1-26.

GROSS, J. J. & JAZAIERI, H. 2014. Emotion, Emotion Regulation, and Psychopathology:An Affective Science Perspective. *Clinical Psychological Science,* 2, 387-401.

GROSS, J. J. & LEVENSON, R. W. 1993. Emotional suppression: physiology, self-report, and expressive behavior. *Journal of personality and social psychology,* 64, 970.

GYURAK, A., GROSS, J. J. & ETKIN, A. 2011. Explicit and implicit emotion regulation: a dual-process framework. *Cognition and emotion,* 25, 400-412.

HAJCAK, G., MACNAMARA, A. & OLVET, D. M. 2010. Event-related potentials, emotion, and emotion regulation: an integrative review. *Developmental neuropsychology,* 35, 129-155.

HALLAM, G. P., WEBB, T. L., SHEERAN, P., MILES, E., NIVEN, K., WILKINSON, I. D., HUNTER, M. D., WOODRUFF, P. W. R., TOTTERDELL, P. & FARROW, T. F. D. 2014. The neural correlates of regulating another person's emotions: an exploratory fMRI study. *Frontiers in Human Neuroscience,* 8.

HALLION, L. S., STEINMAN, S. A., TOLIN, D. F. & DIEFENBACH, G. J. 2018. Psychometric properties of the Difficulties in Emotion Regulation Scale (DERS) and its short forms in adults with emotional disorders. *Frontiers in psychology,* 9, 539.

HOT, P., LECONTE, P. & SEQUEIRA, H. 2005. Diurnal autonomic variations and emotional reactivity. *Biological Psychology,* 69, 261-270.

HUBERT, W. & DE JONG-MEYER, R. 1990. Psychophysiological response patterns to positive and negative film stimuli. *Biological psychology,* 31, 73-93.

HUGHES, D. J., KRATSIOTIS, I. K., NIVEN, K. & HOLMAN, D. 2020. Personality traits and emotion regulation: A targeted review and recommendations. *Emotion,* 20, 63.

HURLEY, R. S. E., LOSH, M., PARLIER, M., REZNICK, J. S. & PIVEN, J. 2007. The Broad Autism Phenotype Questionnaire. *Journal of Autism and Developmental Disorders,* 37, 1679-1690.

JACKSON, D. C., MALMSTADT, J. R., LARSON, C. L. & DAVIDSON, R. J. 2000. Suppression and enhancement of emotional responses to unpleasant pictures. *Psychophysiology,* 37, 515-522.

JAMIESON, S. (2004). Likert scales: How to (ab) use them? *Medical education, 38*(12), 1217-1218.

KASHDAN, T. B. & ROTTENBERG, J. 2010. Psychological flexibility as a fundamental aspect of health. *Clinical psychology review,* 30, 865-878.

KIM, S. H. & HAMANN, S. 2007. Neural correlates of positive and negative emotion regulation. *Journal of Cognitive Neuroscience,* 19, 776-798.

LADEGAARD, N., LARSEN, E. R., VIDEBECH, P., & LYSAKER, P. H. (2014). Higher-order social cognition in first-episode major depression. *Psychiatry Research, 216*(1), 37-43.

LANG, P. J., BRADLEY, M. M. & CUTHBERT, B. N. 2008. International affective picture system (IAPS): affective ratings of pictures and instruction manual. University of Florida, Gainesville. Tech Rep A-8.

LARCOM, M. J. & ISAACOWITZ, D. M. 2009. Rapid emotion regulation after mood induction: Age and individual differences. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences,* 64, 733-741.

LEPORE, S. J., ALLEN, K. & EVANS, G. W. 1993. Social support lowers cardiovascular reactivity to an acute stressor. *Psychosomatic medicine,* 55, 518-524.

LEVY-GIGI, E. & SHAMAY-TSOORY, S. G. 2017. Help me if you can: Evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress. *Journal of Behavior Therapy and Experimental Psychiatry,* 55, 33-40.

LINDSAY, E. K. & CRESWELL, J. D. 2019. Mindfulness, acceptance, and emotion regulation: Perspectives from Monitor and Acceptance Theory (MAT). *Current opinion in psychology,* 28, 120-125.

LINDSEY, E. W. 2020. Relationship context and emotion regulation across the life span. *Emotion,* 20, 59.

LIVINGSTONE, K. M. & ISAACOWITZ, D. M. 2021. Age and emotion regulation in daily life: Frequency, strategies, tactics, and effectiveness. *Emotion,* 21, 39.

LOUGHEED, J. P., KOVAL, P. & HOLLENSTEIN, T. 2016. Sharing the burden: The interpersonal regulation of emotional arousal in mother– daughter dyads. *Emotion,* 16, 83.

MACLEOD, C., RUTHERFORD, E., CAMPBELL, L., EBSWORTHY, G. & HOLKER, L. 2002. Selective attention and emotional vulnerability: assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of abnormal psychology,* 111, 107.

MALOOLY, A. M., GENET, J. J. & SIEMER, M. 2013. Individual differences in reappraisal effectiveness: the role of affective flexibility. *Emotion,* 13, 302.

MATHWORKS, M. 2017. MATLAB and Statistics Toolbox Release. Natick, MA: The MathWorks. Inc.

MAUSS, I. B., LEVENSON, R. W., MCCARTER, L., WILHELM, F. H. & GROSS, J. J. 2005. The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion,* 5, 175.

MAZEFSKY, C. A., PELPHREY, K. A. & DAHL, R. E. 2012. The need for a broader approach to emotion regulation research in autism. *Child development perspectives,* 6, 92-97.

MCRAE, K. & GROSS, J. J. 2020. Emotion regulation. *Emotion,* 20, 1.

MIDKIFF, M. F., LINDSEY, C. R. & MEADOWS, E. A. 2018. The role of coping self-efficacy in emotion regulation and frequency of NSSI in young adult college students. *Cogent Psychology,* 5, 1520437.

MORAWETZ, C., BERBOTH, S. & BODE, S. 2021. With a little help from my friends: the effect of social proximity on emotion regulation-related brain activity. *NeuroImage*, 117817.

NETZER, L., VAN KLEEF, G. A. & TAMIR, M. 2015. Interpersonal instrumental emotion regulation. *Journal of experimental social psychology,* 58, 124-135.

NISHIYAMA, T., SUZUKI, M., ADACHI, K., SUMI, S., OKADA, K., KISHINO, H., SAKAI, S., KAMIO, Y., KOJIMA, M. & SUZUKI, S. 2014. Comprehensive comparison of self-administered questionnaires for measuring quantitative autistic traits in adults. *Journal of autism and developmental disorders,* 44, 993-1007.

NIVEN, K., TROTH, A. C. & HOLMAN, D. 2019. Do the effects of interpersonal emotion regulation depend on people's underlying motives? *Journal of Occupational and Organizational Psychology,* 92, 1020-1026.

NORMAN, G. (2010). Likert scales, levels of measurement and the “laws” of statistics. *Advances in Health Sciences Education, 15*(5), 625-632.

NORRIS, C. J. (2021). The negativity bias, revisited: Evidence from neuroscience measures and an individual differences approach. *Social neuroscience, 16*(1), 68-82.

NOZAKI, Y. & MIKOLAJCZAK, M. 2020. Extrinsic emotion regulation. *Emotion,* 20, 10.

OCHSNER, K. N. & GROSS, J. J. 2005. The cognitive control of emotion. *Trends in cognitive sciences,* 9, 242-249.

OPITZ, P. C., RAUCH, L. C., TERRY, D. P. & URRY, H. L. 2012. Prefrontal mediation of age differences in cognitive reappraisal. *Neurobiology of Aging,* 33, 645-655.

PACELLA, D. & LÓPEZ-PÉREZ, B. 2018. Assessing children's interpersonal emotion regulation with virtual agents: The serious game Emodiscovery. *Computers & Education,* 123, 1-12.

PAPAGEORGIOU, C. & WELLS, A. 2000. Treatment of recurrent major depression with attention training. *Cognitive and Behavioral Practice,* 7, 407-413.

PAUW, L. S., SAUTER, D. A., VAN KLEEF, G. A. & FISCHER, A. H. 2019. Stop crying! The impact of situational demands on interpersonal emotion regulation. *Cognition and emotion,* 33, 1587-1598.

PEIRCE, J., GRAY, J. R., SIMPSON, S., MACASKILL, M., HÖCHENBERGER, R., SOGO, H., KASTMAN, E. & LINDELØV, J. K. 2019. PsychoPy2: Experiments in behavior made easy. *Behavior research methods,* 51, 195-203.

POQUÉRUSSE, J., PASTORE, L., DELLANTONIO, S. & ESPOSITO, G. 2018. Alexithymia and autism spectrum disorder: a complex relationship. *Frontiers in psychology,* 9, 1196.

PREECE, D., BECERRA, R., ROBINSON, K., DANDY, J. & ALLAN, A. 2018. The psychometric assessment of alexithymia: Development and validation of the Perth Alexithymia Questionnaire. *Personality and Individual Differences,* 132, 32-44.

PRUESSNER, L., BARNOW, S., HOLT, D. V., JOORMANN, J. & SCHULZE, K. 2020. A cognitive control framework for understanding emotion regulation flexibility. *Emotion,* 20, 21.

QUIRIN, M. & BODE, R. C. 2014. An alternative to self-reports of trait and state affect. *European Journal of Psychological Assessment*.

QUIRIN, M., KAZEN, M. & KUHL, J. 2009. When nonsense sounds happy or helpless: the Implicit Positive and Negative Affect Test (IPANAT). *Journal of Personality and Social Psychology*, 500.

RAIO, C. M., OREDERU, T. A., PALAZZOLO, L., SHURICK, A. A. & PHELPS, E. A. 2013. Cognitive emotion regulation fails the stress test. *Proceedings of the National Academy of Sciences,* 110, 15139-15144.

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, 587.

ROBINSON, J. L. & DEMAREE, H. A. 2009. Experiencing and regulating sadness: Physiological and cognitive effects. *Brain and cognition,* 70, 13-20.

ROSENBERG, E. L. 1997. Emotions as unified responses. *Paul Ekman Erika L. Rosenberg*, 86.

ROSENBERG, E. L. & EKMAN, P. 1994. Coherence between expressive and experiential systems in emotion. *Cognition & Emotion,* 8, 201-229.

SALSMAN, N. L. & LINEHAN, M. M. 2012. An investigation of the relationships among negative affect, difficulties in emotion regulation, and features of borderline personality disorder. *Journal of Psychopathology and Behavioral Assessment,* 34, 260-267.

SAMSON, A. C., HARDAN, A. Y., PODELL, R. W., PHILLIPS, J. M. & GROSS, J. J. 2015. Emotion regulation in children and adolescents with autism spectrum disorder. *Autism Research,* 8, 9-18.

SASSON, N. J., LAM, K. S., CHILDRESS, D., PARLIER, M., DANIELS, J. L. & PIVEN, J. 2013. The B road A utism P henotype Q uestionnaire: Prevalence and Diagnostic Classification. *Autism Research,* 6, 134-143.

SCHEIBE, S., SHEPPES, G. & STAUDINGER, U. M. 2015. Distract or Reappraise? Age-Related Differences in Emotion-Regulation Choice. *Emotion,* 15, 677-681.

SCHILBACH, L., TIMMERMANS, B., REDDY, V., COSTALL, A., BENTE, G., SCHLICHT, T., & VOGELEY, K. (2013). Toward a second-person neuroscience 1. *Behavioral and brain sciences, 36*(4), 393-414.

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, 1329-1337.

SHAFIR, R. & SHEPPES, G. 2020. How anticipatory information shapes subsequent emotion regulation. *Emotion,* 20, 68.

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, 91-96.

SHEPPES, G. & MEIRAN, N. 2007. Better late than never? On the dynamics of online regulation of sadness using distraction and cognitive reappraisal. *Personality and Social Psychology Bulletin,* 33, 1518-1532.

SHEPPES, G., SCHEIBE, S., SURI, G. & GROSS, J. J. 2011. Emotion-regulation choice. *Psychological science,* 22, 1391-1396.

SHEPPES, G., SCHEIBE, S., SURI, G., RADU, P., BLECHERT, J. & GROSS, J. J. 2014. Emotion Regulation Choice: A Conceptual Framework and Supporting Evidence. *Journal of Experimental Psychology-General,* 143, 163-181.

SHEPPES, G., SURI, G. & GROSS, J. J. 2015. Emotion Regulation and Psychopathology. *Annual Review of Clinical Psychology, Vol 11,* 11, 379-405.

STEPTOE, A. & VÖGELE, C. 1986. Are stress responses influenced by cognitive appraisal? An experimental comparison of coping strategies. *British Journal of Psychology,* 77, 243-255.

STEVENS, J. S., & JOVANOVIC, T. (2019). Role of social cognition in post-traumatic stress disorder: A review and meta-analysis. *Genes, Brain and Behavior, 18*(1), e12518.

SWART, M., KORTEKAAS, R. & ALEMAN, A. 2009. Dealing with feelings: characterization of trait alexithymia on emotion regulation strategies and cognitive-emotional processing. *PloS one,* 4.

SZE, J. A., GYURAK, A., YUAN, J. W. & LEVENSON, R. W. 2010. Coherence between emotional experience and physiology: does body awareness training have an impact? *Emotion,* 10, 803.

TAMIR, M. & MAUSS, I. B. 2011. Social cognitive factors in emotion regulation: Implications for well-being. *Emotion regulation and well-being*. Springer.

TAMIR, M., VISHKIN, A. & GUTENTAG, T. 2020. Emotion regulation is motivated. *Emotion,* 20, 115.

TAYLOR, G. J., BAGBY, M. & PARKER, J. D. 1992. The Revised Toronto Alexithymia Scale: some reliability, validity, and normative data. *Psychotherapy and psychosomatics,* 57, 34-41.

THEEUWES, J. 1991. Exogenous and endogenous control of attention: The effect of visual onsets and offsets. *Perception & psychophysics,* 49, 83-90.

TROY, A. S., SHALLCROSS, A. J., BRUNNER, A., FRIEDMAN, R. & JONES, M. C. 2018. Cognitive reappraisal and acceptance: Effects on emotion, physiology, and perceived cognitive costs. *Emotion,* 18, 58.

UCHINO, B. N., UNO, D. & HOLT-LUNSTAD, J. 1999. Social support, physiological processes, and health. *Current Directions in Psychological Science,* 8, 145-148.

URRY, H. L. 2009. Using reappraisal to regulate unpleasant emotional episodes: Goals and timing matter. *Emotion,* 9, 782.

URRY, H. L. 2010. Seeing, thinking, and feeling: emotion-regulating effects of gaze-directed cognitive reappraisal. *Emotion,* 10, 125.

URRY, H. L. & GROSS, J. J. 2010. Emotion regulation in older age. *Current Directions in Psychological Science,* 19, 352-357.

VAN DER PLOEG, M. M., BROSSCHOT, J. F., THAYER, J. F. & VERKUIL, B. 2016. The implicit positive and negative affect test: Validity and relationship with cardiovascular stress-responses. *Frontiers in psychology,* 7, 425.

VORST, H. C. M. & BERMOND, B. 2001. Validity and reliability of the Bermond-Vorst Alexithymia Questionnaire. *Personality and Individual Differences,* 30, 413-434.

WIENS, S. 2005. Interoception in emotional experience. *Current opinion in neurology,* 18, 442-447.

XIE, X., BRATEC, S. M., SCHMID, G., MENG, C., DOLL, A., WOHLSCHLAEGER, A., FINKE, K., FOESTL, H., ZIMMER, C., PEKRUN, R., SCHILBACH, L., RIEDL, V. & SORG, C. 2016. How do you make me feel better? Social cognitive emotion regulation and the default mode network. *Neuroimage,* 134, 270-280.

ZAKI, J. 2020. Integrating empathy and interpersonal emotion regulation. *Annual review of psychology,* 71, 517-540.

ZAKI, J. & WILLIAMS, W. C. 2013. Interpersonal Emotion Regulation. *Emotion,* 13, 803-810.

Chapter 4 – Investigating the Neural Correlates of Extrinsic and Intrinsic Inter-Personal ER using a Second-Person fMRI Paradigm

Due to the Covid-19 pandemic and the national lockdowns, participant-facing research was not possible in 2020 and severely restricted in 2021. Moreover, the planned replacement of the MRI scanner made it improbable that the planned inter-personal fMRI paradigm aiming to investigate inter-personal ER in a large, sufficiently powered experiment using the same paradigm presented in the previous chapter could be piloted and carried out within the remaining months of my studies. Importantly, the EDA findings presented in Chapter 3 offer support to suggest that there is in fact a physiological benefit to inter-personal ER when participants are regulating their emotions under the guidance of another person. Moreover, these physiological processes underlying improved regulation under external guidance are likely to be enabled by particular neural processes, which were investigated in the current chapter. To mitigate the disruptions caused by the pandemic, previously collected data was analysed to examine the neural correlates underlying inter-personal ER. This chapter offers further insights into physiological – i.e. neural, mechanism which distinguish inter- from intra-personal ER.

4.1 Introduction

4.1.1. The Current Status of Neuroimaging Research on Interpersonal Emotion Regulation

To recap from earlier chapters, emotion regulation (ER) describes the effortful, goal-directed process of modulating the duration, intensity or overall quality of an affective experience (Gross, 1998). Moreover, ER can be divided further into intrinsic and extrinsic, as well as intra- and inter-personal forms (Nozaki & Mikolajczak, 2020); see Table 1 for definitions). Importantly, this conceptualisation of (inter-)personal ER excludes spontaneous or automatic changes in affect and, therefore, phenomena such as social buffering - the soothing effects of the presence of another person, which have been associated with and sometimes been referred to as inter-personal ER (Coan, Schaefer, & Davidson, 2006; Mulej Bratec et al., 2020; Oh, Bailenson, & Welch, 2018; Zaki & Williams, 2013). In the following study, we used dual-fMRI to image the brains of interacting Regulator and Target pairs simultaneously; this allowed us to investigate the brain systems supporting intrinsic inter-personal ER in the Target regulating their emotions under recommendations from their partner, as well as extrinsic inter-personal ER in the Regulator who guides their partner's ER attempts, both within the process of inter-personal ER. Intrinsic intra-personal ER, hereafter referred to as intra-personal ER, is compared directly with inter-personal ER to understand how social influences impact on ER processes.

4.1.2. Examining the Neural Correlates of ER

Previous research has predominantly focused on intra-personal ER, thus the predictions for neural activation patterns during inter-personal ER will be rely heavily on the extensive literature on intra-personal ER. Due to the complex nature of ER processes, which involve strategy selection and goal-monitoring amongst other things, widespread neural activation can be expected (Gross, 2015; Morawetz et al., 2020). Previously, reverse inferences were used to generate a neural model of ER which could then be tested with future studies. Ochsner, Silvers, and Buhle (2012) assumed ER involved encoding the level of arousal elicited by a stimulus, encoding bodily representations of affective experiences, processing one's own mental/affective states or attributing these states to others, and monitoring discrepancies between one's current and desired affective state; and these processes were associated with the observed involvement of the amygdalae, insulae, dorsomedial prefrontal cortex (dmPFC), and dorsal ACC, respectively. Moreover, activations within the posterior PFC/ pre-supplementary motor area (pre-SMA), dorsolateral prefrontal cortex (dlPFC) and inferior frontal gyrus (IFG) were attributed to participants engaging selective attention and working memory when responding to affective stimuli. Activity within the ventrolateral prefrontal cortex (vlPFC) was thought to signify the inhibition of behaviour in pursuit of one's affective goals. Furthermore, the ventral striatum was assumed to encode rewards experienced following successful ER, i.e. the increased convergence between one's desired and one's current affective state. Although this review by Ochsner et al. (2012) offered suggestions of how different brain regions might interact with one another to enable effective ER, future experiments are needed to formally scrutinise the author's assumptions.

Meta-analyses can be particularly useful in elucidating the neural basis of intra-personal ER and offer a foundation from which the neural correlates of inter-personal ER can be understood. A recent meta-analysis of 93 ER studies revealed strategy-, stimulus- and goal-specific neural activations (Morawetz, Bode, Derntl, & Heekeren, 2017). Slight differences in neural activation patterns can be observed depending on the regulatory strategy, however, some key regions appear to be involved reliably in all types of cognitive control of emotions. The left anterior IFG/vlPFC, left pre-SMA and the bilateral insula were shown to be involved in both the increase and decrease of emotions using varied strategies, including cognitive reappraisal, disengagement and expressive suppression. Moreover, decreasing emotions was associated with bilateral neural activity in the vlPFC, dlPFC, dmPFC and the posterior cingulate cortex (PCC). Similarly, increasing emotions was shown to engage the bilateral IFG/vlPFC, motor areas, ventral striatum and dmPFC. Unlike a previous meta-analysis by Frank et al. (2014), which looked at 12 experiments with False Discovery Rate (FDR) correction and found amygdala activation to be involved in ER , the 23 studies included by Morawetz et al. (2017) applied a more conservative cluster-level family-wise error rate (FWER) corrections and found no consistent activation within the amygdalae when regulation conditions were compared to baseline conditions during which participants were asked to not regulate their emotions. While the FWER controls for false positives within any significant voxels, applying this correction to individual significant clusters of activation, greatly reduces the number of voxels to be compared, while still allowing for a stringent control of Type I errors (Eickhoff et al., 2016). The FDR correction applies a threshold only on voxels showing significant activations in an attempt to discover false positives within these supposedly significant voxels (Benjamini & Hochberg, 1995; Genovese & Wasserman, 2002). However, unlike cluster-wise FWER, FDR corrections have been criticised to exhibit reduced sensitivity for Activation Likelihood Estimates meta-analyses (Eickhoff et al., 2016). These meta-analyses counteract the possible influence of false positives of individual studies and increased between-studies variability evident in ER studies using different strategies or regulatory goals.

A meta-analysis of fMRI inter-personal ER studies has yet to be carried out, which reflects the limited number of available studies in this burgeoning field. Nonetheless, findings from intra-personal ER studies, as well as theoretical considerations of processes underlying inter-personal ER have been used to create a model of expected neural activity during inter-personal ER. A model of the neural networks involved in inter-personal ER has been proposed by Reeck, Ames, and Ochsner (2016). As this particular form of ER involves an interaction between at least two people, the authors proposed inter-personal ER involved three neural networks: system I supports cognitive control (dlPFC, vlPFC, posterior medial PFC, and dorsal ACC), system II enables the generation of emotions (amygdala and ventral striatum), and system III is involved in mentalising processes (temporal parietal junction, dorsal premotor regions, dorsal medial PFC, and precuneus). During inter-personal ER, the authors speculated increased activation in system I for Regulators and no significant activation in Targets; increased activation in system II for Targets and no discernible activation in Regulators; and differential activation in Regulators and Targets for system III. In particular, only Regulators were expected to show increased activation in the dorsal premotor regions, whereas activations within the TPJ, dorsal medial PFC and precuneus were proposed for both Regulators and Targets, and thought to differ slightly dependent on one's role within the dyad. Interestingly, there have been some studies investigating inter-personal ER, which have offered partial support for this model (Hallam et al., 2014; Xie et al., 2016).

In one study comparing inter- and intra-personal ER in Regulators, participants watched sad or disgusting videos and were instructed to decrease negative emotions during inter- and intra-personal ER (Hallam et al., 2014). During both inter- and intra-personal ER, a video of another person was embedded within the emotion-eliciting video and their facial expression changed from neutral to sad for sad videos and from neutral to disgusted for disgusting videos. During inter-personal ER, participants were presented with three ER suggestions (e.g. "It's just a film") and asked to recommend one of the strategies to the confederate within the video and that the confederate would only be aware of their responses during these inter-personal trials. Inter-personal ER was associated with activations within the left IFG triangularis, pre-SMA, bilateral inferior temporal gyrus, rostral medial PFC, left ACC, left TPJ and right temporal pole. For intra-personal trials, participants chose one of the three ER strategies to use themselves. Intra-personal ER engaged the left IFG triangularis, posterior SMA, right middle frontal gyrus (MFG), right orbital IFG, left superior frontal gyrus, bilateral supramarginal gyrus/TPJ, left posterior cingulate and the cerebellum. Thus, these findings offer some support for Reeck et al. (2016) neural model of inter-personal ER, as participants show activation within the cognitive control system, as well as the mentalising system. However, this particular study reported no activation within the emotion generative system.

Crucially, participants displayed activation within regions commonly associated with mentalising, such as the TPJ and temporal pole, in both the inter- and intra-personal condition. It remains unclear to what extent this was due to the paradigm – participants saw the video of the other person in both inter- and intra-personal conditions.

In a study focusing on Targets by Xie et al. (2016), participants were introduced to a psychotherapist and told the therapist would be guiding their ER attempts live, whilst participants completed the task in the scanner. Videos were played to participants, during which the therapist either asked participants to simply look at the negative image or provided them with reappraisal instructions (e.g. “Don’t forget, the pictures are not related to you.”). Inter-personal ER was associated with activation in the bilateral dorsolateral and dorsomedial PFC, bilateral OFC, dorsal ACC, inferior parietal cortex and the precuneus, thus offering further support for the neural model of inter-personal ER proposed by Reeck et al. (2016). However, similar to the study by Hallam et al. (2014) examining inter-personal ER in Regulators, within this whole-brain analysis no activation was observed in the emotion generative system, such as the amygdala. Again, in line with the results of Hallam et al. (2014), Targets’ neural activity during inter-personal ER was restricted to cognitive control and socio-cognitive processes. Targets receiving recommendations from a stranger (who was possibly perceived as competent in regulating one’s emotions (Xie et al. (2016)) resembled activations of Regulators guiding a stranger’s ER attempts (Hallam et al., 2014).

4.1.3. Pseudo-social paradigms

Due to ineffective ER being strongly associated with mental health disorders (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Cludius, Mennin, & Ehring, 2020), and poorer social connections and loneliness (Beckes & Coan, 2011; Coan et al., 2017; Gross, 2002), ER research often focuses on Targets in an attempt to improve poor ER abilities. Inter-personal ER is inherently social, yet many studies on inter-personal ER focus on a single person, who is often the Target, thereby disregarding psychological effects, which can only emerge in interactive paradigms, as they are intricately interwoven with the interactive process occurring between two people (Schilbach et al., 2013). Furthermore, inter-personal ER studies have commonly paid less attention to the Regulator, thus less is known about the neural correlates of guiding someone else’s ER attempts. It is likely that dyadic investigations of inter-personal ER have been hindered further by the difficulty of assessing effective decreases following extrinsic inter-personal ER in the Target. For instance, the studies presented above relied on para-social paradigms in which the Target was absent and thus their real-time responses could not be considered. Within these para-social paradigms, participants (Regulators) are asked to imagine an absent other (Targets), i.e. there is no real-time interaction with another person.

Therefore, the degree to which Regulators' and Targets' neural activity during real-time social interactions differs or converges is yet to be determined. The present second-person study extends these previous findings by offering crucial insights into the real-time inter-personal ER process of Regulators and Targets. Importantly, the present second-person paradigm goes beyond processes occurring within the Regulator and Target in isolation, by investigating psychological and affective processes emerging during this true dyadic interaction.

Similar to any interactive process, the ER process and its efficacy can be modulated in numerous ways by characteristics of each person, as well as particularities of the dyadic relationship and interaction. For instance, efficacy can be reduced if there are miscommunications between the Target and Regulator or the Target is unable to regulate their emotions effectively following inter-personal guidance (Reeck et al., 2016). Equally, a Regulator's inability to appropriately guide a Target's ER attempts can reduce the efficacy of extrinsic inter-personal ER (Pacella & López-Pérez, 2018). The ability of Regulators and Targets to effectively recommend or implement ER strategies during inter- and intra-personal ER can also be decreased by problems in socio-cognitive processes, such as the high prevalence of autistic traits (Samson, Hardan, Podell, Phillips, & Gross, 2015), reduced empathy (Nozaki & Mikolajczak, 2020), or failure-oriented personality traits which might limit one's perseverance with ER attempts (Koole & Fockenberg, 2011). Action orientation describes the dispositional tendency to flexibly adapt one's approach to meet situational demands (Kuhl, 1992). The spontaneous use of implicit ER is thought to underlie the distinction between action- and state-oriented personality types (Koole & Fockenberg, 2011). People with greater action-orientation exhibit improved ER which is thought to be influenced by their improved cognitive control and their flexible responses to situational demands compared with state-oriented individuals (Kobylińska & Kusev, 2019; Koole & Fockenberg, 2011). However, Target and Regulator responses depict complementary perspectives of the same phenomenon, and inter-personal ER can only be understood in its entirety if both sides of the coin are scrutinised. Thus, more studies investigating neural activity patterns in Regulators engaged in real social interaction with a Target are needed to understand the complex, dynamic processes of inter-personal ER. Further, although examining Regulators in isolation can extend our understanding of the neural activation patterns of inter-personal ER, truly interactive paradigms are needed for us to fully comprehend the intricate dynamics of giving and receiving ER support.

Previous second-person brain imaging studies offer some insights into the processes involved during real-time interactive affective exchanges. Crucially, similar to dynamic real-life interactions, one person's response is influenced by and influences the other person's response in a bi-directional exchange (Shaw et al., 2019; Špiláková, Shaw, Czekóová, & Brázdil, 2019). In a study by Anders, Heinzle, Weiskopf, Ethofer, and Haynes (2011) six different-sex couples underwent dual-fMRI scanning in an emotion perception paradigm. Females were instructed to communicate an affective state, e.g. sadness or disgust, to their partner via their facial expressions. Males were not informed about the instructions given to their partners and they watched their partners facial expressions whilst trying to feel what their partner was feeling. A time-resolved classification analysis showed that the neural responses from perceivers of the emotional expressions (i.e. males) could be predicted using the sender's (i.e. females) neural response patterns. When each trial was dissected further with a 2 second resolution, recipient's decoded neural activity in early stages resembled neural responses in the early stages of the sender's neural response; and the recipient's late neural activation pattern resembled the sender's late response pattern. These findings suggest that recipients might engage in embodied simulation of the sender's affective state when attempting to process another person's affective experience. Similarly, when related to inter-personal ER, second-person approaches, and dual-fMRI in particular, shed light on the neural processes in both Regulators and Targets, thereby illuminating the true extent to which Regulators engage in processes of embodiment during the provision of extrinsic inter-personal ER.

4.1.4. Aims and Hypotheses

Taken together, these findings suggest that similarities in neural activation can be expected in Regulators and Targets engaged in the Inter-personal ER Task employed in this thesis. Within this task, Targets either self-select an emotion regulation strategy to implement themselves or implement a Regulator-selected strategy. The present study is the first dual-fMRI experiment to examine real-time interactions between Regulators and Targets during inter-personal ER. The present investigation offers insights into how brain structures process intra-personal and extrinsic inter-personal ER in Targets; as well as how observing Targets engage in intra-personal ER and extrinsically guiding the Target's ER attempt is processed by Regulators. Therefore, this study aims to explore whole-brain neural differences and similarities between Regulators and Targets planning and implementing inter- and intra-personal ER. In doing so, we will assess the degree to which the Reeck et al. (2016)'s neural model of inter-personal ER applies to Regulators and Targets engaging in live inter-personal ER.

We also measured person characteristics that have been associated with poorer socio-cognitive processing and ER abilities to determine if and how they influence neural responses during ER and ER efficacy.

Hypotheses:

I. Targets will produce lower subjective ratings of negative affect and decreased neural activations within the limbic system following inter- relative to intra-personal ER.

II. Traits associated with difficulties in social functioning, such as high levels of autistic traits, low levels of empathy and low levels of action orientation, will be associated with higher ratings of negative affect following inter- and intra-personal ER (i.e. ineffective ER) and less neural activation in cognitive control regions during intra-personal ER for Targets and inter-personal ER for Regulators.

III. Targets engaged in intra-personal ER will display widespread activation in cognitive control (e.g. dlPFC, vlPFC and ACC) and emotion generative regions (i.e. the amygdala) during the selection as well as the implementation of an appropriate strategy.

IV. During inter-personal ER, Targets will exhibit reduced prefrontal activations (i.e. cognitive control) whilst Regulators select a strategy for them and increased prefrontal activation when actively implementing the Regulator-selected strategy – Regulators will display the reverse pattern.

V. Inter-personal ER in both Regulators and Targets will also engage brain regions commonly associated with mentalising, such as the dmPFC, TPJ and temporal pole.

VI. When selecting an ER strategy for Targets, Regulators' neural responses will resemble Targets' neural activations during the implementation of an ER strategy.

4.2. Methods

4.2.1. Participants

A total of 54 right-handed participants (26 males) completed the Inter-personal ER Task whilst undergoing fMRI. On the day of the experiment, participants were paired into age-matched same-sex Regulator-Target dyads. The data from 4 pairs was excluded from subsequent analyses on the basis of behavioural criteria detailed below, leaving 23 dyads: 13 male participants were assigned the role of the Regulator (Age_M= 25.00; Age_{SD}= 3.06) and paired with 13 male Targets (Age_M= 25.08; Age_{SD}= 2.81); and 10 female participants took on the role of the Regulator (Age_M= 24.2; Age_{SD}= 1.69) and were paired with 10 female Targets (Age_M= 24.2; Age_{SD}= 2.20).

4.2.2. Design

Using a within-subjects design, which extended the behavioural paradigm presented in Chapter 3, participants underwent five conditions coded using the Cogent 2000 toolbox (http://www.vislab.ucl.ac.uk/cogent.php). During an Inter-personal Regulation (Inter_{ER}) condition, Regulators chose a regulation strategy – either Disengagement or Reappraisal, for the Targets to implement when viewing negatively valence images. During an Intra-personal Regulation (Intra_{ER}) condition, Targets chose their own regulation strategy. In two Frame conditions, Regulators either selected a green or blue border to frame the image ($\text{Inter}_{\text{Frame}}$) or Targets chose a frame colour themselves ($\text{Intra}_{\text{Frame}}$). The behavioural paradigm was extended with an Affect Labelling condition, in which Regulators were asked to predict the Targets rating for each picture, whilst Targets simply viewed the images without frames or implementing a strategy before rating the image at the end of the trial.

4.2.3. Inter-Personal Emotion Regulation Task

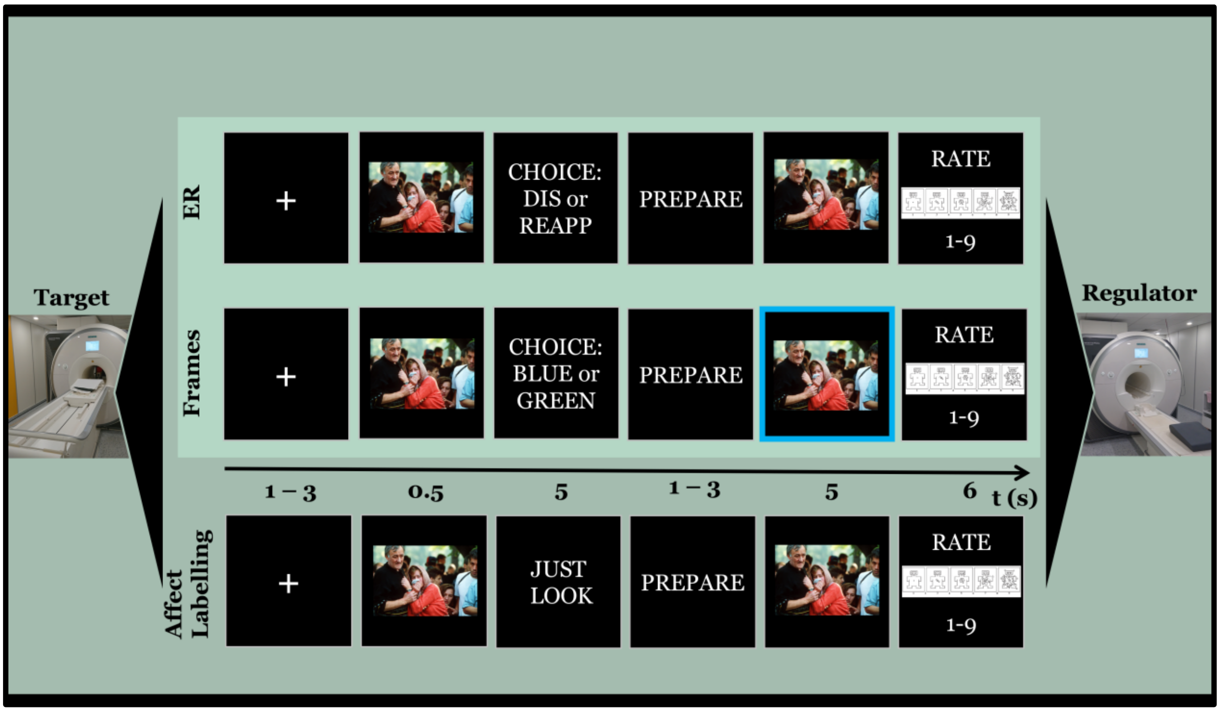


Figure 4.1.
Inter-Personal Emotion Regulation Task – stimuli presentation was identical for Targets and Regulators.

The experiment consisted of one continuous scanning session lasting approximately 60 minutes. During a single functional run, which lasted 52 minutes, dyads completed the five conditions – Inter_{ER}, Intra_{ER}, $\text{Inter}_{\text{Frame}}$, $\text{Intra}_{\text{Frame}}$ and Affect Labelling in a randomised event-related manner (see section Figure 4.1. for further details). In all trials of all conditions, both

Regulators and Targets were presented with a fixation cross prior to seeing a brief preview of an image. During ER trials, Targets implemented an ER strategy that had been chosen for them by the Regulator (Inter_{ER}) or one that they had self-selected (Intra_{ER}). To increase ecological validity, both individuals were unconstrained in their choices; Regulators were free to recommend either Disengagement or Reappraisal on the Inter_{ER} trials, and Targets were free to choose between the two strategies during Intra_{ER} trials. During Frame trials, Targets were either recommended a blue or green frame to be presented around a subsequent presentation of the image ($\text{Inter}_{\text{Frame}}$), or Targets chose between a blue or green frame themselves ($\text{Intra}_{\text{Frame}}$). Frame trials were used to introduce a control trial to ER trials during which Regulators and Targets were still actively selecting between two choices – a green or a blue frame. However, Targets were explicitly instructed not to alter their affective experience during these trials. Targets then prepared to implement the strategy or to look at the pictures for Frame and Affect Labelling trials in a subsequent longer presentation of the image. Crucially, during the Affect Labelling condition, Regulators were asked to predict Targets' scores before Targets rated the image at the end of the trial. Affect Labelling trials were used to determine the level of discrepancy between Regulators' predicted and Targets' actual rating responses. This allows us to determine whether task performance, i.e. ER efficacy, was influenced by the Regulator's ability to correctly identify – or learn to identify, the Target's affective responses. Finally, at the end of each trial Targets were required to rate their emotional response on a scale from 1 (low) – 9 (high) using the self-assessment manikin (Lang et al., 2008) following ER or simply looking at the image. Dyads completed 30 trials of each condition, resulting in a total of 150 trials for the entire functional run. Participants selected their strategy recommendations or affective ratings using a four-button response box, which allowed them to move along a sliding scale in order to select their response. After each trial, a 1000 – 3000ms jitter was used to ensure different timepoints of the haemodynamic response function were captured. A schematic representation of the task can be viewed in Figure 1.

4.2.3.1. IAPS Images

The task involved the use of 30 images which had been selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Participants saw each image once in each of the conditions – Inter_{ER}, Intra_{ER}, $\text{Inter}_{\text{Frame}}$, $\text{Intra}_{\text{Frame}}$, and Affect Labelling; therefore, they encountered each image five times during the 150 trials of the experiment. The images included depictions of crying infants and mutilations, with a varied range of normative arousal level ranged between 3.95 and 7.26 (mean= 5.59, SD= .93), and the normative valence ranged between 1.78 and 3.85 (mean= 2.69, SD= .82). Stimuli were classed as low or high arousal images following a median split of the selected images. Low arousal images had a mean arousal level of 4.91 (SD= .61) and a mean valence of 3.12 (SD= .7), whereas high arousal images had a mean arousal level of 6.36 (SD= .51) and a mean valence of 2.21 (SD= .69). Importantly, images classed as low and high arousal images were sufficiently different from one another, as they displayed significantly different levels of normative arousal ($t_{(28)}$= -6.97, p< .001) and valence ($t_{(28)}$= 3.58, p= .001).

4.2.4. Self-Report Measures

4.2.4.1. Autism

Autistic traits were assessed using the Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), a 50-item questionnaire that has been shown to have good internal reliability for the overall scale (.82) and the subscales (mean of .65, Austin, 2005; Baron-Cohen et al., 2001). Questions are arranged into five 10-item subscales covering different domains: social skill, attention switching, attention to detail, communication, and imagination. Participants rated statements, such as “When I was young, I used to enjoy playing games involving pretending with other children”, on a 4-point scale from “Definitely agree” to “Definitely disagree”. Although the factor structure has been criticised, with Kloosterman, Keefer, Kelley, Summerfeldt, and Parker (2011) and Hoekstra et al. (2011) suggesting a 28-item scale, the scale has been shown to have good internal consistency (Cronbach’s α ranging between .63 and .77). In our sample, the AQ showed good internal consistency (Cronbach’s α = .80).

4.2.4.2. Empathy

The Interpersonal Reactivity Index (Davis, 1983) measured empathy using a five-point Likert scale ranging from “Does not describe me well” to “Described me very well”. The 28 items map onto four dimensions of empathy, captured by the following subscales: empathic concern (EC), personal distress (PD), fantasy (FS), and perspective taking (PT). The EC, PD and FS subscales concern emotional empathy, as they assess the extent to which people experience emotions of concern for others, experience distress in response to another’s distress, and the ability to emotionally relate to fictional characters, respectively (Shamay-Tsoory, 2011; Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). Conversely, the PT subscale measures cognitive empathy also often referred to as mentalising, i.e. the ability to take on another person’s perspective (Kessler, Cao, O'Shea, & Wang, 2014; Schurz et al., 2021). Total scores are computed for each subscale, and the scale is intended to be used as a continuous metric, without cut-off points for low- or high-scorers. The test has been demonstrated to have acceptable internal consistency with a mean Cronbach’s alpha across the four scales ranging from .64 to .8 (mean= .73, Baldner & McGinley, 2014; Fernández, Dufey, & Kramp, 2011). The Cronbach alpha scores were acceptable for the PT, EC, PD, and FS subscales and ranged from.62, .81, .67, and .79 for the respective subscales (mean= .79).

4.2.4.3. Personality

The Action Control Scale (ACS; Kuhl, 1994) was used to assess dimensions of participants' personality by distinguishing between preferences for action- versus state-orientated ER. Action orientation relates to people's tendencies towards taking decisive actions and initiative, while state-orientated ER refers to indecisiveness and rumination (Jostmann & Koole, 2007; Kuhl, 1992). Importantly, action control is concerned with self-regulation and cognitive control and therefore a particularly intriguing personality factor to examine in relation to the cognitive control of emotions (Koole & Jostmann, 2004). It can be divided into three subscales concerning action orientation after failures (AOF), decision- (AOD) and performance-related (AOP) action orientation (Blunt & Pychyl, 2005). Participants are presented with 36 items, e.g. "When I have a boring assignment: …" and asked to choose between an option A (e.g. "I usually don't have any problem getting through it") or B (e.g. "I sometimes just can't get moving on it"), with one of these options mapping onto action orientation and the other onto state orientation. Higher scores on each subscale represent great action- (or goal-) orientated ER tendencies. The scale has been shown to have acceptable internal consistency (mean AOF α= .79; mean AOD α= .76, and AOP α= .64 (Baumann & Kuhl, 2002; Blunt & Pychyl, 2005). Acceptable internal consistency scores were observed within our sample (mean AOF α= .58; mean AOD α= .7, and AOP α= .64).

4.2.5. fMRI Data Acquisition

Two identical 3T Siemens Prisma scanners acquired structural and functional images from Targets' and Regulators' concurrently using 64-channel bird-cage head coils. High-resolution T1-weighted images were obtained for Targets and Regulators (TR= 2300ms , TE= 2.33ms, flip angle= 8°, FoV= 224mm, 1 mm^3 isotropic voxels). One long functional run acquired T2*-weighted images using an EPI sequence with a top-down interleaved slice order. Thirty-four axial slices with a slice thickness of 4mm were acquired to ensure whole-brain coverage (TR= 2000ms, TE= 35ms, flip angle= 60°, FoV= 204, 3 x 3 x 4 mm^3 voxels). Dyads underwent a single functional run consisting of approximately 1570 volumes. Both scanners were connected to one stimulus PC, thereby ensuring that dyads were presented with identical stimuli simultaneously. In both runs, an external programmable signal generator (Siglent SDG1025, www.siglent.com) initiated synchronous acquisition sequences in both scanners.

4.2.6. MRI Data Pre-processing

The structural and functional brain images were preprocessed using various utilities packaged within FMRIB's software library (FSL; Jenkinson, Beckmann, Behrens, Woolrich, & Smith, 2012). Participants' T1-weighted structural images were skull-stripped using FSL's Brain Extraction Tool (fractional intensity threshold = 0.1, vertical fractional gradient = 0). The functional time-series were then preprocessed using FEAT: volumes were slice-time corrected; a 100-second temporal high-pass filter was applied to counteract scanner drift; and images were spatially smoothed using a Gaussian Kernel with FWHM of 5mm. The preprocessed time-series were then registered to participants' T1 brain-extracted structural image using a linear Boundary Based Registration (BBR) transformation and a 90 degree search and the MNI 152 brain using a linear transformation with 12 DOFs and a 90 degree search using FLIRT (Jenkinson, Bannister, Brady, & Smith, 2002; Jenkinson & Smith, 2001). To improve motion correction, standard motion correction using MCFLIRT was followed with independent component analysis: Using MELODIC, 50 independent components were identified and assessed with the Spatially Organised Component Klassifikator (SOCK; Bhaganagarapu, Jackson, & Abbott, 2013) in order to identify components that resembled artefacts related to residual motion and physiological noise. Artefactual components were then regressed out of participants' time-series using *fsl_regfilt*, before running first- and higher-level analyses.

4.3. Analysis

4.3.1 Behavioural Analysis

Separate correlation matrices were calculated for Regulators and Targets to investigate relationships between participants' traits (i.e. scores on the AQ, IRI, and ACS), the Regulator's and Target's overall performance during ER trials, and Target ratings following intra- or inter-personal ER. A performance metric for Regulators was computed by subtracting Targets' ratings during the Affect Labelling condition, during which they had been instructed not to regulate their emotional reactions to the images, from their ratings under the Inter_{ER} condition. Similarly, Target performance was quantified by subtracting their ratings during the Affect Labelling condition from their Intra_{ER} ratings. Thus, negative values represented better performance during Inter_{ER} or Intra_{ER}, whereas positive values represented ineffective ER. This performance metric was computed to assess brain-behaviour associations, i.e. to determine cortical regions involved in regulatory efficacy during Inter_{ER} or Intra_{ER}.

Since Targets and Regulators were free to choose either Disengagement or Reappraisal on each of the ER trials, this resulted in unequal trial numbers of each strategy for each dyad. Thus, linear mixed effects modelling (LMM) was employed to investigate differences in Target behavioural ratings during the different trial types. Blue and green frame trials were collapsed into Frame trials, and compared to Disengagement and Reappraisal trials. From the 27 original pairs, four dyads were removed from both the behavioural and fMRI analyses due to a misunderstanding of task instructions or technical difficulties in the recording of accurate responses, resulting in a total of 46 participants. The distribution of each pairs' selection of each strategy is presented in Table 4.1.

Table 4.1.

Number of Disengagement and Reappraisal Trials for each Pair.

	Inter$_{ER}$		Intra$_{ER}$	
Pair	Disengagement	Reappraisal	Disengagement	Reappraisal
1	11	17	16	13
2	11	19	18	10
3	14	17	9	17
4	14	16	13	15
5	13	17	10	18
6	16	14	17	13
7	15	15	14	16
8	12	18	15	15
9	13	16	10	20
10	16	13	15	15
11	11	10	30	0
12	10	19	13	16
13	14	16	13	17
14	16	13	15	15
15	18	11	22	8
16	5	14	11	16
17	15	15	15	13
18	13	17	3	26
19	17	13	13	17
20	12	17	17	13
21	5	20	5	25
22	14	15	19	9
23	13	13	11	15

4.3.2. fMRI Data Analysis

First-level analysis

FSL's FEAT tool was used to run a first-level fixed-effects general linear model (GLM) analysis to investigate blood-oxygen level dependent (BOLD) responses associated with the six sub-trial events depicted in Figure 2.4. in the Methods Chapter (Chapter 2) : although subsequent contrasts focused only on the choice period (5000 ms) and extended viewing of the image (5000 ms), to maximise the signal-to-noise ratio we also modelled the fixation cross (500 ms), preview of the image (500 ms), preparation period (1000 – 3000 ms), rating response (6000 ms) and the jittered inter-trial interval (1000 – 3000 ms) as additional regressors of no interest. The onsets of the various task events were convolved with a double-gamma haemodynamic response function. Motion regressors were not specified, as SOCK had been used to identify and remove independent components resembling motion and physiological noise during preprocessing. Using FILM, pre-whitening was applied to combat temporal autocorrelations (Woolrich, Ripley, Brady, & Smith, 2001). Focused contrasts of the parameter estimates (COPEs; presented in Table 4.2) from these first-level analyses were then carried forward for group-level analyses.

Table 4.2.

First-level GLM contrasts descriptions used for both Regulators and Targets

COPE	Hypothesis	Description	Regulators	Targets
1	IV, V	Choosing Inter$_{ER}$ vs Choosing Inter$_{Frame}$	Responses specific to selecting a strategy for another person.	Observe Regulators select a strategy for the Target.
2	III	Choosing Intra$_{ER}$ vs Choosing Intra$_{Frame}$	Observing Targets select their own strategy.	Responses specific to self-selecting a strategy.
3	I	Choosing Inter$_{ER}$ vs Intra$_{ER}$	Activation specific to actively selecting a strategy for another compared with watching the other select their own strategy.	Activation specific to passively observing Regulators select a strategy for them compared with selecting their own strategy.
4	IV, V	Ext. Viewing Inter$_{ER}$ vs Ext.Viewing Inter$_{Frame}$	Responses to observing Targets implement a Regulator-selected strategy.	Responses to implementing a Regulator-selected strategy.
5	III	Ext. Viewing Intra$_{ER}$ vs Ext. Viewing Intra$_{Frame}$	Observe Targets implement a self-selected strategy.	Activations during implementing a self-selected strategy.
6	I	Ext. Viewing Inter$_{ER}$ vs Intra$_{ER}$	Observing Targets implement a Regulator-selected strategy.	Activations during implementing a Regulator-selected strategy.
7	VI	Choosing Inter$_{ER}$ > Ext. Viewing Inter$_{ER}$	Regulators choosing then watching Targets implement their chosen strategy.	Targets watching Regulators choose, then implementing the Regulator-selected strategy.
8		High Ext. Viewing Intra$_{ER}$ > Low Ext. Viewing Intra$_{ER}$	Observing Targets implement a Target-selected strategy during high arousal trials.	Implementing a self-selected strategy during high arousal trials.
9		High Ext. Viewing Intra$_{ER}$ vs Low Ext. Viewing Intra$_{ER}$ > High Ext. Viewing Inter$_{ER}$ vs Low Ext. Viewing Inter$_{ER}$	Observing Targets implement a Target-relative to a Regulator-selected strategy during high arousal trials.	Implementing a self-relative to a Regulator-selected strategy during high arousal trials.

Note. Inter= Inter-personal condition; Intra= Intra-personal condition; Ext. Viewing= extended viewing

Group-level analysis

Group-level within-subject analyses were carried out using mixed-effects modelling in FEAT. To restrict analyses to with-brain grey matter locations, thereby reducing noise arising from susceptibility artefacts around airways outside the brain, a binarised grey matter mask was applied to each contrast. A description of all COPEs, alongside the neural activation patterns investigated during particular periods of Inter$_{ER}$ and Intra$_{ER}$ and the specific hypothesis that they evaluate are presented in Table 4.2. For Regulators, we compared BOLD responses measured during their selection of a strategy relative to a frame for their recommendation (COPE 1; Choosing Inter$_{ER}$ > Choosing Inter$_{Frame}$); when they observed Targets implement a

Regulator- versus Target-selected strategy (COPE 4; Implement Inter_{ER} > Implement IntraER); and when during their choice of a regulation strategy compared the period in which they passively watched Targets self-select a strategy (COPE 3; Choosing Inter_{ER} > Choosing Intra_{ER}).

For Targets, contrasts were performed to identify differential BOLD responses during their self-selection of a strategy relative to self-selection of a frame (COPE1; Choosing Intra_{ER} > Choosing $\text{Intra}_{\text{Frame}}$); implementing a self-selected strategy relative to passively viewing the images within self-selected frames (COPE2; Implementing Intra_{ER} > Implementing $\text{Intra}_{\text{Frame}}$); implementing a Regulator-selected strategy relative to viewing images in a Regulator-selected coloured frame (COPE3; Implement Inter_{ER} > Implement $\text{Inter}_{\text{Frame}}$); implementing a Regulator-selected strategy compared to implementing a self-selected strategy (COPE4: Implement InterER > Implement IntraER); and observing the Regulator choose a strategy relative to self-selecting a strategy (COPE3; Choosing Inter_{ER} > Choosing Intra_{ER}). A further Target-specific COPE examined brain regions exhibiting increased BOLD signal during the choice of an ER strategy compared with the implementation of their self-selected strategy (COPE1>COPE2).

We also computed between-group contrasts to ascertain whether there is any specificity of activations for Regulators choosing a strategy for a Target (COPE1; Choosing Inter_{ER} > Choosing $\text{Inter}_{\text{Frame}}$) relative to a Target actively implementing a Regulator-selected ER strategy (COPE4; Implement Inter_{ER} > Implement $\text{Inter}_{\text{Frame}}$). The reverse of all aforementioned contrasts were also performed.

Since non-parametric permutation inference offers more precise control over false positives than other methods of multiple comparison correction (Eklund et al., 2016), whole-brain group-level statistical maps were corrected with FSL's randomise command (Winkler, Ridgway, Webster, Smith, & Nichols, 2014). A total of 5000 permutations with threshold-free cluster enhancement were run on each contrast. The resulting t-maps were then thresholded with a probability map ($p < .05$) to determine clusters of significant activation for each COPE. Peak activations from these significant clusters with a minimum cluster size of 10 and a minimum z-statistic of 4 were extracted.

Regions-of-interests analysis

In addition to whole-brain analyses, we performed exploratory region-of-interest (ROI) analyses to permit (1) a descriptive comparison of our results with other investigations into inter-personal ER and (2) a more nuanced evaluation of our hypotheses. To this end, we focused only on specific contrasts: for Targets, this included their implementation of Regulator-selected strategies compared with viewing Regulator-selected frames (COPE4). For Regulators, we focused on their choice of ER strategy compared with their choice of frame colour (COPE1). Eleven ROIs identified by the meta-analysis of Morawetz et al. (2017) were used to examine patterns of neural activations expressed in these COPEs for Regulators and Targets. Using meta-analytically defined ROIs avoided issues relating to double-dipping (Kriegeskorte, Simmons, Bellgowan, & Baker, 2009). The centre of gravity co-ordinates for these ROIs are presented in Table 4.3., around which spherical ROIs of 5mm radius were created with *fslmaths*. BOLD responses expressing each of the COPEs within these 11 ROIs were correlated with participants' self-report measures and task performance to examine brain-behaviour relationships. Importantly, we observed great overlap between these meta-analytic ROIs and peak activations from our GLM analyses for the inter-personal ER contrasts of interest for Regulators (COPE 1) and Targets (COPE 4; see Figure 5). The key difference between the present GLM and the meta-analytic results was the lack of activation in the amygdalae. However, as inconsistent findings regarding the amygdala's involvement in ER have been reported (Berboth, Windischberger, Kohn, & Morawetz, 2021), the two amygdalae were included, despite no activity in the amygdalae being observed in the whole-brain analyses.

Table 4.3.

Peak Co-Ordinates of the ROIs Derived from a Meta-Analysis by Morawetz, Bode, Derntl, et al. (2017)

		MNI Co-Ordinates		
ROI Label	Hemisphere	x	y	z
MFG/dlPFC	L	-43	13	42
MFG/dlPFC	R	42	19	42
IFG/vlPFC	L	-48	21	-1
IFG/vlPFC	R	47	28	-6
SMA	B	-2	17	53
SFG/MFG	L	-32	49	13
SMG	L	-51	-56	30
SMG	R	56	-54	34
MTG	L	-58	-37	-2
Amygdala	L	-25	-3	-15
Amygdala	R	23	-5	-15

Note. L= left, R= right

4.4 Results

4.4.1. Behavioural Data

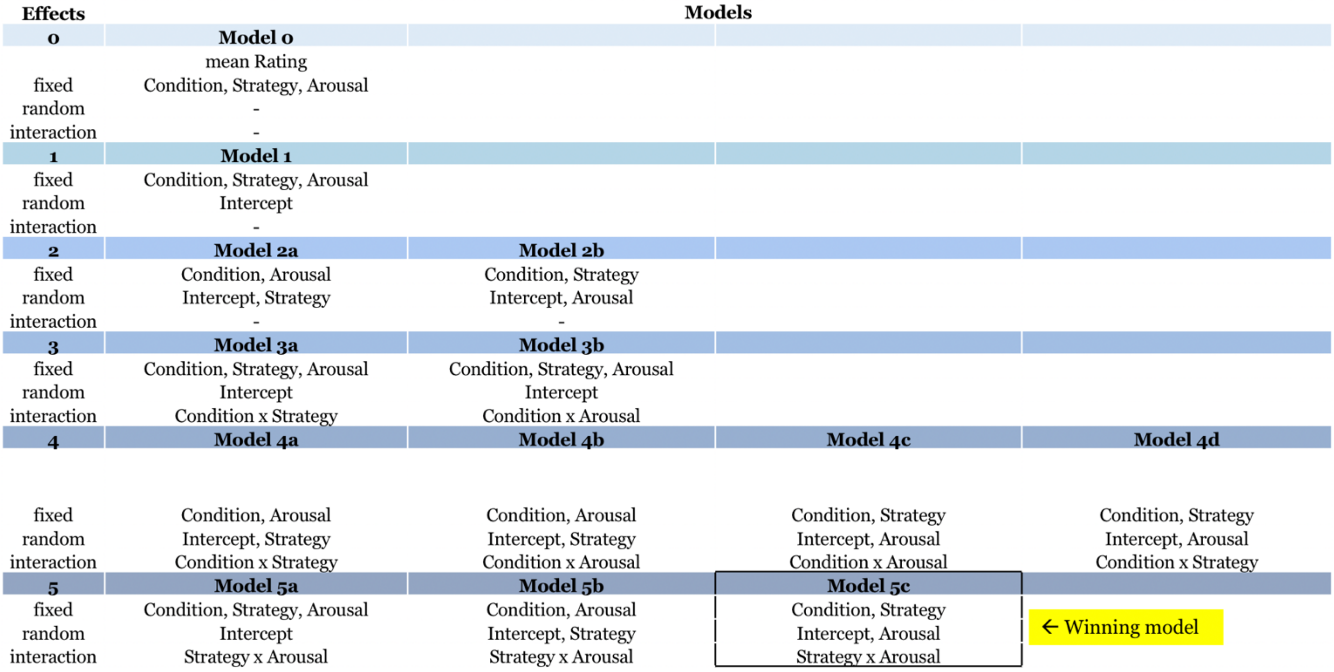
Targets' mean rating responses are presented in Table 4.4. Overall, participants rating responses for both the inter- and intra-personal condition, two levels of arousal and the three different strategies are relatively low and exhibit minimal variation.

Table 4.4.
Mean ratings (± standard error) for the main effects of Condition, Strategy and Arousal.

	Condition		Strategy			Arousal	
	Inter	Intra	Diseng.	Reapp.	Frame	Low	High
Mean (SE)	3.16 (.16)	3.2 (.16)	3.1 (.17)	2.79 (.17)	3.65 (.16)	2.52 (.13)	3.83 (.2)

Following the same approach as the EDA examination, various linear mixed models were computed and Akaike's Information Criteria (AIC; Sakamoto, Ishiguro, & Kitagawa, 1986) was used to compare the models using a step-up approach (see Figure 4.2.; exact details are provided within the Methods in Chapter 2). The following equation describes the best-fitting model (see Table 4.5.) with the lowest AIC for rating responses, in which *i* is estimated for each participant *j*:

$$\text{(I)} \qquad \boldsymbol{Rating_{ij}} = \beta_{0j} + \beta_1(Condition) + \beta_2(Strategy) + \beta_{3j}(Arousal) + \beta_4(Strategy\ x\ Arousal) + e_{ij}$$



Effects	Models				
0	**Model 0**				
	mean Rating				
fixed	Condition, Strategy, Arousal				
random	-				
interaction	-				
1	**Model 1**				
fixed	Condition, Strategy, Arousal				
random	Intercept				
interaction	-				
2	**Model 2a**	**Model 2b**			
fixed	Condition, Arousal	Condition, Strategy			
random	Intercept, Strategy	Intercept, Arousal			
interaction	-	-			
3	**Model 3a**	**Model 3b**			
fixed	Condition, Strategy, Arousal	Condition, Strategy, Arousal			
random	Intercept	Intercept			
interaction	Condition x Strategy	Condition x Arousal			
4	**Model 4a**	**Model 4b**	**Model 4c**	**Model 4d**	
fixed	Condition, Arousal	Condition, Arousal	Condition, Strategy	Condition, Strategy	
random	Intercept, Strategy	Intercept, Strategy	Intercept, Arousal	Intercept, Arousal	
interaction	Condition x Strategy	Condition x Arousal	Condition x Arousal	Condition x Strategy	
5	**Model 5a**	**Model 5b**	**Model 5c**		
fixed	Condition, Strategy, Arousal	Condition, Arousal	Condition, Strategy		
random	Intercept	Intercept, Strategy	Intercept, Arousal	← Winning model	
interaction	Strategy x Arousal	Strategy x Arousal	Strategy x Arousal		

Figure 4.2.
Model specifications for the linear mixed effect modelling.

Descriptive statistics for the ratings are displayed in Figure 4.3. There was no significant main effect of Condition, indicating no reliable differences in ratings between Inter- and Intra-personal trials (p= .623). Post-hoc comparisons of the significant main effect of Strategy (p< .001) revealed that ratings were significantly higher on Frame trials relative to both Reappraisal and Disengagement trials (both p< .001). A direct comparison of the active ER strategies Reappraisal and Disengagement revealed significantly lower ratings for Reappraisal relative to Disengagement trials (p= .004). A significant main effect of Arousal revealed that participants rated low arousal trials significantly lower than high arousal trials (p< .001). Post-hoc examinations of the significant Strategy-by-Arousal interaction effect (p< .001) indicated that under low arousal, there was no significant difference between Disengagement and Reappraisal trials (p= .252) but significantly lower ratings for both Disengagement (p= .041) and Reappraisal (p< .001) trials relative to Frame trials. Under high arousal, Disengagement trials were rated significantly higher than Reappraisal trials (p= .013), and again Frames were rated higher than both Disengagement (p< .001) and Reappraisal (p< .001) trials.

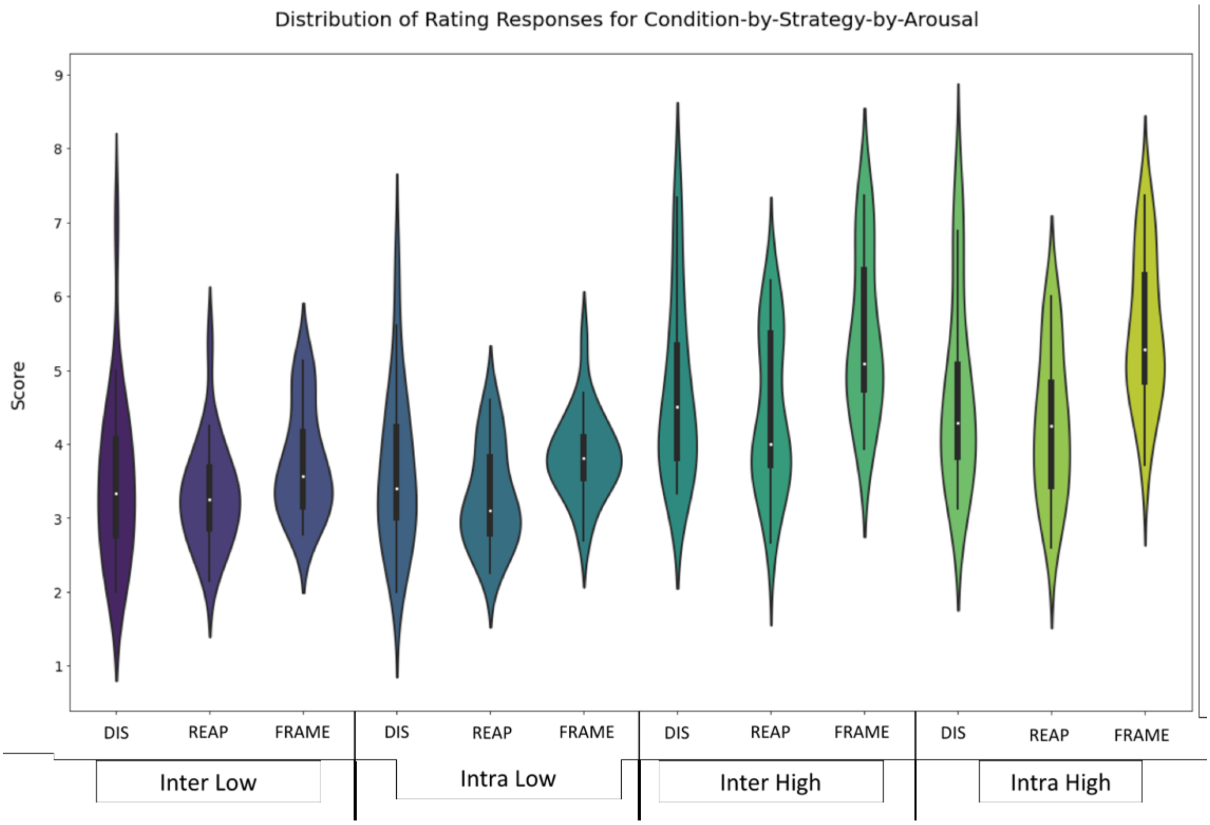


Figure 4.3.
Means and Standard Deviations for the LMM Results.

Table 4.5.

Estimates (± standard error) of fixed and random effects for the linear mixed effects model applied to ratings.

	Intercept (β_0)	Condition (β_1)	Strategy (β_2)		Arousal (β_{3j})	Strategy x Arousal (β_4)		
			Diseng.	Reapp.		Diseng. Low	Reapp. Low	Frame Low
Rating	4.51 (.21)**	-0.03 (.07)	-0.79 (.11)**	-1.19 (.12)**	-1.7 (.14)**	-1.2 (.17)**	-1.03 (.17)**	-1.7 (.14)**

Note. The reference for the Condition effect was the Intra-personal condition and negative estimates indicate lower ratings during the Inter- compared with the Intra-personal condition. Frame trials served as the reference category for the Strategy effect; negative estimates suggest lower ratings during Disengagement and Reappraisal trials relative to Frame trials. High arousal trials served as the reference category for the Arousal effect, with negative estimates suggesting lower rating responses during low arousal trials. *p < .05 and **p< .001.

In Figure 4.4, participants' choices for Disengagement or Reappraisal in response to either low- or high-arousal images for the current fMRI experiment are compared to intra-personal choices in the EDA experiment presented in Chapter 3. Whilst participants in the EDA experiments on average showed no preference for Disengagement in response to low- (mean= 7.01, SD= 3.03) or high-arousal images (mean= 6.82, SD= 2.72), Regulators within the fMRI experiments showed a slight preference for Reappraisal for low-arousal images (mean= 9.04, SD= 2.35) and no clear strategy preference for high-arousal images (Disengagement mean= 7.13, Disengagement SD= 2.09).

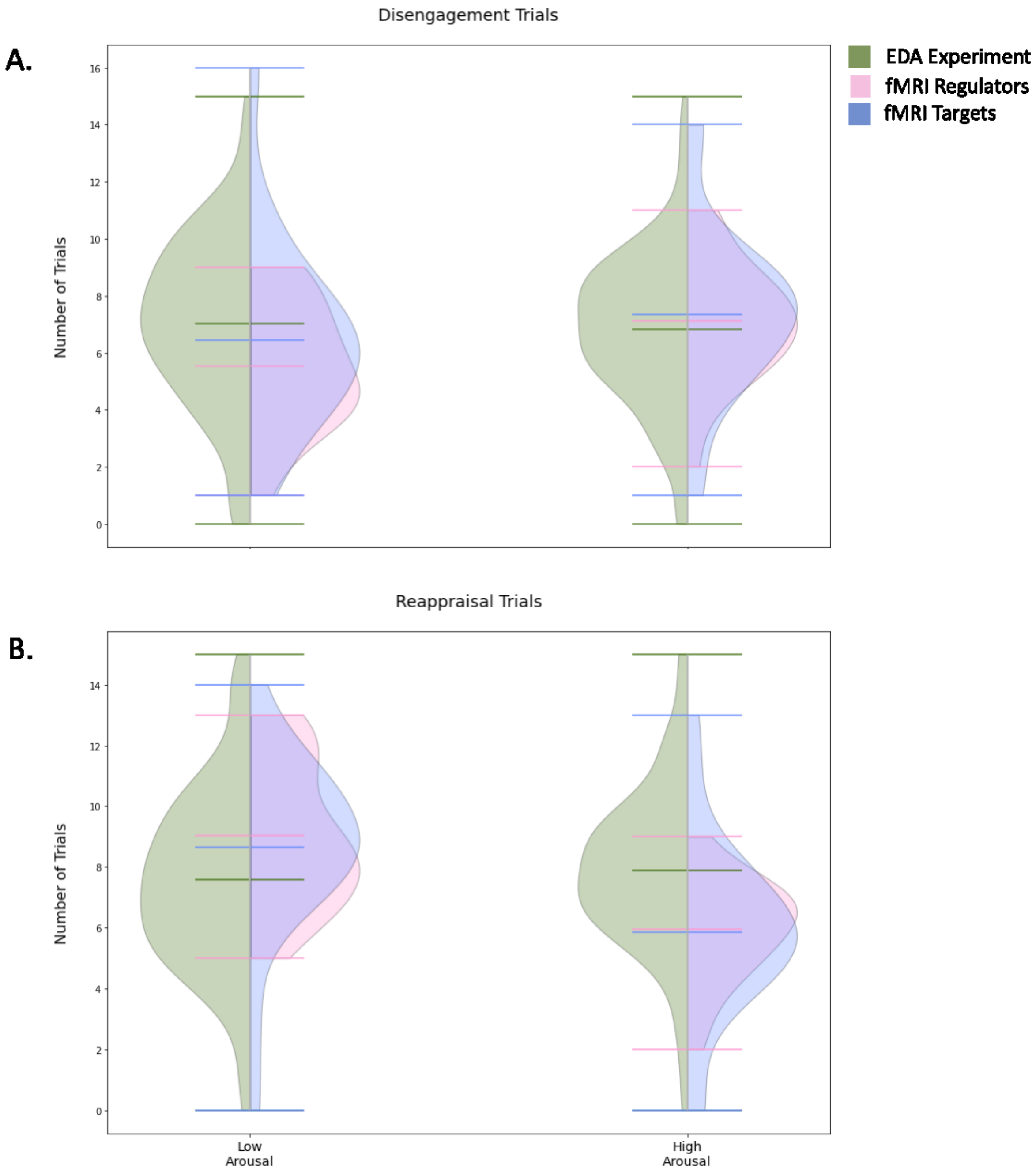


Figure 4.4.
Distribution of Strategy Choices for the EDA Experiment (Chapter 3) and Regulators and Targets for the Current fMRI Experiment. *Note*. Minimum, mean and maximum values are presented as coloured lines with the respective colours for each group (see legend).

4.4.2. Whole-Brain GLM Analyses

All of the clusters reported below exceeded a minimum spatial extent of 10 voxels. Only the largest cluster within a given brain region is reported where multiple clusters of at least 10 voxels were identified with the same structure (based on anatomical labels from the Automated Anatomical Labelling system [AAL], with labels generated using the R package label4mri; Chuang, 2021). All values reported below were obtained following non-parametric permutation testing. The following whole-brain results will be organised by COPEs, thus starting with Regulator then Target activations, and examining brain responses to ER choices prior to the extended viewing. Finally, neural responses differing between Regulators and Targets will be scrutinised directly.

Regulators Choosing a Strategy versus a Frame for Targets

When Regulators chose a strategy rather than a frame for Targets (COPE 1), large activations across the frontal pole, dorsolateral, dorsomedial and ventrolateral PFC, temporal pole, cingulate cortex, precuneus, SMG, and right cerebellum was observed (see Table 4.6. and Figure 4.5). These activations were primarily located within the left hemisphere, with some exceptional right hemispheric activation in the PFC – i.e. the SFG and MFG, as well as subcortical structures - i.e. the cerebellum, ACC and caudate nucleus.

Table 4.6.

Clusters expressing peak activation in Regulators when Regulators chose an ER strategy relative to a coloured frame for Targets (COPE 1).

Label	x	y	z	voxels	max
Frontal lobe					
MFG	-30	60	8	3690	7.83
IFG *triangular*	-52	20	-2	163	5.79
orbital	-44	30	-14	19	5.33
SFG	20	22	50	80	5.43
medial	4	44	38	18	4.78
medial	-6	58	28	33	4.79
MFG	28	30	34	26	4.74
Parietal lobe					
precuneus	-4	-68	44	91	5.58
postcentral gyrus	-22	-38	58	30	4.78
supramarginal gyrus	-46	-44	30	12	4.38
angular gyrus	-50	-58	34	164	6.03
Temporal lobe					
MTG	-48	-32	0	218	6.34
STG	-62	-42	22	77	6.29
Occipital lobe					
middle occipital lobe	-36	-74	40	12	4.83
Subcortical structures					
cerebellum	50	-56	-30	448	8.88
middle cingulate gyrus	-4	-20	32	59	5.29
posterior cingulum gyrus	-2	-44	26	45	5.45
anterior cingulate gyrus	14	30	28	12	5.87
caudate nucleus	20	-2	20	10	6.45

Note. max = maximum t-statistic with $p < .05$. Co-ordinates are provided with 2 mm^3 resolution in MNI space.

Targets Choosing a Strategy versus a Frame Colour

When Targets self-selected a strategy compared with a Frame (COPE2), widespread activation was observed across the bilateral dorsomedial PFC; the left dorsolateral and ventrolateral PFC; the left precuneus; bilateral anterior to posterior temporal lobes, and across the cingulate gyri and the cerebellum (see Table 4.7 and Figure 4.5.). The reverse contrast only yielded widespread activation across the occipital lobes.

Table 4.7.

Clusters of BOLD response in Targets during COPE 2 (their self-selection of an ER strategy).

Label	x	y	z	voxels	max *t*-value
Frontal lobe					
MFG	-38	52	2	2648	8.01
	36	52	12	41	4.68
SMA	0	12	58	718	6.28
SFG *medial*	12	60	26	239	7.1
	-2	34	54	26	5.53
IFG *orbital*	50	20	-6	171	5.41
triangular	-42	22	28	40	5.21
Parietal lobe					
angular gyrus	-46	-54	34	1312	7.92
	50	-50	32	113	6.09
precuneus	-6	-60	36	26	5.01
Temporal lobe					
MTG	-52	-20	-12	325	6.31
	60	-56	20	12	5.02
STG	48	-30	4	49	5.42
ITG	-48	-6	-26	12	5.2
Subcortical structures					
caudate	-12	8	14	313	7.24
	12	-4	16	43	5.45
middle cingulate gyrus	-14	-44	38	62	6.84
insula	-38	6	0	30	6.1
cerebellum	18	-88	-32	2086	11.4
	-38	-58	-28	21	5.08

Note. The maximum values reported here represent one-sample t-statistics (p< .05) following non-parametric permutation testing. Co-ordinates are provided with 2 mm^3 resolution in MNI space. Abbreviations: IFG= inferior frontal gyrus, ITG= inferior temporal gyrus, MFG= middle frontal gyrus, MTG= middle temporal gyrus, SFG= superior frontal gyrus, SMA= supplementary motor area, STG= superior temporal gyrus.

Inter- versus Intra-Personal Choice of a Strategy for Regulators and Targets

Brain regions of both Regulators and Targets expressing increased activation during Regulator- relative to Target-selected choices of ER strategies were examined (COPE 3), however, only clusters for Regulators withheld stringent non-parametric permutation testing (p< .05) and thus, only these are presented in Table 8. Regulators displayed widespread activation within the dorsolateral and -medial PFC, and some activation in the left posterior parietal and left occipital regions (see Table 4.9. and Figure 4.5.). For Targets, the reverse contrast was run to determine whether some regions displayed greater activation during Target-directed (i.e. self-selected) relative to Regulator-directed choices, however, this contrast also yielded no significant BOLD responses. Similarly, brain responses in Targets and Regulators during the implementation of Regulator- relative to Target-selected strategies were examined, revealing only significant activations (p< .05) in small clusters within the left posterior frontal and left parietal cortices, as well as across the right cerebellum for Regulators (see Table 4.9. and Figure 4.5.). Targets displayed no significant increases in activations during the implementation of Target-, i.e. self-selected strategies relative to Regulator-selected strategies, or during the implementation of the reversed contrast.

Table 4.8.

Clusters of BOLD response in Regulators during Regulators' choice of ER strategy (COPE 3).

Label	x	y	z	voxels	max
Frontal lobe					
SFG *medial*	-8	30	38	70	5.6
	-24	58	24	16	4.89
MFG	-32	52	2	65	4.82
SMA	-8	20	56	65	6.73
IFG *triangular*	-36	34	24	10	4.67
Parietal lobe					
angular gyrus	-52	-60	36	156	6.53
IPG	-50	-54	52	21	4.76
Occipital lobe					
calcerine fissure	-2	-98	4	93	5.62

Note. Only Regulators exhibited significant activations for COPE 3 and these were all restricted to the left hemisphere. Co-ordinates are provided with 2 mm^3 resolution in MNI space. max= maximum t-statistic with p< .05.

Targets Implementing a self- or Regulator-Selected Strategy

When Targets implemented a strategy recommended to them by the experimenter versus viewing images presented in the Regulator's choice of a blue or green frame (COPE 4), significant BOLD responses were minimal and limited to the left angular gyrus (p< .05, see Table 4.9. and Figure 4.5.). However, when implementing a self-selected strategy versus viewing images presented in a self-selected coloured frame (COPE 5), Targets displayed widespread activity across the bilateral dorsolateral, ventrolateral, and dorsomedial PFC, the left IPG, bilateral superior and medial temporal regions, as well as subcortical activation in the insula, ACC and right cerebellum (see Table 4.8. and Figure 4.5.). Again, the reverse contrast only revealed widespread activation across the occipital lobes.

Table 4.9.

Clusters of BOLD response in Targets during their implementation of a Regulator- (COPE 4) or self- (COPE 5) selected ER strategy.

Contrast	Label	x	y	z	voxels	max
COPE 4	angular gyrus	-44	-64	46	82	5.18
COPE 5	**Frontal lobe**					
	SMA	-6	12	70	323	6.4
		10	14	52	29	5.29
	precentral gyrus	-44	6	46	259	6.85
	MFG	-30	46	20	222	5.57
	MFG	28	44	22	43	4.93
	SFG	28	56	14	50	5.01
	IFG *triangular*	-40	34	28	21	5.29
		36	32	28	13	5.14
	opercular	-42	16	22	19	5.24
		48	16	12	143	5.75
	Parietal lobe					
	IPG	-46	-54	48	130	5.88
	Temporal lobe					
	MTG	-46	-16	-12	182	6.65
		-46	-52	16	111	5.48
		58	-58	12	19	5.29
	STG	64	-44	18	116	5.37
		-68	-48	12	19	4.96
	temporal pole *superior*	-52	18	-10	48	5.98
	Subcortical structures					
	Insula	-26	24	-6	45	5.42
	anterior cingulate gyrus	8	28	18	17	5.46
	middle cingulate gyrus	8	28	40	12	4.86
	Cerebellum	22	-82	-36	145	6.58

Note. max= maximum t-statistic with p< .05 after non-parametric permutation testing. Co-ordinates are provided with 2 mm^3 resolution in MNI space.

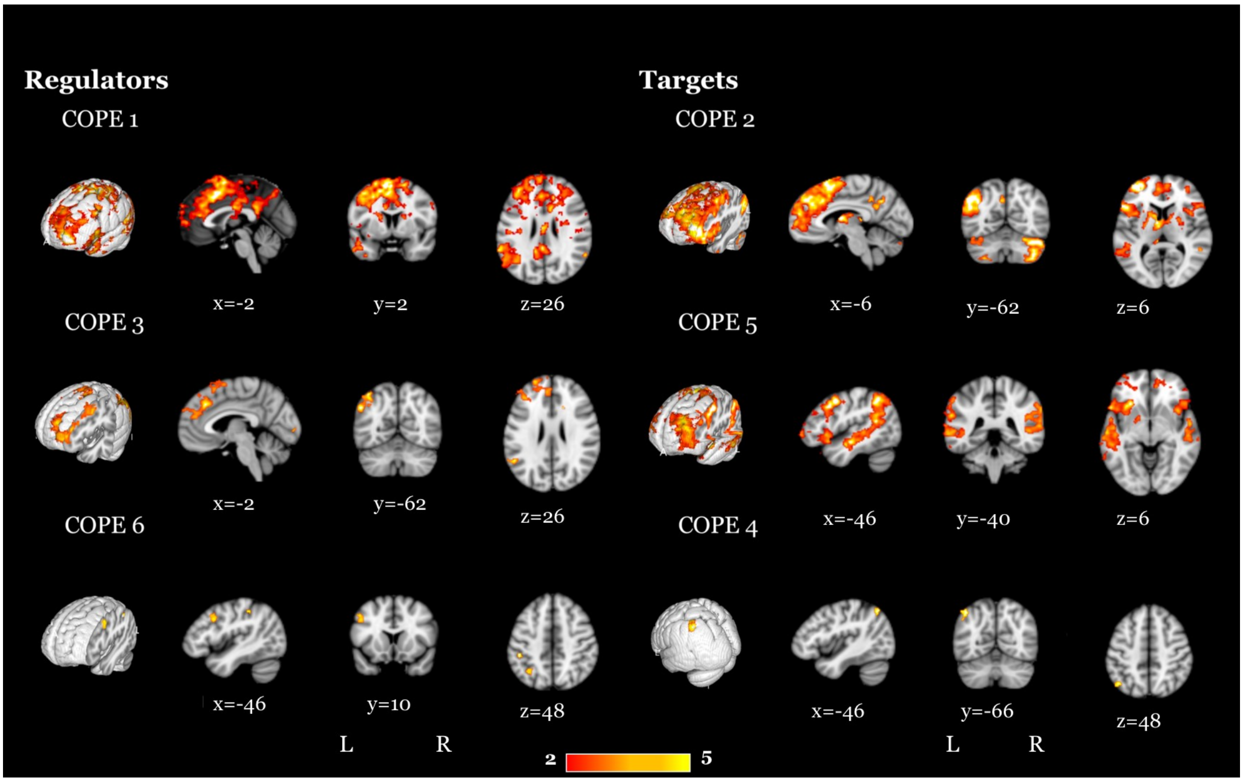


Figure 4.5.
Within-group t-maps for Regulators and Targets with significant BOLD activation presented for clusters surpassing a threshold of p< .05 following non-parametric permutation testing and overlaid on the standard 152 MNI brain with 2mm resolution. Non-parametric permutation testing with threshold-free cluster enhancement was used to control for multiple comparisons (minimum cluster size= 10, minimum z-statistic= 4). The contrasts assessing differential activation in Targets' BOLD responses when Targets implemented Regulator-selected versus self-selected strategies, and the reverse contrast, yielded no significant clusters of activation and are therefore not depicted here.

Implementing inter- relative to intra-personal ER

For COPE 6, only Regulators exhibited significant activations during Targets implementation of the Regulator- relative to Target-selected ER strategy, therefore only the significant regions observed in Regulators are presented in Table 4.10. Regulators activations were restricted to left hemispheric activation within fronto-parietal regions, and some right cerebellar activations. The reverse contrast yielded no significant activations for both Regulators and Targets.

Table 4.10.

Clusters of BOLD response in Targets and Regulators during Targets' implementation of ER in the inter- or intra-personal condition (COPE 6).

Label	x	y	z	voxels	max
Frontal lobe					
MFG	-44	12	36	66	4.84
Precentral gyrus	-36	2	32	16	4.85
Parietal lobe					

SPG	-32	-60	46	50	4.58
IPG	-46	-36	48	31	5.44
Subcortical structures					
cerebellum	26	-64	-28	477	6.87

Note. max= maximum t-statistic with p< .05. Co-ordinates for Regulators are provided with 2 mm^3 resolution in MNI space. Targets displayed no significant activations.

Regulators choosing and Targets implementing this Regulator-selected Strategy

A between-groups comparison was performed between Regulators' brain activity during the recommendation of a strategy relative to a frame and the subsequent brain activation of Targets when implementing this Regulator-selected strategy relative to a frame (COPE 7; see Figure 4.6). This allowed us to scrutinise whether people engage similar brain regions during the (extrinsic) selection of a strategy to recommend another and those involved when implementing these externally recommended strategies; in other words, whether Regulators' choices involved a simulation of Targets' responses during ER. When Regulators chose a strategy for the Targets, increased activation was lateralised entirely to the left hemisphere and observed across the pre- and postcentral gyri (see Table 4.11., Figure 4.6.). The reverse contrast yielded no significant activations, however; Targets implementing Regulator-selected strategies did not involve greater activation than Regulators choosing a strategy for them anywhere, or the additional engagement of other brain regions.

Table 4.11.

Clusters displaying peak activation for the between-group interaction effect examining differential neural activation during Regulators' choices of ER strategies over frames and Targets' implementation of the selected strategies over frames (COPE 7).

Label	x	y	z	voxels	max
Frontal lobe					
Precentral gyrus	-36	-12	62	97	6.23
Rolandic operculum	-48	-20	22	41	5.13
SMA	-10	-10	52	28	5.19
Parietal lobe					
Postcentral gyrus	-50	-20	32	403	6

Note. All contrasts examined activation during the inter-personal condition. Co-ordinates are provided with 2 mm^3 resolution in MNI space.

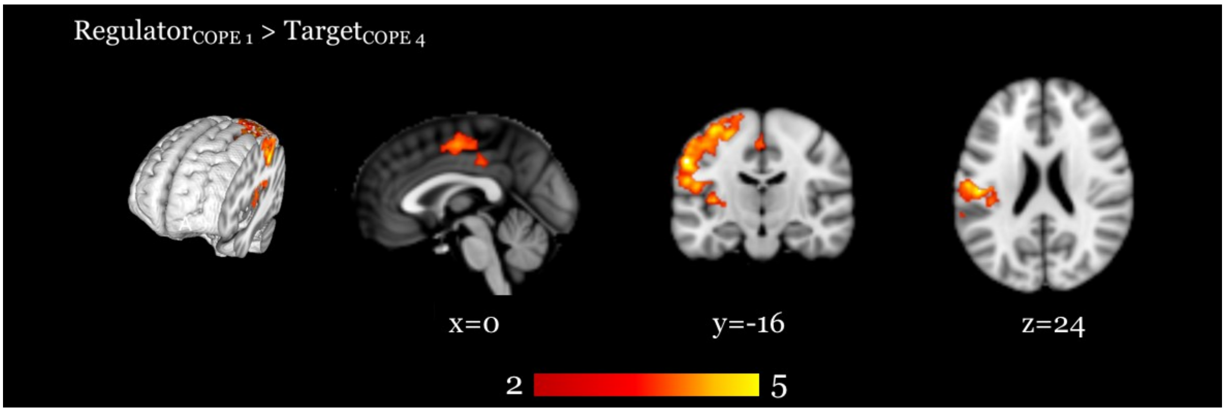


Figure 4.6.
Between-group activation maps showcasing significant t-values ($p< .05$) for brain regions exhibiting greater activity during Regulators' choice of a strategy compared with Target activations during the implementation of this Regulator-selected strategy (COPE 7). Non-parametric permutation testing with threshold-free cluster enhancement was used to control for multiple comparisons (minimum cluster size= 10, minimum z-statistic= 4).

4.4.2.1. Arousal Effects

In line with the findings from Chapter 3, where EDA metrics were modulated by the normative arousal level of images, the influence of arousal on participants' ratings and brain responses was examined. All low Inter_{ER} and Intra_{ER} trials were combined into Low trials, and all high Inter_{ER} and Intra_{ER} trials were combined into High trials, for both Regulators and Targets. For Regulators, brain responses during the choice period were scrutinised, whereas the extending viewing phase was examined for Targets. Interestingly, no significant main effect of Arousal was detected during the ER strategy choice period for both Regulators and Targets. As no brain regions exhibited significantly greater activations during high relative to low arousal images following cluster-wise thresholding at the whole-brain level, small volume analyses of bilateral amygdala activations were carried out using unthresholded and amygdala-masked images. These analyses probed whether amygdala responses were present yet too weak to be detected with more stringent thresholding at the whole-brain level (Figure 4.7.). The bilateral amygdala masks used for these analyses were identical to the meta-analytically derived ROIs used in the ROI analyses (Figure 4.10.). Moreover, Targets show no significant activations during the implementation of high versus low arousal trials at the whole-brain level, but they did show right amygdala activations for the unthresholded masked contrast.

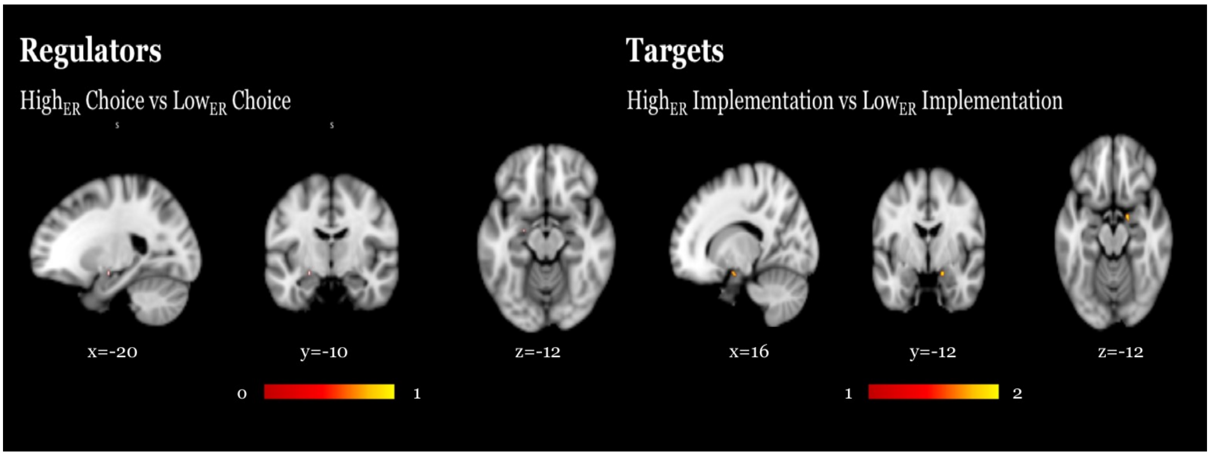


Figure 4.7.
Regulator and Target activations within bilateral amygdalae for high relative to low arousal images. Note: Images present unthresholded small volume analyses ($p<.05$).

There were no significant clusters of activation at the whole-brain level or only within the amygdala for Regulators when the Condition-by-Arousal interaction was examined during the choice of a strategy by the Regulator (i.e. Inter$_{ER}$) or Target (i.e. Intra$_{ER}$) strategy. Significant Condition-by-Arousal interactions were only observed for Targets during the implementation phase and are presented in Figure 4.8. During high compared with low arousing Intra$_{ER}$, significant activations were observed within the left postcentral gyrus which extended into the left precentral gyrus. Comparing high versus low arousal Inter$_{ER}$ and Intra$_{ER}$ trials directly showed no significant activations specific for Inter$_{ER}$, however, Intra$_{ER}$ was associated with left postcentral gyrus, the precentral gyrus and some left superior parietal lobule activation. Importantly, according to the LMM results of participants' rating responses, the model that best fit the data included a random effect for arousal. Thus, Targets' rating responses are best described using individual slopes for each pair, however, a fixed arousal effect for the group is presented in Figure 4.3. (left violin plots) for simplicity. Participants rated high arousal relative to low arousal images as more arousing following both inter- and intra-personal ER. Further, low arousal images were rated similarly during Inter$_{ER}$ and Intra$_{ER}$, as were high arousal images. Thus, overall, these findings suggest that participants experienced the effect of arousal as comparable during Inter$_{ER}$ and Intra$_{ER}$.

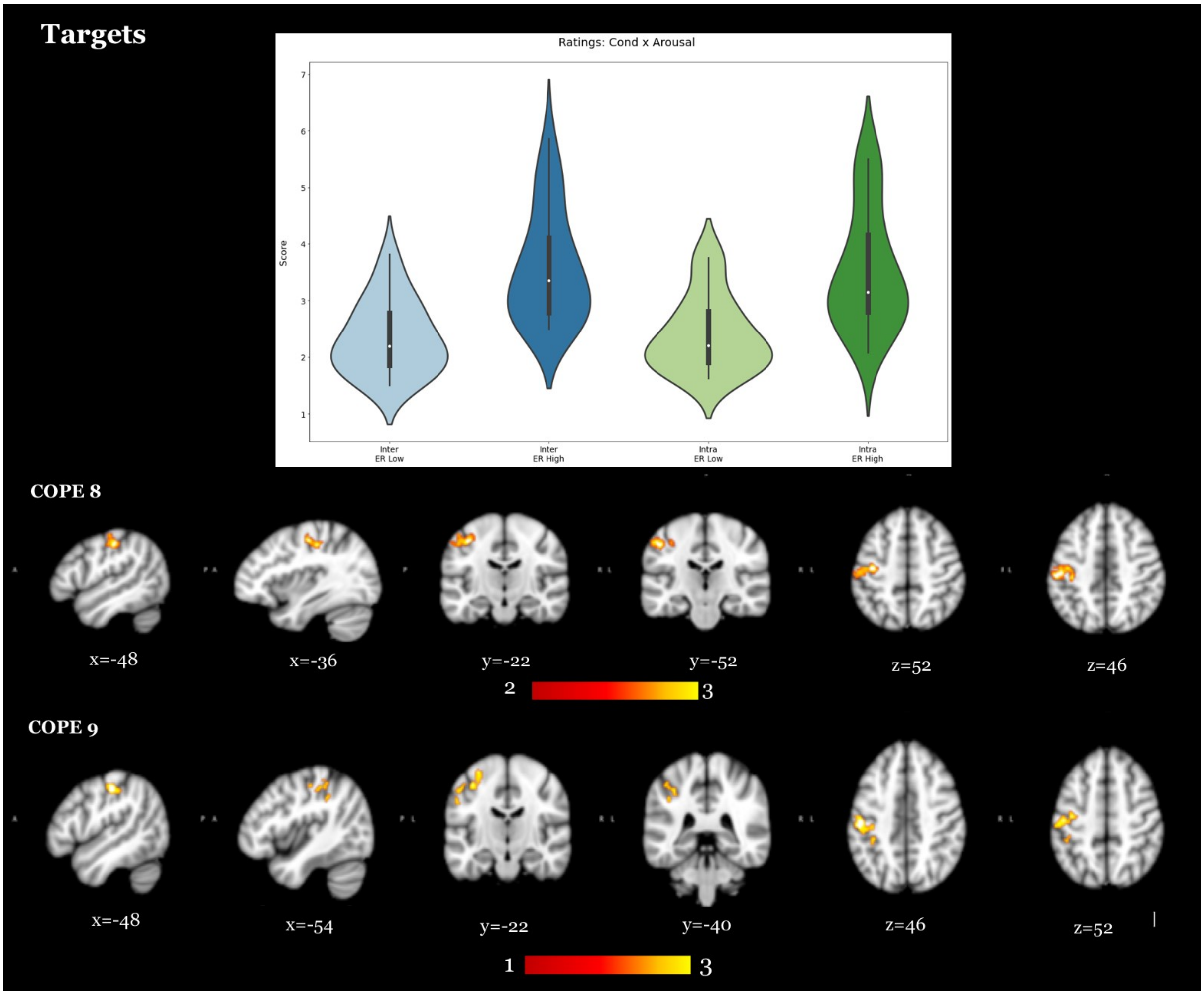


Figure 4.8.
Targets' significant clusters of activation for the Condition-by-Arousal interaction. Non-parametric permutation testing with threshold-free cluster enhancement was used to control for multiple comparisons (minimum cluster size= 10, minimum z-statistic= 4).

Due to the reduced size of the amygdala-masked analyses, uncorrected parameter estimates were computed. Therefore, these ROI-analyses were repeated with less and more stringent significance level. Significant results at a threshold of p<.05 for the amygdala analyses were carried out with the varying significance levels, however, only the significance level of p< .05 is presented in Table 4.12. Only COPE 3 (High vs Low – Intra.ER Choice) showed significant activation within the left amygdala at a significance level of p< .01, and no significant activation was observed at the more stringent threshold of p< .001. It should be noted, that capturing accurate amygdala activity is hindered by its location near the ventricles which introduces substantial noise from air and bone tissue (Olman, Davachi, & Inati, 2009). This noise is exacerbated by the number of available low or high arousal trials paired with the reduced sample size Regulators and Targets were examined separately. Thus, the amygdala seems to be involved within the present ER task for both Regulators and Targets, however, due to noise the signal might not always be detectable.

Table 4.12.

Amygdala-masked results for ps <.05.

	p<.05	
	Left	Right
Cope 6	●	
Cope 2		
Cope 3	●	●
Cope 2 > Cope 3		
Cope 3 > Cope 2		●
Cope 11		
Cope 7		●
Cope 8		●
Cope 7 > Cope 8		
Cope 8 > Cope 7	●	●

● = significant activation observed

4.4.3. Examining Potential Habituation Effects in the Amygdala

The lack of activation within the amygdala, and other key limbic system structures, within the whole-brain results was striking. The amygdala is consistently linked to a myriad of affective processes (Sergerie, Chochol, & Armony, 2008) and has been shown to be down-regulated during ER tasks (Paret et al., 2014). Crucially, the amygdala exhibits habituation effects for repeatedly presented stimuli (Plichta et al., 2014), as was the case in the present dataset. As described in the Methods section above, a total of 30 images were presented to participants within each condition, resulting in participants viewing each image five times, once for each of the five conditions: Inter_{ER}, $\text{Inter}_{\text{Frame}}$, Intra_{ER}, $\text{Intra}_{\text{Frame}}$ and Affect Labelling. In order to investigate whether activations of regions within the limbic system in general, and the amygdala in particular, were affected by the repeated image presentations, we examined linear changes, as well as step-wise changes at the whole-brain level.

To establish whether the amygdala or other brain responses declined from the first to the fifth iteration of the image presentations, two explorative analyses were run to explore habituation effects in the amygdala. Firstly, linear changes in activation, i.e. decreases and increases, were examined within the sample. A GLM analysis examined linear decreases and increases in whole-brain neural activation across successive presentations of the 30 stimulus images (results are summarised in Table 4.13). Secondly, responses during the first image presentation, when the encountered stimulus was still novel to participants, was compared to the four subsequent image presentations in a step-wise habituation analysis. Importantly, this probed regions expressing any other forms of non-linear habituation effects which could not be scrutinised with a linear contrast. These contrasts were computed for all images collapsed across high and low arousal levels, as well as two separate analyses, distinguishing between the first iteration of high or low arousal images and their respective following image presentations. In order to increase the signal-to-noise ratio, and as the preview period was likely to impact affective processes in Regulators and Targets equally, these analyses examined the preview period for Regulators and Targets as a unitary group. Activation patterns are presented in Figure 4.9.

Table 4.13.

Regions Displaying Linear Decreases and Increases in Activation across the Five Image Presentations for Targets.

Decrease	Increase
SMA	B Frontal pole
R IFG	L Precentral gyrus
B Precentral gyrus	R Postcentral gyrus
B Paracingulate gyrus	B Paracingulate gyrus
B ACC	B ACC
L Insula	B PCC
B LOC	R Thalamus
L Putamen	B LOC
L Thalamus	L Planum temporale
L Pallidum	B MFG
R Frontal Pole	L IFG
	B Precuneus
	B Angular gyrus
	B Supramarginal gyrus
	B MTG
	B STG

Note. B= bilateral, L= left, R= right

The first habituation analysis assessing linear changes, revealed brain regions exhibiting linear decreases in Targets to be centred around initial processing regions required for the elicitation of an affective response, e.g. the LOC and insula. Whereas, brain regions involved in higher cognitive processes, such as ER, including the frontal pole or MTG exhibit increases as Targets engage in the ER task (see Figure 4.9.).

The second, step-wise habituation analyses revealed significant decreases within the limbic system from the first to all subsequent image presentations (Figure 4.9.). When all first iterations of the image previews were compared with all subsequent image previews, widespread activation were observed primarily across numerous subcortical regions (bilateral PCC, L amygdalae, bilateral posterior parahippocampal gyrus, bilateral thalamus, bilateral caudate, bilateral insulae, bilateral putamen, bilateral hippocampus, and bilateral cerebellum), as well as some parietal (bilateral SMG, bilateral angular gyrus, and bilateral precuneus), temporal (bilateral temporal pole, bilateral MTG, and bilateral fusiform cortex), and occipital (bilateral LOC, bilateral occipital pole, bilateral intracalcerine cortex, and bilateral supracalcerine cortex) regions. Similarly, when only high arousal images were considered, widely distributed activations were present across subcortical regions (bilateral thalamus, bilateral putamen, left pallidum, left insula, right caudate, bilateral parahippocampal gyrus, bilateral PCC, and bilateral cerebellum), parietal (left precuneus, bilateral superior parietal lobule, bilateral angular gyrus, and parietal operculum cortex), temporal (bilateral MTG and bilateral ITG) and occipital regions (bilateral LOC, and bilateral lingual gyrus). However, these activations were reduced and predominantly left-lateralised when only low arousal images were considered, with activations predominantly clustering around subcortical regions (left amygdala, bilateral thalamus, left caudate, left hippocampus, and bilateral cerebellum), with few occipital regions (left LOC, left cuneal cortex, left occipital fusiform gyrus, bilateral temporal occipital fusiform cortex) and the left precuneus showing decreases with following image presentations.

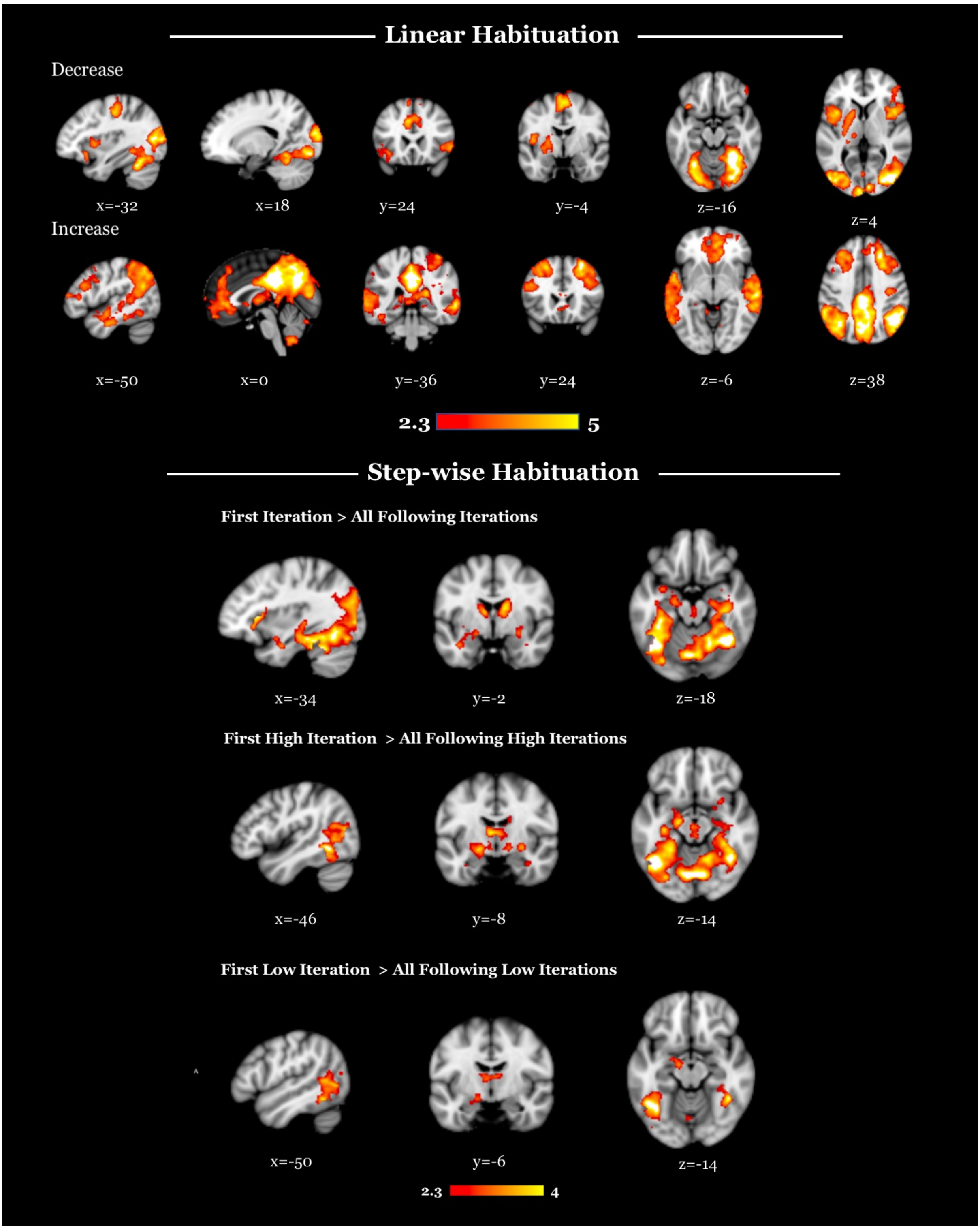


Figure 4.9.
Linear habituation: Regions exhibiting linear changes in activation from the first to the fifth iteration of the images for Targets. Step-wise habituation: Combined Regulator and Target Activations for the first image preview period relative to the following four iterations for all images (top row), for high arousal images only (middle row) and low arousal images (bottom row). Cluster correction with a z threshold of 2.3 and significance threshold of .05 was used to correct for multiple comparisons.

4.4.4. ROI Analyses

As mentioned previously, the following ROI analyses interrogated brain regions identified in a recent meta-analysis, which are presented in Table 4.3. above (Morawetz, Bode, Derntl, et al., 2017). The meta-analytically defined regions overlapped greatly with regions displaying peak activation following GLM analyses in our data. See Figure 10 for a visualisation of ROIs created with peak activations from Morawetz et al. (2017). For both Regulators and Targets, we focused on contrasts which emphasised the interaction within the dyad. For Targets, the key contrast of interest concerned the implementation of a Regulator-selected strategy relative to the viewing of an image within a Regulator-selected coloured frame (COPE 4). However, due to the limited activations observed during these trials, ROIs presented in Figure 10 are also compared to activations during the implementation of a self-selected strategy (COPE 5). On the other hand, activation during the choice of a strategy relative to a frame within the 11 ROIs was particularly interesting for Regulators (COPE 1). These two contrasts were presented for both Regulators and Targets in Figure 4.10.

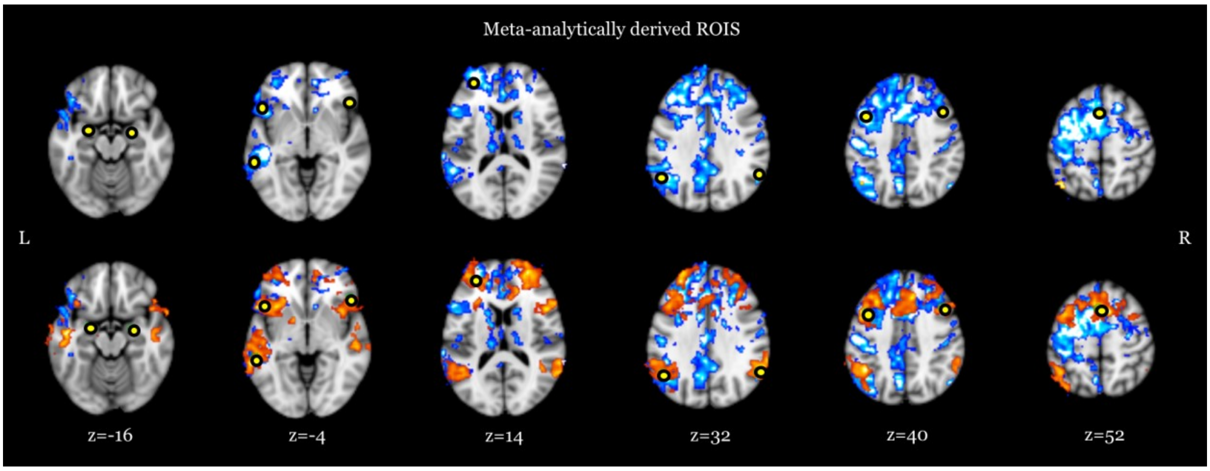


Figure 4.10.
ROIs derived from Morawetz, Bode, Derntl, et al. (2017) meta-analysis are overlayed over Regulator (COPE 1 top and bottom row) and Target (COPE 4 top; COPE 5 bottom row) activations observed during the inter-personal ER paradigm. Co-ordinates are provided with 2 mm^3 resolution in MNI space. Note. L= left, R= right.

Systems I, II, and III

According to Reeck et al. (2016) inter-personal ER involves a neural network that can be divided into three systems: system I is required for cognitive control and the effortful down-regulation of the emotion generative system III, whereas system II is involved in socio-cognitive processing. Differences in ROI activations during the choice of an inter-personal strategy and the implementation of an inter-personal strategy are depicted in Figure 4.11. During the selection of a strategy relative to a frame colour, ROIs within system I of the Regulators' brains are particularly increased within the left hemisphere (left IFG and left

MFG). For Targets, a similar left hemispheric increase in system I can be observed when they implement the Regulator-selected strategies. Overall, the Regulators' and Targets' activation patterns within system I resemble one another quite closely during Regulators' strategy selection periods. In the current ROIs, the bilateral amygdalae represent system III and the right amygdala shows increased activation when either counterpart is not actively engaged in the task; i.e. when Targets passively observe Regulators select a regulatory strategy for them, or when Regulators watch the stimuli as Targets implement the Regulator-selected strategy.

Within system II, Regulators and Targets also show similar increases in activation in the right SMG, left SFG/MFG, and left MTG when Regulators are selecting a strategy; however, during the Targets' implementation of these strategies the dyads show similar increased activation in the right SMG, and differential activation in the remaining ROIs of system II. Whilst Regulators exhibit decreased activation within the left SMG, left MFG/SFG, and left MTG, activation for Targets remains high. Interestingly, similar to the dissociation within the right amygdala, the left SMG shows increased activation for active involvement in the task, i.e. during Regulators' strategy selection, or Targets' strategy implementation, and reduced activity for passive involvement, i.e. when Targets observe the Regulators' selection and when Regulators watch Targets implement the strategies. Further, in both Targets and Regulators, increased activity in the amygdala corresponds with reduced activity in the left SMG and vice versa.

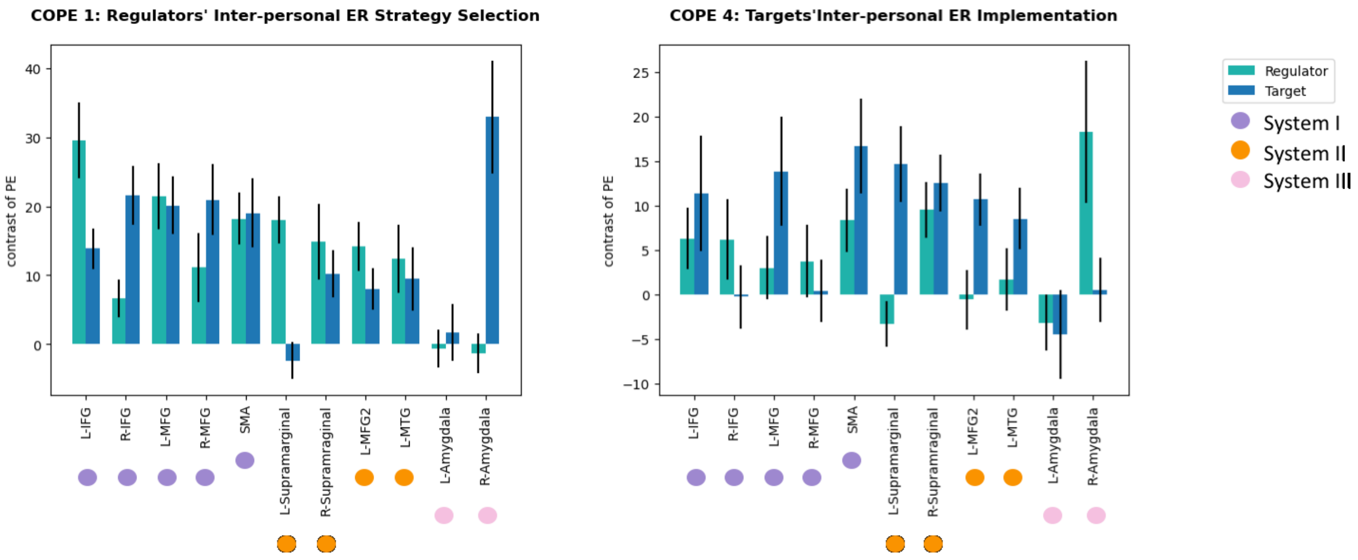


Figure 4.11.
Activations represent the mean of Regulators' and Targets' median activations within each ROI. **A.** Regulator and Target activations during the Regulators' selection of a strategy relative to a frame. **B.** Regulator and Target activations during the Targets' implementation of a Regulator-selected strategy relative to a Regulator-selected frame.

4.4.4.1. Brain-behaviour correlations

The following exploratory ROI analyses were used to examine potential brain-behaviour associations to inform future investigations, however, although significance values are reported these are not confirmatory for a priori defined hypotheses. Within the aforementioned 11 ROIs, some activations were correlated significantly with participants' self-report measures (AQ, ACS, IRI and UCLA) and task performance. The correlation matrix for Regulators and Targets are presented in Table 4.14. and 4.15., respectively.

For Regulators and Targets, scores on the AQ were positively correlated with personal distress ($r= .3$, $p< .05$) and negatively correlated with decision-related action orientation (AOD; $r= -.4$, $p< .001$). Personal distress was negatively correlated with both subscales of the ACS ($r= -.54$, $p< .001$ for AOF, and $r= -.31$, $p< .05$ for AOD). Both Regulators' and Targets' task performance was not correlated with any of the self-report measures or ROI activations (all $ps> .05$). In terms of associations between the self-report measures and BOLD signals extracted from the ROI, three significant correlations emerged for Regulators and two for Targets: Regulators' personal distress scores were positively correlated with activations in both the right MFG ($r= .48$, $p< .05$) and right SMG ($r= .43$, $p< .05$). Regulators' AOD scores were negatively correlated with their neural activations within the left MTG ($r= -.48$, $p< .05$). Targets' left MFG/SFG activity was positively correlated with their AQ scores ($r= .54$, $p< .001$) and activation within the left SMG was positively correlated with participants' personal distress scores ($r= 44$, $p< .05$).

For Targets, all of the ROIs in system I were significantly correlated with one another (all $ps< .05$); whereas the bilateral MFG showed fewer significant correlations with other system I ROIs for Regulators. Furthermore, all but three correlations between the Target's system I and II ROIs were significantly correlated with one another. Only activity in the left SMG was not significantly correlated with the bilateral IFG, and the right SMG was also not significantly correlated with the right IFG (all $ps> .05$). Again, fewer correlations were observed in Regulators when system I and II ROIs were examined. Regulators' left SMG activity showed significant correlations with the left IFG ($r= .51$, $p< .05$) and bilateral MFG ($r= .48$ and $r= .45$ for the left and right MFG, respectively, both $ps< .05$). Additionally, the right MFG was significantly correlated with both the right SMG ($r= .63$, $p< .001$) and the left MTG ($r= .52$, $p< .05$). No significant correlations emerged between system II and III ROIs for Regulators (all $ps> .05$).

Table 4.14. Correlation Matrix of Regulators' Self-Report Measures, Task Performance and ROI Activity

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
1. AQ																			
2. PT	-.15																		
3. FS	.15	.16																	
4. EC	-.24	**.36***	.18																
5. PD	**.3***	-.16	.12	.27															
6. AOF	-.25	.15	-.21	-.29	**-.54****														
7. AOD	**-.4****	.25	-.21	.17	**-.3***	**.35***													
8. Perf$_R$	-.07	-.28	-.07	.04	.23	**-.43***	.07												
9. Perf$_T$	-.16	-.02	-.03	.15	.27	-.34	.03	**.83****											
10. L-IFG	-.23	-.05	.21	.14	-.05	-.20	-.11	.c	.c										
11. R-IFG	.17	.06	.16	.02	.05	-.02	-.3	.c	.c	**.46***									
12. L-MFG	-.20	-.11	-.25	.1	.18	-.10	.03	.c	.c	**.52***	.29								
13. R-MFG	-.02	-.1	-.18	.07	**.48***	-.26	-.12	.c	.c	.4	.29	**.8****							
14. SMA	.15	.1	.09	.08	-.12	.32	.05	.c	.c	**.43***	**.66****	.19	.19						
15. L-SMG	-.08	-.07	-.27	-.08	.00	.21	.09	.c	.c	**.51***	.25	**.48***	**.45***	**.55****					
16. R-SMG	.27	-.01	-.17	-.09	**.43***	.03	.01	.c	.c	.08	.19	.34	**.63****	**.42***	**.6****				
17. L-MFG2	-.05	-.02	.39	-.12	-.30	.21	-.13	.c	.c	.31	.24	-.05	.00	.4	.15	.1			
18. L-MTG	.14	-.09	-.15	.01	.22	-.13	**-.48***	.c	.c	.13	.39	.34	**.52***	.31	.30	**.54****	.05		
19. L_Amy	-.04	.13	.36	.18	-.06	.22	-.12	.c	.c	.00	-.09	-.30	-.22	.00	-.07	-.21	.25	-.14	
20. R_Amy	-.09	.39	.23	.13	-.24	.30	.12	.c	.c	.10	.22	-.13	-.16	.21	.00	-.17	.26	.02	**.63****

Note. ROI activity was extracted for COPE 1. *p< .05, **p< .001, the four subscales of the Interpersonal Reactivity Index (IRI) are presented separately: perspective taking (PT), fantasy (FS), empathic concern (EC) and personal distress (PD). Two of the Action Control Scale (ACS) subscales are presented above: action-orientation after failure (AOF) and decision-related action-orientation (AOD). L-MFG2= left SFG/MFG. Abbreviations: Perf$_R$= Regulator performance; Perf$_T$= Target performance, L= left, R= right, Amy= amygdala, ●System I, ●System II, ●System III. Correlations are not corrected for multiple comparisons.

Table 4.15.

Correlation Matrix of Targets' Self-Report Measures, Task Performance and ROI Activity

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
1. AQ																			
2. PT	-.15																		
3. FS	.15	.16																	
4. EC	-.24	**.36***	.18																
5. PD	**.3***	-.16	.12	.27															
6. AOF	-.25	.15	-.21	-.29	**-.54****														
7. AOD	**-.4****	.25	-.21	.17	**-.31***	**.35***													
8. Perf$_R$	-.07	-.28	-.07	.04	.23	**-.43***	.07												
9. Perf$_T$	-.16	-.02	-.03	.15	.27	-.34	.03	**.83****											
10. L-IFG	.1	-.36	.05	.05	-.04	-.36	.17	**.42***	.21										
11. R-IFG	.08	-.13	.05	.16	-.14	-.41	-.03	.37	.33	**.74****									
12. L-MFG	.07	.03	.13	.33	.12	-.15	-.14	.00	.12	**.57****	**.55****								
13. R-MFG	.2	-.11	-.14	.08	.1	-.22	-.15	.00	-.01	**.55****	**.47***	**.69****							
14. SMA	.16	-.20	-.01	.00	-.16	-.01	-.04	.14	.17	**.77****	**.66****	**.83****	**.62****						
15. L-SMG	.15	-.04	-.05	.3	**.44***	-.13	-.08	.14	.10	.34	.2	**.63****	**.62****	.39					
16. R-SMG	.26	-.32	-.12	.04	.15	-.18	-.29	-.09	-.05	**.44***	.35	**.64****	**.59****	**.57****	**.59****				
17. L-MFG2	**.54****	-.21	.1	-.16	-.17	-.19	-.36	.09	-.04	**.49***	**.56****	**.57****	**.41***	**.62****	.28	.37			
18. L-MTG	.1	-.13	-.01	-.13	-.23	.04	-.11	.26	.13	**.62****	**.62****	**.56****	**.45***	**.77****	**.5***	**.42***	**.61****		
19. L_Amy	.16	.08	-.05	-.07	-.32	-.03	.12	-.29	-.26	.12	.18	.25	.24	.23	.12	**.44***	.29	.18	
20. R_Amy	-.01	.02	.09	.07	-.22	-.13	.05	-.29	-.33	.23	.23	**.43***	.35	.33	.18	.24	**.44***	.32	**.68****

Note. ROI activity was extracted for COPE 4. *p< .05, **p< .001, the four subscales of the Interpersonal Reactivity Index (IRI) are presented separately: perspective taking (PT), fantasy (FS), empathic concern (EC) and personal distress (PD). Two of the Action Control Scale (ACS) subscales are presented above: action-orientation after failure (AOF) and decision-related action-orientation (AOD). L-MFG2= left SFG/MFG. Abbreviations: Perf$_R$= Regulator performance; Perf$_T$= Target performance, L= left, R= right, Amy= amygdala, ●System I, ●System II, ●System III. Correlations are not corrected for multiple comparisons.

4.5. Discussion

In this study, we set out to investigate the neural systems that support us in regulating someone else's emotions (extrinsic ER) as well as those underpinning the implementation of ER strategies instructed by another person (intrinsic ER). To do so, we explored neural processes in both interactants during live inter-personal ER using a second-person paradigm. Three key findings emerged and are discussed further below: First, contrary to our hypothesis, no significant differences in rating or neural responses were observed for Targets when they implemented self- or Regulator-selected ER strategies (intra- or inter-personal ER, respectively), suggesting both the implementation of inter- and intra-personal intrinsic ER rely on a similar neural network. It should be noted that rating responses for inter- relative to intra-personal ER were lower, although rating responses between the conditions did not differ significantly from one another, and this difference may reach significance using a larger sample. Second, only few personal characteristics emerged as potential modulators of inter-personal ER efficacy, suggesting that perhaps social factors, such as social proximity, might exert greater modulatory effects during interactive, dyadic ER. Third, selecting an ER strategy for someone else engages a brain network similar to that associated with the implementation of ER, suggesting that embodied processes underlying intra-personal ER might also underlie inter-personal ER. Following from the Results section, the neural activation patterns during the choice of a strategy will be discussed before exploring the activations associated with implementing these ER strategies.

4.5.1. Inter- vs Intra-Personal Strategy Selections

When inter- and intra-personal ER choices are compared, Regulators show left-hemispheric activations in key nodes associated with socio-cognitive and socio-affective processes, including the angular gyrus, medial SFG, MFG, IFG and IPG (Schurz et al., 2021; Van Overwalle, 2009). For instance, the angular gyrus is associated with mentalising, which would allow the Regulator to understand the Target's experience, particularly when this experience is different to the Regulator's own experience (Seghier, 2013). In fact, the SMG which is located within the IPG is associated with distinguishing between one's own and another person's perspective, particularly in regards to overcoming one's own egocentricity bias, which, again, is particularly useful in regulating another person's emotion when they are distinct from our own (Silani, Lamm, Ruff, & Singer, 2013). Thus, it is unsurprising that inter-relative to intra-personal ER choices required the recruitment of socio-cognitive brain regions in Regulators. However, it should be noted, that this distinct activation pattern in Regulators is likely influenced by the present experimental design and particular contrasts. For Regulators, this contrast compared one condition in which the Regulators are actively engaged in this inter-personal process of recommending a strategy to someone else versus passively watching someone choose their own strategy. Nonetheless, naturalistic inter-personal ER is likely to resemble other naturalistic dyadic interactions (Redcay & Schilbach, 2019; Xie et al., 2016), thus similarly involving times during which the Regulator actively engages in regulatory behaviours (e.g. choosing a strategy), and passively observes the Target (e.g. observing them implement the strategy).

4.5.2. Inter- vs Intra-Personal ER Implementation

Previous findings on the benefits of inter-personal regulation within Targets has been mixed, with authors assuming beneficial effects for inter-personal regulation for familiar dyads, such as couples (Coan et al., 2017; Levy-Gigi & Shamay-Tsoory, 2017), parent-child dyads (Lougheed, Koval, & Hollenstein, 2016), and close friends (Morawetz et al., 2021), but attenuated or even detrimental effects when conducted between strangers (Coan et al., 2017; Morawetz et al., 2021). Moreover, assessing the efficacy of inter-personal ER is complicated further by its divergent effects on self-reports, physiological and neural response systems (see Chapter 2, and Morawetz et al., 2021 for further discussion). Following from Chapter 3, where inter-personal ER was associated with reduced electrodermal activity but not subjective ratings when compared with intra-personal ER, a difference between the inter- and intra-personal trials was expected for neural activations only. However, no significant differences in rating responses or neural activation patterns were observed for Targets implementing a self- versus a Regulator-selected strategy.

Previous neuroimaging studies on the effects of social buffering suggest inter-personal ER is highly effective and have yielded interesting findings, which might give insights into neural mechanisms that underlie inter-personal ER. Participants in another study rated the valence of both true and sham pain trials as less negative and demonstrated attenuated neural activation in regions associated with the processing of threats of pain, such as the anterior cingulate cortex (ACC) and caudate, when holding their partner's hand; whereas this beneficial inter-personal effect was absent when holding the hand of a stranger (Coan et al., 2017). This suggests differences in the efficacy of inter-personal ER when directed by loved ones versus strangers. In a study by Morawetz, Berboth, and Bode (2021), participants rated their ER attempts as most successful when they were guided by a close friend compared with intra-personal attempts or following the guidance from a stranger. In fact, inter-personal ER guided by a stranger was rated as the least effective approach. Further, decreases in amygdala activation implying effective down-regulation of negatively valenced affect was only observed during intra-personal and inter-personal ER when a friend assisted the Target's ER. The authors speculate that increased activity within the amygdala observed during stranger-directed inter-personal ER, was associated with stress or threat responses in the Target. Thus, strangers guiding Target's ER process might inadvertently elicit threat responses, i.e. negative affect, which counteract attempts of down-regulating negative affect. We investigated inter- and intra-personal ER, during which participants rated intra-personal ER trials as more effective in down-regulating negative affect relative to inter-personal ER. Crucially, however, electrodermal activity demonstrated the opposite – *improved* ER under inter- compared with intra-personal ER (see Chapter 2). This discrepancy between objective (i.e. electrodermal activity) and subjective (i.e. ratings) measures suggests that participants benefitted from inter-personal ER more than regulating their own emotions, although this benefit was missed when they were asked to evaluate their subjective experience via the rating scores. Furthermore, the experimenter took on the role of the Regulator, thus participants might have had more confidence in their own compared with a stranger's ability to regulate their emotions. Taken together, these findings suggest the efficacy of inter-personal ER is impacted by various factors, such as the degree of familiarity between the Target (i.e. the person implementing the ER) and the Regulator (i.e. the person guiding the Target's regulatory attempts); and further highlights differences in experiential and physiological indices of ER efficacy (Gross, 1998; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005).

It is also crucial to remember that the evidence on the efficacy of inter-personal ER presented here is tentative, as this process can be influenced by a myriad of different factors, that might not be evident with the limited sample size. Moreover, the lack of both differential rating responses and neural differences between the implementation of inter- and intra-personal ER could also be due to increased variations in Regulator and Target strategy choices. These differences in the number of choices for each ER strategy under the inter- and intra-personal conditions could have introduced substantial levels of noise from which the overall efficacy of both inter- and intra-personal ER could not be estimated accurately, particularly as the two strategies are associated with slight differences in neural activation patterns (Moodie et al., 2020). We were unable to ascertain the arousal-dependent differential efficacy of the strategies, which has been demonstrated in previous studies: intra-personal reappraisal has been shown to be preferred and more effective under low arousal and disengagement under high arousal (Moodie et al., 2020; Sheppes et al., 2014). However, we were unable to replicate this finding in both the EDA results (see Chapter 3) and the current fMRI experiment – overall distributions as well as the mean ratings for both strategies did not differ during low or high arousal, suggesting Disengagement and Reappraisal were experienced as equally effective in decreasing negative emotions in response to both low and high arousal images.

Previously, ER flexibility has been shown to be necessary for adaptive intra-personal ER (Pruessner, Barnow, Holt, Joormann, & Schulze, 2020) and there is preliminary evidence to suggest flexibility is vital for effective inter-personal ER as well (Butler, 2017; Lougheed & Hollenstein, 2016). When strategy choices between the EDA experiment (Chapter 3) are compared to participants' choices in the current fMRI experiment, Regulators display no clear arousal-dependent preference for either strategy. Similarly, while Target distributions for Disengagement trials display no clear preference, there seem to be some slight differences for Reappraisal preferences, which might become more evident with a larger sample and more strategy trials. In particular, Targets preferred Reappraisal for low arousal trials, although the difference between low and high arousal trials was not significant. Therefore, the lack of a clear strategy preference under low or high arousal should not dissuade researchers to incorporate choice behaviours in their ER paradigms.

4.5.3. Implementing Inter-Personal ER

Targets only exhibited differential activation within the left angular gyrus, when the implementation of inter-personal ER strategies was contrasted with intra-personal ER implementation. The angular gyrus is a key region associated with social cognition (Van Overwalle, 2009), which has been linked to semantic processing, multisensory integration and the inference of other's mental states (Seghier, 2013). In the context of ER, socio-cognitive processes are thought to be required in the understanding of the other person's experiences, needs and beliefs, which is essential for two people to interact with one another effectively (Reeck et al., 2016; Zaki, 2020).

There may be different reasons for the limited responses observed in Targets during the implementation of extrinsic inter-personal ER, with one possible explanation being the social proximity within the dyad. The influence of social proximity on ER has recently been examined to determine whether inter-personal ER is influenced by how connected the Target feels to the Regulator. A recent study by Morawetz et al. (2021) compared Targets' neural responses during intra-personal ER with two forms of inter-personal ER – friend-directed ER and stranger-directed ER. Participants were instructed to either look passively at the image (control condition) or decrease negative emotions without specifying a particular strategy. During Friend trials, the participant's friend's name was presented alongside a statement instructing them to down-regulate the negative emotion (e.g. "Laura says: 'Keep calm'"). Using meta-analytically defined ROIs based on the model by Reeck et al. (2016), the authors revealed brain regions sensitive to the social contexts regardless of whether the Target was interacting with a stranger or a friend, as well as regions modulated by social proximity; i.e. showing differential activity during inter-personal friend and inter-personal stranger trials. While the amygdala showed the greatest activation during stranger-directed inter-personal ER trials, the bilateral supramarginal gyrus (SMG), left middle temporal gyrus (MTG), and the left superior/middle frontal gyrus (SFG/MFG) displayed the greatest activations for friends, followed by the stranger and revealed the least activation during intra-personal ER. These findings offer some initial evidence to suggest that brain regions associated with the socio-cognitive processes involved in inter-personal ER are sensitive to the social contexts and are possibly modulated by how connected we feel to the other. Further, perhaps the efficacy of inter-personal ER relies on the nature of the social relationship between Targets and Regulators.

4.5.4. Comparing Regulator- and Target-Specific Regulation Patterns

Comparing Regulators' neural responses when selecting a strategy to Targets' responses when implementing this Regulator-selected strategy allowed us to determine activations specific to regulating another person's emotions. Regulators showed activity across the frontal and parietal midline regions, which have previously been associated with socio-cognitive and embodied processes (Kiverstein & Miller, 2015; Schurz et al., 2021; Van Overwalle, 2009), which can be considered to indicate taking on the other person's perspective and embodying their affective experience when providing extrinsic ER. Crucially, when the reverse contrast was scrutinised for Targets, no significant activations were observed, suggesting that the implementation of ER strategies recommended by another person does not engage additional brain regions to selecting a strategy for someone else. These shared neural activations offer further support for similarities between the process of extrinsic and intrinsic (inter-personal) ER. Thus, taken together with the lack of significantly different activation between inter- and intra-personal ER in Targets, implementing inter-personal ER does not appear to be more or less demanding than self-regulating one's emotions alone, and intrinsic inter-personal ER appears to rely on the same neural network as intra-personal ER.

4.5.5 Lack of Amygdala Activation

Although the amygdala is regarded as a central node within the emotion generative network and therefore also the ER network (Lee, Heller, Van Reekum, Nelson, & Davidson, 2012; Morawetz, Bode, Baudewig, & Heekeren, 2017), we did not observe any significant activation in the bilateral amygdalae for either Regulators or Targets. Previous research has shown the amygdala to be involved in affective processing (Phelps & LeDoux, 2005) and to be modulated by ER efforts (Ochsner, Bunge, Gross, & Gabrieli, 2002; Öhman, 2005). Direct stimulation of the amygdala has been shown to lead to physiological changes in electrodermal responses and heart rate, without affecting subjective ratings (Inman et al., 2020). A recent meta-analysis showed the amygdala as the target of neurofeedback in 19 studies and training the up- and down-regulation of amygdala activity was shown to successfully modify both positive and negative emotions (Linhartova et al., 2019). Furthermore, the amygdala appears to be involved in a myriad of different processes and has been found to be particularly sensitive to both social (Choe, Shaw, & Forbes, 2015) and non-social threat stimuli (Fox, Oler, Tromp, Fudge, & Kalin, 2015), involved in fear conditioning (LeDoux, 2003), and the processing of both negative and positive affect (Lindquist, Satpute, Wager, Weber, & Barrett, 2016). When navigating the world, we constantly make decisions on whether to engage with or disengage from internal or external stimuli, and guiding our approach and avoidance behaviours is thought to be the primary role of emotions. The amygdala has also been shown to respond to novelty (Weierich, Wright, Negreira, Dickerson, & Barrett, 2010), possibly by appraising new information to allow for an assessment of whether the novel entity should be attended to or avoided. This would support why amygdala activation is commonly observed during emotional processing (Phelps & LeDoux, 2005), valence assessments (Barrett, Mesquita, Ochsner, & Gross, 2007), the processing of novelty (Blackford, Buckholtz, Avery, & Zald, 2010), affective intensity (Frank et al., 2014) and threat (LeDoux & Brown, 2017).

Conversely, the lack of amygdala activation observed in the present study could be due to the study design and our choice of contrasts. It is likely that habituation effects, which have been reported for the amygdala (Sergerie, Chochol, & Armony, 2008), occurred following the repeated presentation of affective stimuli. Once the novel affective stimulus has been appraised, the amygdala might no longer be involved in processing this stimulus. Due to its central localisation and connections to distant cortical regions, the amygdala is thought to divert attention to novel and important stimuli, and to be involved in stimulus encoding (Adolphs & Spezio, 2006). This allows the individual to allocate resources and attend to relevant stimuli via visual and somatosensory cortices and thereby regulate social behaviours (Todd & Anderson, 2009). As our participants saw each image five times (once in each of the five conditions), one would expect increased amygdala activation during the first presentation of the emotion-eliciting IAPS images, followed by habituation effects for subsequent presentations. Thus, this repeated presentation of the images is likely to have led to habituation effects, thereby decreasing our ability to detect amygdala activation after averaging across early and late trials, leading to diminished response. Indeed, although the reductions in amygdalar activations were not necessarily linear, as they were not captured by our analyses probing linear decreases in activations from the first to the fifth image presentation, the step-wise, non-linear analyses showed marked reductions within the limbic system. These reductions were driven primarily by the high arousal images, showcasing reductions in limbic regions including the amygdala, insula, hippocampus and caudate. Nonetheless, even the low arousal images showed marked reductions with subsequent image presentations in the amygdala, caudate and thalamus. Importantly, no decreases were observed in prefrontal regions commonly associated with cognitive control – in fact, these regions, such as the left IFG and bilateral frontal poles, displayed linear increases with each image presentation, suggesting increases in task ability as the experiment progressed. Furthermore, our particular contrasts investigated differential activation during ER and when passively viewing images presented in coloured frames. As both of these conditions are likely to involve affective processes, such as emotion generation, subtracting these conditions from one another removes the affective processes they have in common. Thus, the remaining activation is associated with cognitive control rather than emotion generation, as participants were required to exert cognitive control over the emotions elicited by the images.

4.5.6. Individual Differences in ER: Brain-Behaviour Correlations

Task performance was not related significantly to ROI activations or any of the self-report measures for either Regulators' nor Targets'. It is possible that this was due to floor effects, as Target's rating responses clustered around the lower end of the spectrum.

For Regulators and Targets, autism quotient (AQ) scores were positively correlated with the personal distress (PD) scores from the Interpersonal Reactivity Index (IRI; Davis, 1983), as well as negatively correlated with decision-related action-orientation scores from the Action Control Scale (ACS; Kuhl, 1994). Moreover, PD was positively correlated with both left SFG/MFG activations as well as AQ scores. This suggests that individuals with stronger autistic phenotypes exhibited higher levels of distress when observing other's affective reactions, which is in line with previous findings (Zhao, Li, Song, & Shi, 2019). Autism has been associated with deficits in cognitive empathy and no substantial alterations in affective empathy (Blair, 2005). Furthermore, when affective empathic deficits are reported in autism, they are thought to be driven by alexithymia, which is highly comorbid with autistic traits (Bird et al., 2010). In fact, people with autistic traits have been shown to have difficulties with cognitive empathy yet their affective empathy abilities resemble typically developing individuals (Rueda, Fernández-Berrocal, & Baron-Cohen, 2015). Previous reviews have reported the decreased ability of autistic individuals to distinguish between representations of the self and others (Lamm, Bukowski, & Silani, 2016; Smith, 2009). However, neuroimaging studies distinguishing cognitive forms of self-other distinctions supported by activations of the right TPJ, from affective forms rooted in right SMG activations, offer support for impaired cognitive yet preserved affective self-other distinction in people with autism (Hoffmann, Koehne, Steinbeis, Dziobek, & Singer, 2016). The TPJ, which overlaps with the SMG, has been shown to be required for the processing of social stimuli, such as eye gaze or the inference of mental states (Samson, Apperly, Chiavarino, & Humphreys, 2004), particularly within the right hemisphere (Irish, Kumfor, Hodges, & Piguet, 2013; McDonald, Dalton, Rushby, &

Landin-Romero, 2019). Therefore, in regards to the particular IAPS images we used to elicit negative emotions, which included depictions of people in distress and pain, are likely to have had a greater impact on these participants with poorer self-other distinction and greater personal distress, thereby resulting in the need to down-regulate levels of arousal that are higher than those with lower levels of autistic traits.

Further, those with higher AQ scores were also more likely to exhibit state- rather than decision-related action-orientation, which hinders persistence with ER efforts particularly when people experience these regulatory attempts as difficult (Koole & Fockenberg, 2011) and is in line with findings suggesting increased avoidance behaviours in autism (Egan, Linenberg, & O'Nions, 2019). As ER can be understood as an attempt to change one's current state in line with a particular goal, the regulating person is required to identify the need to regulate, select an appropriate strategy, monitor their goals and flexibly modify their current approach if the desired goal state is not achieved (Sheppes, Suri, & Gross, 2015). Taken together, viscerally experiencing someone else's suffering and an inability to persist with one's own ER goals might offer an explanation of previous findings of autism being linked to high comorbidities with affective disorders, such as anxiety disorders (White et al., 2014), poorer ER abilities (Samson et al., 2015), and decreased flexibility (Cai, Richdale, Uljarević, Dissanayake, & Samson, 2018).

Finally, a positive correlation was also reported for AQ scores and ROI activations within the left SFG/MFG during Targets' implementation of Regulator-directed ER, which offers further support of the increased demands of regulating one's emotions in the presence of and with guidance from another person for those with pronounced autistic traits. A lesion study revealed the SFG to be involved in higher order working memory processes, such as monitoring and mental manipulation of domain-general stimuli (Boisgueheneuc et al., 2006). Within the context of ER, the SFG is thought to be vital for sustaining regulatory efforts and exerting cognitive control by modulating the limbic system (Frank et al., 2014). Thus, greater responses within this brain region during ER in individuals reporting stronger autistic phenotypes might indicate that they require more effort to down-regulate their emotions. Interestingly, Morawetz et al. (2021) found this ROI to be modulated by social proximity during inter-personal ER, as greater activations were observed during inter- relative to intra-personal ER overall; and these increases were greater for friends relative to strangers. In regards to participants with higher AQ scores, this might offer further support for the assumption that regulating in the presence of, or with the help of another person was associated with increased efforts. Although assessing differences in ER efficacy is difficult due to the lack of reliable amygdala activation, the lack of correlations between task performance and other self-report measures suggests efficacy was not influenced by personality characteristics. Indeed, the EDA findings presented in Chapter 3 also raised doubts on the malleability of ER efficacy based on personality characteristics, thus future studies should consider potential inter- rather than intra-personal factors, such as the social proximity of the dyad. Therefore, although those with high levels of autistic traits appear to exert greater efforts during ER, their regulatory outcomes do not differ from those with less autistic traits.

PD was also positively correlated with Targets' left SMG during the implementation of Regulator-directed ER, whereas PD was positively correlated with Regulators' right SMG. The bilateral SMG has been associated with processing self-location; i.e. the sense of one's body within a particular physical location (Ionta et al., 2011). The right SMG has been found to be involved in disregarding one's own affective state when processing the affective state of another person; i.e. overcoming affective egocentricity bias (Silani et al., 2013). Therefore, Regulators with high PD scores might have shown increased activations within the right SMG reflective of their difficulties in detaching from the other's negative affective experience. Contrarily, Targets' intra-personal and intrinsic inter-personal ER efforts might have been less affected by trait differences in PD and socio-cognitive processing.

For Regulators, activations within the right MFG during the selection of an ER strategy for the Target were also positively correlated with PD scores. The right MFG has been shown to consolidate information from the dorsal and ventral attention streams, thereby enabling the endogenous diversion of attention from an exogenous cue (Japee, Holiday, Satyshur, Mukai, & Ungerleider, 2015), whereas the right supramarginal gyrus has been associated with distinguishing ourselves from others during affective empathy (Hoffmann et al., 2016). Thus, participants with greater PD scores might struggle with self-other distinctions, and therefore require more effort in directing attention to perform the task, i.e. effortfully disengage from the images in order to select an appropriate ER strategy for Targets. However, future studies have yet to discern the mechanisms underlying the provision of extrinsic ER in order to determine whether regulating someone else's emotions might in turn divert the Regulator's attention away from the emotion eliciting stimulus, thereby acting as a form of ER in itself.

Activity of the left MTG during Regulators' selections of an ER strategy for Targets was negatively correlated with decision-related action-orientation, thereby suggesting increased activation in the left MTG was related to increased state-orientation – i.e. decreased action-orientation. The MTG is thought to synthesise multimodal information, particularly from auditory and visual streams (Visser, Jefferies, Embleton, & Lambon Ralph, 2012), which has been found to be particularly involved for reappraisal (Morawetz et al., 2017), and functionally connects the amygdala with the dlPFC when cognitive control is exerted on emotion generation (Ochsner et al., 2002). Further, a TMS study implicated the posterior MTG in the controlled retrieval of semantic information, i.e. top-down processes of ignoring irrelevant yet related information in order to retrieve particular information, whereas the angular gyrus was found to be necessary for automatic semantic retrieval; i.e. bottom-up retrieval of highly related concepts (Davey et al., 2015). As a key hub connecting the dlPFC and amygdala, it appears that action-oriented Regulators engaged in less intrinsic ER during the regulation of Targets' emotions. Conversely, state-oriented Regulators might require the down-regulation of their own emotional experiences before regulating another person's emotions. Future studies are required to assess whether action- and state-oriented Regulators also differed in their success in reducing negative affect in Targets, however, these preliminary findings suggest there may be trait differences in individuals' abilities to effectively down-regulate another person's emotion.

4.5.7. Embodied Processes of Directing Another Person's ER

In order to provide extrinsic, inter-personal ER, Regulators need to appraise the emotion-eliciting stimulus, then select an appropriate strategy for someone else. Therefore, the Regulator is thought to need to distinguish between themselves and the other, as researchers assume that the Regulator takes the Target's aims (Tsai, 2007) and capabilities (Reeck et al., 2016) into consideration. For instance, a parent helping their child regulate their emotions would have to take the age and cognitive capacities of the child into consideration when selecting an appropriate regulatory approach. Interestingly, Regulators' actively selecting a strategy for Targets relative to selecting a frame colour for Targets was associated with left hemispheric activity across regions commonly associated with ER (Kohn et al., 2014), such as the SMA, and IFG, as well as regions that have previously been associated with socio-cognitive processes, such as self-other distinctions and understanding another's beliefs (Schurz et al., 2021), including the angular gyrus and medial SFG. Thus, selecting a strategy for someone else appears to engage the ER network which is activated when we regulate our own emotions in conjunction with socio-cognitive brain regions. Perhaps, then, Regulators engage in a process of embodiment by taking on the Target's perspective when they select a strategy for the other person, as embodiment has previously been linked to a plethora of social cognitions, such as mentalising, attitudes and emotions (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005). In particular, understanding another's affective experience has been shown to involve similar neural networks between the interactants (Lamm & Majdandžić, 2015). Thus, shared neural networks are likely to also be crucial in the Regulator's understanding of the Target's emotional experiences and how to best regulate them.

4.5.8. Conclusion

The second-person paradigm enabled the investigation of neural responses in both the Regulator and the Target, as they engaged in inter-personal ER, which demonstrated striking similarities between extrinsic and intrinsic inter-personal processes. The present findings indicate that the neural activation patterns of Regulators and Targets resemble one another closely during inter-personal ER, suggesting the Regulators' extrinsic inter-personal ER attempts are guided by their embodiment of the Target's experience. Whilst Regulators and Targets appear to engage a similar regulatory network during inter-personal ER, there are slight differences in activations which emerge particularly during active versus passive segments of the trials for Regulators. Moreover, although there were no significant differences in efficacy between the inter- and intra-personal condition, the distribution patterns of rating responses offer tentative support for the superior efficacy of inter-personal ER which might be ascertained with a larger sample size or with increased ER trials. In regards to the modulatory effect of personal characteristics on inter-personal ER, only limited support was found for characteristics commonly associated with intra-personal ER success. Results regarding autistic traits and PD highlight the importance of examining cognitive and affective empathy separately and seem to be key influences on ER when we regulate our emotions in the presence of and with the help of others.

However, it remains to be determined whether there are also inter-individual factors which drive differences in the efficacy of inter-personal ER. Although, the current findings offered minimal support for the malleability of inter-personal ER by the Regulator or Target's personal characteristics, social factors, which for instance are altered in autism might influence inter-personal ER to a greater degree. Future studies could assess whether differences in Theory of Mind, social proximity or our ability to distinguish between ourselves and the other can influence inter-personal ER efficacy. The current study did not investigate social factors explicitly, which could have modulated the extent to which Regulators and Targets were able to engage in inter-personal ER effectively. Nonetheless, we provided some insights into the neural activation patterns of both Regulators and Targets whilst engaging in a second-person inter-personal ER paradigm. Moreover, in order to obtain a comprehensive picture of the processes involved in both Regulators and Targets during real-time inter-personal ER, Regulators' affective experiences should also be probed in the future, for instance by obtaining ratings from Regulators following the viewing of the images or the provision of strategy recommendations to the Target. This will provide some insights into the extent to which Regulators might engage in intra-personal ER during the extrinsic inter-personal regulation of the Targets' emotions.

References

Adolphs, R., & Spezio, M. (2006). Role of the amygdala in processing visual social stimuli. *Progress in brain research, 156*, 363-378.

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review, 30*(2), 217-237. doi:10.1016/j.cpr.2009.11.004

Anders, S., Heinzle, J., Weiskopf, N., Ethofer, T., & Haynes, J.-D. (2011). Flow of affective information between communicating brains. *Neuroimage, 54*(1), 439-446.

Austin, E. J. (2005). Personality correlates of the broader autism phenotype as assessed by the Autism Spectrum Quotient (AQ). *Personality and Individual Differences, 38*(2), 451-460.

Baldner, C., & McGinley, J. J. (2014). Correlational and exploratory factor analyses (EFA) of commonly used empathy questionnaires: New insights. *Motivation and Emotion, 38*(5), 727-744.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, malesand females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31*(1), 5-17.

Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology, 58*, 373-403. doi:10.1146/annurev.psych.58.110405.085709

Baumann, N., & Kuhl, J. (2002). Intuition, affect, and personality: unconscious coherence judgments and self-regulation of negative affect. *Journal of Personality and Social Psychology, 83*(5), 1213.

Beckes, L., & Coan, J. A. (2011). Social baseline theory: The role of social proximity in emotion and economy of action. *Social and Personality Psychology Compass, 5*(12), 976-988.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal statistical society: series B (Methodological), 57*(1), 289-300.

Berboth, S., Windischberger, C., Kohn, N., & Morawetz, C. (2021). Test-retest reliability of emotion regulation networks using fMRI at ultra-high magnetic field. *Neuroimage, 232*, 117917.

Bhaganagarapu, K., Jackson, G. D., & Abbott, D. F. (2013). An automated method for identifying artifact in independent component analysis of resting-state fMRI. *Frontiers in Human Neuroscience, 7*, 343.

Bird, G., Silani, G., Brindley, R., White, S., Frith, U., & Singer, T. (2010). Empathic brain responses in insula are modulated by levels of alexithymia but not autism. *Brain, 133*(5), 1515-1525.

Blackford, J. U., Buckholtz, J. W., Avery, S. N., & Zald, D. H. (2010). A unique role for the human amygdala in novelty detection. *Neuroimage, 50*(3), 1188-1193.

Blair, R. J. R. (2005). Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric populations. *Consciousness and cognition, 14*(4), 698-718.

Blunt, A., & Pychyl, T. A. (2005). Project systems of procrastinators: A personal project-analytic and action control perspective. *Personality and Individual Differences, 38*(8), 1771-1780.

Boisgueheneuc, F. d., Levy, R., Volle, E., Seassau, M., Duffau, H., Kinkingnehun, S., . . . Dubois, B. (2006). Functions of the left superior frontal gyrus in humans: a lesion study. *Brain, 129*(12), 3315-3328.

Butler, E. A. (2017). Emotions are temporal interpersonal systems. *Current Opinion in Psychology, 17*, 129-134. doi:10.1016/j.copsyc.2017.07.005

Cai, R. Y., Richdale, A. L., Uljarević, M., Dissanayake, C., & Samson, A. C. (2018). Emotion regulation in autism spectrum disorder: Where we are and where we need to go. *Autism Research, 11*(7), 962-978.

Campos, J. J., Campos, R. G., & Barrett, K. C. (1989). Emergent themes in the study of emotional development and emotion regulation. *Developmental psychology, 25*(3), 394.

Choe, D. E., Shaw, D. S., & Forbes, E. E. (2015). Maladaptive social information processing in childhood predicts young men's atypical amygdala reactivity to threat. *Journal of Child Psychology and Psychiatry, 56*(5), 549-557.

Chuang, Y.-S. (2021). label4MRI: MRI-labeling. R package (Version 1.2).

Cludius, B., Mennin, D., & Ehring, T. (2020). Emotion regulation as a transdiagnostic process. *Emotion, 20*(1), 37.

Coan, J. A., Beckes, L., Gonzalez, M. Z., Maresh, E. L., Brown, C. L., & Hasselmo, K. (2017). Relationship status and perceived support in the social regulation of neural responses to threat. *Social Cognitive and Affective Neuroscience, 12*(10), 1574-1583.

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological science, 17*(12), 1032-1039.

Davey, J., Cornelissen, P. L., Thompson, H. E., Sonkusare, S., Hallam, G., Smallwood, J., & Jefferies, E. (2015). Automatic and controlled semantic retrieval: TMS reveals distinct contributions of posterior middle temporal gyrus and angular gyrus. *Journal of Neuroscience, 35*(46), 15230-15239.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology, 44*(1), 113.

Egan, V., Linenberg, O., & O'Nions, E. (2019). The measurement of adult pathological demand avoidance traits. *Journal of Autism and Developmental Disorders, 49*(2), 481-494.

Eickhoff, S. B., Nichols, T. E., Laird, A. R., Hoffstaedter, F., Amunts, K., Fox, P. T., . . . Eickhoff, C. R. (2016). Behavior, sensitivity, and power of activation likelihood estimation characterized by massive empirical simulation. *Neuroimage, 137*, 70-85.

Fernández, A. M., Dufey, M., & Kramp, U. (2011). Testing the psychometric properties of the Interpersonal Reactivity Index (IRI) in Chile. *European Journal of Psychological Assessment*.

Fox, A. S., Oler, J. A., Tromp, D. P., Fudge, J. L., & Kalin, N. H. (2015). Extending the amygdala in theories of threat processing. *Trends in neurosciences, 38*(5), 319-329.

Frank, D., Dewitt, M., Hudgens-Haney, M., Schaeffer, D., Ball, B., Schwarz, N., . . . Sabatinelli, D. (2014). Emotion regulation: quantitative meta-analysis of functional activation and deactivation. *Neuroscience & Biobehavioral Reviews, 45*, 202-211.

Genovese, C., & Wasserman, L. (2002). Operating characteristics and extensions of the false discovery rate procedure. *Journal of the Royal Statistical Society: Series B (Statistical Methodology), 64*(3), 499-517.

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. doi:10.1037/0022-3514.74.1.224

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*(3), 281-291. doi:10.1017/s0048577201393198

Gross, J. J. (2015). Emotion Regulation: Current Status and Future Prospects. *Psychological Inquiry, 26*(1), 1-26. doi:10.1080/1047840x.2014.940781

Hallam, G. P., Webb, T. L., Sheeran, P., Miles, E., Niven, K., Wilkinson, I. D., . . . Farrow, T. F. D. (2014). The neural correlates of regulating another person's emotions: an exploratory fMRI study. *Frontiers in Human Neuroscience, 8*. doi:10.3389/fnhum.2014.00376

Hasson, U., & Frith, C. D. (2016). Mirroring and beyond: coupled dynamics as a generalized framework for modelling social interactions. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1693), 20150366.

Hoekstra, R. A., Vinkhuyzen, A. A., Wheelwright, S., Bartels, M., Boomsma, D. I., Baron-Cohen, S., . . . Van Der Sluis, S. (2011). The construction and validation of an abridged version of the autism-spectrum quotient (AQ-Short). *Journal of Autism and Developmental Disorders, 41*(5), 589-596.

Hoffmann, F., Koehne, S., Steinbeis, N., Dziobek, I., & Singer, T. (2016). Preserved self-other distinction during empathy in autism is linked to network integrity of right supramarginal gyrus. *Journal of Autism and Developmental Disorders, 46*(2), 637-648.

Inman, C. S., Bijanki, K. R., Bass, D. I., Gross, R. E., Hamann, S., & Willie, J. T. (2020). Human amygdala stimulation effects on emotion physiology and emotional experience. *Neuropsychologia, 145*, 106722.

Ionta, S., Heydrich, L., Lenggenhager, B., Mouthon, M., Fornari, E., Chapuis, D., . . . Blanke, O. (2011). Multisensory mechanisms in temporo-parietal cortex support self-location and first-person perspective. *Neuron, 70*(2), 363-374.

Irish, M., Kumfor, F., Hodges, J. R., & Piguet, O. (2013). A tale of two hemispheres: contrasting socioemotional dysfunction in right-versus left-lateralised semantic dementia. *Dementia & neuropsychologia, 7*, 88-95.

Japee, S., Holiday, K., Satyshur, M. D., Mukai, I., & Ungerleider, L. G. (2015). A role of right middle frontal gyrus in reorienting of attention: a case study. *Frontiers in systems neuroscience, 9*, 23.

Jenkinson, M., Bannister, P., Brady, M., & Smith, S. (2002). Improved optimization for the robust and accurate linear registration and motion correction of brain images. *Neuroimage, 17*(2), 825-841.

Jenkinson, M., Beckmann, C. F., Behrens, T. E., Woolrich, M. W., & Smith, S. M. (2012). Fsl. *Neuroimage, 62*(2), 782-790.

Jenkinson, M., & Smith, S. (2001). A global optimisation method for robust affine registration of brain images. *Medical image analysis, 5*(2), 143-156.

Jostmann, N. B., & Koole, S. L. (2007). On the regulation of cognitive control: Action orientation moderates the impact of high demands in Stroop interference tasks. *Journal of Experimental Psychology: General, 136*(4), 593.

Kessler, K., Cao, L., O'Shea, K. J., & Wang, H. (2014). A cross-culture, cross-gender comparison of perspective taking mechanisms. *Proceedings of the Royal Society B: Biological Sciences, 281*(1785), 20140388.

Kinreich, S., Djalovski, A., Kraus, L., Louzoun, Y., & Feldman, R. (2017). Brain-to-brain synchrony during naturalistic social interactions. *Scientific reports, 7*(1), 1-12.

Kircher, T., Blümel, I., Marjoram, D., Lataster, T., Krabbendam, L., Weber, J., . . . Krach, S. (2009). Online mentalising investigated with functional MRI. *Neuroscience letters, 454*(3), 176-181.

Kiverstein, J., & Miller, M. (2015). The embodied brain: towards a radical embodied cognitive neuroscience. *Frontiers in Human Neuroscience, 9*, 237.

Kloosterman, P. H., Keefer, K. V., Kelley, E. A., Summerfeldt, L. J., & Parker, J. D. (2011). Evaluation of the factor structure of the Autism-Spectrum Quotient. *Personality and Individual Differences, 50*(2), 310-314.

Kobylińska, D., & Kusev, P. (2019). Flexible emotion regulation: How situational demands and individual differences influence the effectiveness of regulatory strategies. *Frontiers in Psychology, 10*, 72.

Kohn, N., Eickhoff, S. B., Scheller, M., Laird, A. R., Fox, P. T., & Habel, U. (2014). Neural network of cognitive emotion regulation - An ALE meta-analysis and MACM analysis. *Neuroimage, 87*, 345-355. doi:10.1016/j.neuroimage.2013.11.001

Koole, S. L., & Fockenberg, D. A. (2011). Implicit emotion regulation under demanding conditions: The moderating role of action versus state orientation. *Cognition and emotion, 25*(3), 440-452.

Koole, S. L., & Jostmann, N. B. (2004). Getting a grip on your feelings: effects of action orientation and external demands on intuitive affect regulation. *Journal of Personality and Social Psychology, 87*(6), 974.

Kriegeskorte, N., Simmons, W. K., Bellgowan, P. S., & Baker, C. I. (2009). Circular analysis in systems neuroscience: the dangers of double dipping. *Nature neuroscience, 12*(5), 535-540.

Kuhl, J. (1992). A theory of self-regulation: Action versus state orientation, self-discrimination, and some applications. *Applied Psychology, 41*(2), 97-129.

Kuhl, J. (1994). Action versus state orientation: Psychometric properties of the Action Control Scale (ACS-90). *Volition and personality: Action versus state orientation, 47*(56).

Lamm, C., Bukowski, H., & Silani, G. (2016). From shared to distinct self–other representations in empathy: evidence from neurotypical function and socio-cognitive disorders. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1686), 20150083.

Lamm, C., & Majdandžić, J. (2015). The role of shared neural activations, mirror neurons, and morality in empathy–A critical comment. *Neuroscience Research, 90*, 15-24.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International affective picture system (IAPS): affective ratings of pictures and instruction manual. University of Florida, Gainesville*. Retrieved from

LeDoux, J. (2003). The emotional brain, fear, and the amygdala. *Cellular and molecular neurobiology, 23*(4), 727-738.

LeDoux, J. E., & Brown, R. (2017). A higher-order theory of emotional consciousness. *Proceedings of the National Academy of Sciences, 114*(10), E2016-E2025.

Lee, H., Heller, A. S., Van Reekum, C. M., Nelson, B., & Davidson, R. J. (2012). Amygdala–prefrontal coupling underlies individual differences in emotion regulation. *Neuroimage, 62*(3), 1575-1581.

Levy-Gigi, E., & Shamay-Tsoory, S. G. (2017). Help me if you can: Evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress. *Journal of Behavior Therapy and Experimental Psychiatry, 55*, 33-40. doi:10.1016/j.jbtep.2016.11.008

Lindquist, K. A., Satpute, A. B., Wager, T. D., Weber, J., & Barrett, L. F. (2016). The brain basis of positive and negative affect: evidence from a meta-analysis of the human neuroimaging literature. *Cerebral cortex, 26*(5), 1910-1922.

Linhartova, P., Latalova, A., Kosa, B., Kasparek, T., Schmahl, C., & Paret, C. (2019). fMRI neurofeedback in emotion regulation: A literature review. *Neuroimage, 193*, 75-92. doi:10.1016/j.neuroimage.2019.03.011

Liu, N., Mok, C., Witt, E. E., Pradhan, A. H., Chen, J. E., & Reiss, A. L. (2016). NIRS-based hyperscanning reveals inter-brain neural synchronization during cooperative Jenga game with face-to-face communication. *Frontiers in Human Neuroscience, 10*, 82.

López-Pérez, B., & Pacella, D. (2019). Interpersonal emotion regulation in children: Age, gender, and cross-cultural differences using a serious game. *Emotion*.

Lougheed, J. P., & Hollenstein, T. (2016). Socioemotional Flexibility in Mother-Daughter Dyads: Riding the Emotional Rollercoaster Across Positive and Negative Contexts. *Emotion, 16*(5), 620-633. doi:10.1037/emo0000155

Lougheed, J. P., Koval, P., & Hollenstein, T. (2016). Sharing the burden: The interpersonal regulation of emotional arousal in mother– daughter dyads. *Emotion, 16*(1), 83.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion, 5*(2), 175.

McDonald, S., Dalton, K. I., Rushby, J. A., & Landin-Romero, R. (2019). Loss of white matter connections after severe traumatic brain injury (TBI) and its relationship to social cognition. *Brain imaging and behavior, 13*(3), 819-829.

Moodie, C. A., Suri, G., Goerlitz, D. S., Mateen, M. A., Sheppes, G., McRae, K., . . . Gross, J. J. (2020). The neural bases of cognitive emotion regulation: The roles of strategy and intensity. *Cognitive, Affective, & Behavioral Neuroscience*, 1-21.

Morawetz, C., Berboth, S., & Bode, S. (2021). With a little help from my friends: the effect of social proximity on emotion regulation-related brain activity. *Neuroimage*, 117817.

Morawetz, C., Bode, S., Baudewig, J., & Heekeren, H. R. (2017). Effective amygdala-prefrontal connectivity predicts individual differences in successful emotion regulation. *Social Cognitive and Affective Neuroscience, 12*(4), 569-585.

Morawetz, C., Bode, S., Derntl, B., & Heekeren, H. R. (2017). The effect of strategies, goals and stimulus material on the neural mechanisms of emotion regulation: a meta-analysis of fMRI studies. *Neuroscience & Biobehavioral Reviews, 72*, 111-128.

Morawetz, C., Riedel, M. C., Salo, T., Berboth, S., Eickhoff, S., Laird, A. R., & Kohn, N. (2020). Multiple large-scale neural networks underlying emotion regulation. *Neuroscience & Biobehavioral Reviews*.

Mulej Bratec, S., Bertram, T., Starke, G., Brandl, F., Xie, X., & Sorg, C. (2020). Your presence soothes me: a neural process model of aversive emotion regulation via social buffering. *Social Cognitive and Affective Neuroscience, 15*(5), 561-570.

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review, 9*(3), 184-211.

Nozaki, Y., & Mikolajczak, M. (2020). Extrinsic emotion regulation. *Emotion, 20*(1), 10.

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

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-E24.

Oh, C. S., Bailenson, J. N., & Welch, G. F. (2018). A systematic review of social presence: Definition, antecedents, and implications. *Frontiers in Robotics and AI, 5*, 114.

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

Olman, C. A., Davachi, L., & Inati, S. (2009). Distortion and signal loss in medial temporal lobe. *PloS one, 4*(12), e8160.

Pacella, D., & López-Pérez, B. (2018). Assessing children's interpersonal emotion regulation with virtual agents: The serious game Emodiscovery. *Computers & Education, 123*, 1-12.

Palumbo, R. V., Marraccini, M. E., Weyandt, L. L., Wilder-Smith, O., McGee, H. A., Liu, S., & Goodwin, M. S. (2017). Interpersonal autonomic physiology: A systematic review of the literature. *Personality and Social Psychology Review, 21*(2), 99-141.

Paret, C., Kluetsch, R., Ruf, M., Demirakca, T., Hoesterey, S., Ende, G., & Schmahl, C. (2014). Down-regulation of amygdala activation with real-time fMRI neurofeedback in a healthy female sample. Frontiers in Behavioral Neuroscience, 8. doi:UNSP 29910.3389/fnbeh.2014.00299.

Phelps, E. A., & LeDoux, J. E. (2005). Contributions of the amygdala to emotion processing: from animal models to human behavior. *Neuron, 48*(2), 175-187.

Plichta, M. M., Grimm, O., Morgen, K., Mier, D., Sauer, C., Haddad, L., . . . Schwarz, A. J. (2014). Amygdala habituation: a reliable fMRI phenotype. *Neuroimage, 103*, 383-390.

Pruessner, L., Barnow, S., Holt, D. V., Joormann, J., & Schulze, K. (2020). A cognitive control framework for understanding emotion regulation flexibility. *Emotion, 20*(1), 21.

Redcay, E., & Schilbach, L. (2019). Using second-person neuroscience to elucidate the mechanisms of social interaction. *Nature Reviews Neuroscience, 20*(8), 495-505.

Reeck, C., Ames, D. R., & Ochsner, K. N. (2016). The social regulation of emotion: An integrative, cross-disciplinary model. *Trends in Cognitive Sciences, 20*(1), 47-63.

Rueda, P., Fernández-Berrocal, P., & Baron-Cohen, S. (2015). Dissociation between cognitive and affective empathy in youth with Asperger Syndrome. *European Journal of Developmental Psychology, 12*(1), 85-98.

Sakamoto, Y., Ishiguro, M., & Kitagawa, G. (1986). Akaike information criterion statistics. *Dordrecht, The Netherlands: D. Reidel, 81*(10.5555), 26853.

Samson, A. C., Hardan, A. Y., Podell, R. W., Phillips, J. M., & Gross, J. J. (2015). Emotion regulation in children and adolescents with autism spectrum disorder. *Autism Research, 8*(1), 9-18.

Samson, D., Apperly, I. A., Chiavarino, C., & Humphreys, G. W. (2004). Left temporoparietal junction is necessary for representing someone else's belief. *Nature neuroscience, 7*(5), 499-500.

Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., & Vogeley, K. (2013). Toward a second-person neuroscience 1. *Behavioral and brain sciences, 36*(4), 393-414.

Schurz, M., Radua, J., Tholen, M. G., Maliske, L., Margulies, D. S., Mars, R. B., . . . Kanske, P. (2021). Toward a hierarchical model of social cognition: A neuroimaging meta-analysis and integrative review of empathy and theory of mind. *Psychological Bulletin, 147*(3), 293.

Seghier, M. L. (2013). The angular gyrus: multiple functions and multiple subdivisions. *The Neuroscientist, 19*(1), 43-61.

Sergerie, K., Chochol, C., & Armony, J. L. (2008). The role of the amygdala in emotional processing: a quantitative meta-analysis of functional neuroimaging studies. *Neuroscience & Biobehavioral Reviews, 32*(4), 811-830.

Shamay-Tsoory, S. G. (2011). The neural bases for empathy. *The Neuroscientist, 17*(1), 18-24.

Shamay-Tsoory, S. G., Aharon-Peretz, J., & Perry, D. (2009). Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. *Brain, 132*(3), 617-627.

Shamay-Tsoory, S. G., & Mendelsohn, A. (2019). Real-life neuroscience: an ecological approach to brain and behavior research. *Perspectives on Psychological Science, 14*(5), 841-859.

Shaw, D., Czekóová, K., Gajdoš, M., Staněk, R., Špalek, J., & Brázdil, M. (2019). Social decision-making in the brain: Input-state-output modelling reveals patterns of effective connectivity underlying reciprocal choices. *Human Brain Mapping, 40*(2), 699-712.

Shaw, D. J., Czekóová, K., Staněk, R., Mareček, R., Urbánek, T., Špalek, J., . . . Brázdil, M. (2018). A dual-fMRI investigation of the iterated Ultimatum Game reveals that reciprocal behaviour is associated with neural alignment. *Scientific reports, 8*(1), 1-13.

Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., & Gross, J. J. (2014). Emotion Regulation Choice: A Conceptual Framework and Supporting Evidence. *Journal of Experimental Psychology-General, 143*(1), 163-181. doi:10.1037/a0030831

Sheppes, G., Suri, G., & Gross, J. J. (2015). Emotion Regulation and Psychopathology. *Annual Review of Clinical Psychology, Vol 11, 11*, 379-405. doi:10.1146/annurev-clinpsy-032814-112739

Silani, G., Lamm, C., Ruff, C. C., & Singer, T. (2013). Right supramarginal gyrus is crucial to overcome emotional egocentricity bias in social judgments. *Journal of Neuroscience, 33*(39), 15466-15476.

Smith, A. (2009). The empathy imbalance hypothesis of autism: a theoretical approach to cognitive and emotional empathy in autistic development. *the Psychological record, 59*(3), 489-510.

Špiláková, B., Shaw, D. J., Czekóová, K., & Brázdil, M. (2019). Dissecting social interaction: dual-fMRI reveals patterns of interpersonal brain-behavior relationships that dissociate among dimensions of social exchange. *Social Cognitive and Affective Neuroscience, 14*(2), 225-235.

Tamir, M. (2011). The Maturing Field of Emotion Regulation. *Emotion Review, 3*(1), 3-7. doi:10.1177/1754073910388685

Tang, H., Mai, X., Wang, S., Zhu, C., Krueger, F., & Liu, C. (2016). Interpersonal brain synchronization in the right temporo-parietal junction during face-to-face economic exchange. *Social Cognitive and Affective Neuroscience, 11*(1), 23-32.

Todd, R. M., & Anderson, A. K. (2009). Six degrees of separation: the amygdala regulates social behavior and perception. *Nature neuroscience, 12*(10), 1217-1218.

Tsai, J. L. (2007). Ideal Affect Cultural Causes and Behavioral Consequences. *Perspectives on Psychological Science, 2*(3), 242-259. doi:10.1111/j.1745-6916.2007.00043.x

Van Overwalle, F. (2009). Social cognition and the brain: a meta-analysis. *Human Brain Mapping, 30*(3), 829-858.

Visser, M., Jefferies, E., Embleton, K. V., & Lambon Ralph, M. A. (2012). Both the middle temporal gyrus and the ventral anterior temporal area are crucial for multimodal semantic processing: distortion-corrected fMRI evidence for a double gradient of information convergence in the temporal lobes. *Journal of Cognitive Neuroscience, 24*(8), 1766-1778.

Weierich, M. R., Wright, C. I., Negreira, A., Dickerson, B. C., & Barrett, L. F. (2010). Novelty as a dimension in the affective brain. *Neuroimage, 49*(3), 2871-2878.

White, S. W., Mazefsky, C. A., Dichter, G. S., Chiu, P. H., Richey, J. A., & Ollendick, T. H. (2014). Social-cognitive, physiological, and neural mechanisms underlying emotion regulation impairments: Understanding anxiety in autism spectrum disorder. *International Journal of Developmental Neuroscience, 39*, 22-36.

Winkler, A. M., Ridgway, G. R., Webster, M. A., Smith, S. M., & Nichols, T. E. (2014). Permutation inference for the general linear model. *Neuroimage, 92*, 381-397.

Woolrich, M. W., Ripley, B. D., Brady, M., & Smith, S. M. (2001). Temporal autocorrelation in univariate linear modeling of FMRI data. *Neuroimage, 14*(6), 1370-1386.

Xie, X., Bratec, S. M., Schmid, G., Meng, C., Doll, A., Wohlschlaeger, A., . . . Sorg, C. (2016). How do you make me feel better? Social cognitive emotion regulation and the default mode network. *Neuroimage, 134*, 270-280. doi:10.1016/j.neuroimage.2016.04.015

Zaki, J. (2020). Integrating empathy and interpersonal emotion regulation. *Annual Review of Psychology, 71*, 517-540.

Zaki, J., & Williams, W. C. (2013). Interpersonal Emotion Regulation. *Emotion, 13*(5), 803-810. doi:10.1037/a0033839

Zhao, X., Li, X., Song, Y., & Shi, W. (2019). Autistic traits and prosocial behaviour in the general population: test of the mediating effects of trait empathy and state empathic concern. *Journal of Autism and Developmental Disorders, 49*(10), 3925-3938.

Chapter 5 – General Discussion

Social processes are an integral part of human functioning (Van Overwalle, 2009), and affective researchers are turning their attention towards the social influences on affective processes (Zaki & Williams, 2013). This investigative shift emphasises the inherently social nature of emotions (Butler, 2017), the social contexts in which affective experiences develop across the lifespan (Barthel, Hay, Doan, & Hofmann, 2018), the various inter-personal forms of ER we seek from and offer to others (Christensen, van Dyk, Nelson, & Vasey, 2020), as well as how inter-personal ER affects our relationships with others (Williams, Morelli, Ong, & Zaki, 2018). Indeed, most of what we believe to know about human experiences and behaviour stems from research on individuals probed in isolation, however, contemporary researchers call for increased ecological validity by examining these processes within the social contexts they generally unfold in (Schilbach et al., 2013). Moreover, Fotopoulou and Tsakiris (2017) take a step further by proposing the radical idea, that all psychological and physiological processes, such as thoughts or homeostasis, which we consider to be inherently subjective, originate from social interactions. Thus, they advocate for our understanding of individuals to be reframed to assume the social as the necessary starting point without which no self could emerge, and further, no psychological processes, such as emotion generation and regulation, would occur. Regardless of where one sits on this spectrum concerning the individual or social origins of a myriad of psychological processes, it is evident that humans require others for healthy and normal mental and physical development from birth (Gee, 2016; Kiel & Kalomiris, 2015; Olsavsky et al., 2013), for psycho-social adjustment during childhood and adolescence (Barthel et al., 2018; Hollenstein, Tighe, & Lougheed, 2017), for one's well-being in adulthood (Heinrich & Gullone, 2006; Valtorta, Kanaan, Gilbody, Ronzi, & Hanratty, 2016), as well as a protective factor against increased morbidity in old age (Lang, Staudinger, & Carstensen, 1998; Quinones, Markwardt, & Botoseneanu, 2016). Therefore, it is of paramount importance that psychologists and neuroscientists understand human processes as they would unfold naturally outside of the laboratory.

As we move towards more naturalistic investigations of human processes, there is a need to identify which previous findings from third-person paradigms are still effective in explaining human processes outside of the laboratory and which additional phenomena emerge and can only be identified within true social interactions (De Bruin, Van Elk, & Newen, 2012). This is not to suggest that findings from intra-person ER or studies relying on third-person paradigms offer no intriguing insights into ER. On the contrary, previous studies have provided valuable insights into the mechanisms underlying (primarily intra-personal) ER (Goldin, McRae, Ramel, & Gross, 2008; Morawetz et al., 2020), individual differences in ER abilities (Lee, Heller, Van Reekum, Nelson, & Davidson, 2012; Morawetz, Bode, Baudewig, & Heekeren, 2017), the individual and social consequences of ineffective ER (Crowell, Puzia, & Yaptangco, 2015; English & Eldesouky, 2020), or even factors which can increase or decrease the efficacy of ER attempts (De Castella et al., 2013; Ford & Gross, 2019). Intra-personal ER has received substantial scientific investigation (Bahl & Ouimet, 2022; Benfer, Bardeen, & Clauss, 2018; Bradley et al., 2010; Gross, 1998b), therefore, it provides a useful starting point from which inter-personal ER can be explored and understood. In particular, comparing inter-personal ER with previous findings from intra-personal ER enabled the evaluation of current theories on the mechanisms underlying inter-personal ER. Here, three main theories were compared to determine which of these theories provides support for the advantages seen for inter-personal ER: theories of embodied cognition (Kiverstein & Miller, 2015), social baseline approaches, and cognitive control perspectives, such as the neural ER model proposed by Kohn et al. (2014) or the social regulation cycle developed by Reeck, Ames, and Ochsner (2016). In order to explore these processes that underlie effective inter-personal ER, the psychophysiological and neural basis of inter-personal ER were examined.

The themes which emerged across the previously presented empirical investigations are clustered around the key questions this thesis set out to explore, therefore, these questions will be addressed in order. The main questions concerned (1) the efficacy of inter-personal ER, (2) how inter-personal ER can be measured, (3) the mechanisms underlying inter-personal ER, and (4) whether individual differences modulate the efficacy of inter-personal ER. In order to address the first question regarding the efficacy of inter-personal ER, findings of comparisons between inter- and intra-personal ER, as well as between inter-personal ER and the just-look Frame conditions for both the EDA and fMRI experiment will be reviewed. This will provide a comparison between two explicit forms of ER (i.e. inter- and intra-personal ER), and a comparison between explicit and implicit ER (i.e. the use of strategies within inter-personal ER trials, and the inter-personal Frame trials during which participants were instructed to respond naturally). Question 2 will be explored by evaluating the particular ER paradigm used across the experiments, the strengths and limitations of multi-method assessments of affect, and the use of traditional third- and contemporary second-person paradigms. Conclusions from the psychophysiological and neural data will be used in conjunction with current theories on the physiological neural influences emergent in social interactions will be drawn from in order to determine the mechanism that might underlie inter-personal ER (question 3). Finally, the various person characteristics measured across the laboratory and online experiments in Chapter 3, and the second-person fMRI experiment will be scrutinised to identify possible modulators of inter-personal ER efficacy and discuss the potential limitations of assessing intra-personal characteristics for the investigation of modulators of inter-personal processes.

5.2. Examining the Efficacy of, the Mechanisms Underlying, and the Factors which Modulate Inter-Personal ER

5.2.1. What Do the EDA and fMRI Experiments Tell Us about the Efficacy of Inter-Personal ER?

The experiments detailed within this thesis offer some support in favour of improved efficacy during inter- relative to intra-personal ER, particularly when physiological and neural processes are considered. However, it is striking that the ratings, which previously suggested improved inter- over intra-personal ER, were unable to provide any further support for this previously reported finding (Levy-Gigi & Shamay-Tsoory, 2017; Morawetz et al., 2021). One could assume that the stimuli used to elicit affective responses might have led to differential results between the previously reported and the present findings, and hindered the extent to which efficacy of inter-personal ER could be evaluated. Most of the previous experiments used highly arousing images taken from the International Affective Picture System (Lang et al., 2008), which one might suspect to be a reason underlying the discrepancy between the present and previous findings (Alghamdi, Regenbrecht, Hoermann, & Swain, 2017). However, these divergent findings are unlikely solely due to the normative arousal level of the images employed within the experiments presented in Chapter 3 and 4. Similar to the previous studies, both experiments presented in this thesis made use of the IAPS images. Whilst images used in Chapter 3 consisted of images which should be considered low and moderately arousing (e.g. in comparison to Sheppes et al., 2014), highly negative images were used in Chapter 4. The images included in Chapter 4 included highly arousing images, for example depictions of mutilations, whereas low arousal images included scenes of furniture or portraits of people. Crucially, if the level of normative arousal had been too low to elicit reliable differences in affect prior to and following arousal, this would have been expected for the EDA study presented in Chapter 3 alone. Moreover, considering that participants regulating their emotions always interacted with someone who was a stranger to them; i.e. the experimenter in Chapter 3 and another participant they were paired with on the day in Chapter 4, it is intriguing that no significant difference in efficacy between the inter- and intra-personal condition in favour of the intra-personal regulation was reflected in the rating responses, and further, that physiological responses suggest improved ER under external guidance. It should also be noted that we are likely to recruit others to help us regulate emotions of varying arousal levels (Christensen et al., 2020; Colombo et al., 2020), thus investigating the inter-personal regulation of moderately negative emotions contributes to our understanding of the regulation of the full scope of affective experiences.

Following on from the aforementioned line of thought, another reason for the discrepant findings might be due to relational proximity of participants within the experiments of Chapter 3 and 4. As mentioned above, previous studies examined inter-personal ER in dyads in close relationships, such as mother-daughter dyads (Lougheed et al., 2016), romantic partners (Levy-Gigi & Shamay-Tsoory, 2017), or close friends (Morawetz et al., 2021), whereas the present dyads always involved unrelated strangers. In fact, there are findings to suggest that inter-personal regulation is diminished or that threat responses are heightened by interactions with a stranger (Coan et al., 2006; Morawetz et al., 2021). Although it should be emphasised that the present results do not offer strong evidence to suggest strangers do indeed elicit diminished ER or heightened threat responses, social proximity is still a relevant factor to consider in regards to regulatory efficacy between the conditions (Fröding & Peterson, 2012; Morawetz et al., 2021; Sahi et al., 2020). Indeed, the rating responses for both the EDA and fMRI experiment suggest that participants felt they benefitted equally from either inter- or intra-personal ER, rather than experiencing diminished ER efficacy during intrinsic inter-personal ER. Moreover, the electrodermal responses suggest that physiologically they benefitted more from receiving ER support from another person, even when this person was a stranger to them. Future studies are needed to disentangle the precise effects of social proximity on ER by examining ER efficacy of Targets following inter-personal ER guided by a close other versus a stranger. However, the current findings suggest that even strangers might be able to offer some regulatory benefits in decreasing negative emotions in Targets. Perhaps, studies on synchronicity, particularly in conjunction with second-person paradigms, could shed some light on whether social proximity within the regulating dyad increases over time, thereby exerting the beneficial effects of inter-personal ER (Bevilacqua et al., 2019; Karvonen et al., 2016), or whether more fundamental aspects underlying interactions per se drive the beneficial effects of social ER as postulated by the Social Baseline Theory (Beckes & Coan, 2011).

5.2.2. What Needs to be Considered when Measuring and Assessing Inter-Personal ER?

Can compare it to Intra, Frames and other just-look conditions, but maybe we also need to be thinking of inter-personal metrics (e.g. synchrony), how we understand others (ToM & empathy)

The efficacy of inter-personal ER can be determined by comparing it to intra-personal ER, due to the amount of knowledge affective researchers have amassed about intra-personal regulation (Gross, 2015). Mirroring intra-personal ER, we can assume that flexibility is important in meeting situational demands (Kobylińska & Kusev, 2019; Tamir & Ford, 2012), and ensuring adequate psycho-social functioning (Bahl & Ouimet, 2022; Bonanno & Burton, 2013) and well-being (Colombo et al., 2020; English & Eldesouky, 2020). We can also examine whether the stimulus characteristics, such as the level of arousal, influence our inter-personal ER strategy choices. Thus, the studies presented within this thesis consistently used an intra-personal ER condition to assess the efficacy of inter-personal regulation. Moreover, this contrast can be used to determine whether individual differences in intra-personal ER abilities (Barańczuk, 2019; John & Gross, 2004; Lee et al., 2012; Morawetz et al., 2017) modulate one's ability to implement or even provide inter-personal ER. Although the relationship between Regulators' own intra-personal ER was not measured and no conclusions can be drawn about how this ability influences our abilities to guide someone else's regulatory attempts, we can tentatively assume that due to the lack of difference in efficacy between Targets' implementation of inter- and intra-personal ER, inter-personal regulation can be implemented equally by proficient and less effective self-regulators. Nonetheless, targeted investigations are needed to confidently determine how self-regulation of good and poor regulators influences their abilities to implement inter-personal ER.

Another approach to assessing the efficacy of inter-personal ER can be taken from intra-personal ER research, which ordinarily asks participants to regulate their emotions using a particular strategy in the experimental condition, whilst participants simply look at the image in the control condition (e.g. (Moodie et al., 2020; Qi et al., 2017). As described in Chapter 2, the experiments employed within this thesis adapted the traditional just-look baseline conditions, to ensure participants were required to make a choice during both the experimental as well as the control conditions. Therefore, participants would choose between a blue or green frame to be presented around the image, they would subsequently just look at whilst they responded naturally to this image. The frames were found to have a regulatory effect in and of themselves, potentially by serving as a salient distractor which directed participants attention away from the emotion-eliciting features of the images (Bartolomeo et al., 2020; Bernat, Cadwallader, Seo, Vizueta, & Patrick, 2011). Nonetheless, the consistent evidence linking naturalistic, healthy behaviour to flexible responding, suggests that choice behaviour should continue to be investigated in ER research (Bonanno & Burton, 2013; Kashdan & Rottenberg, 2010; Kobylińska & Kusev, 2019; Levy-Gigi et al., 2016; Pruessner et al., 2020). Thus, choice should be given to participants, however, the subsequent stimulus presentation should avoid using any perceptual distractors. Indeed, it can be argued that the current experiments contrasted inter- and intra-personal forms of explicit, i.e. goal-directed, forms of ER with implicit, i.e. voluntary or automatic, forms of regulation. Furthermore, using various baselines that go beyond the traditional just-look conditions, might result in unexpected findings which will shed light on the complex processes involved in various forms of ER.

Finally, it should also be noted, that in order to fully understand inter-personal ER, we need to move beyond intra-personal ER and attempting to equate these individual processes observed by measuring humans in isolation (Schilbach, 2016). In fact, social neuroscientists argue that inter-personal processes yield phenomena that go beyond each individual's contributions, but rather the interaction between individuals itself yields important psychosocial functions, which can only be captured when investigating humans during real-time social interactions (De Bruin et al., 2012; Redcay & Schilbach, 2019). Thus, it is vital that affective psychologists and neuroscientists continue to investigate affective processes in real-time dyadic interactions. These dyadic interactions enable the measurement of parameters, that emerge during interactions, such as inter-personal synchrony. For instance, psychophysiological synchrony between students and their teachers have been shown to be key predictors of student engagement, as well as student attainment (Bevilacqua et al., 2019). Within clinical settings, inter-personal synchrony has been shown to be diminished for couples with conflicts, such as inter-personal violence (Karvonen et al., 2016; Paananen et al., 2018), and increased client-therapist synchrony is associated with improved treatment outcomes (Karvonen et al., 2016). Thus, examining the synchrony between Regulators and Targets might help us assess which conditions and situational context foster improved inter-personal ER in dyads. Beyond synchrony, understanding how we understand others can help shed light on how inter-personal ER can be improved. In order to recommend effective ER to someone else, we must be able to identify the need for the other person to regulate their emotions, assess whether regulatory efforts are effective and know when to continue or terminate regulation (Dixon-Gordon, Bernecker, & Christensen, 2015; Zaki, 2020; Zaki & Williams, 2013). Theory of Mind describes our ability to understand the thoughts and beliefs or others, thereby representing a cognitive route to understanding others (Kanske et al., 2015; Quesque & Rossetti, 2020). Contrarily, empathy describes our abilities to vicariously feel what someone else might be feeling, thereby providing an affective route to understanding others (Lamm & Majdandžić, 2015; Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). Therefore, Theory of Mind and empathy might present two fruitful avenues for further investigation, to determine whether differences in how we understand others leads to differential outcomes in inter-personal ER efficacy.

Furthermore, the use of second-person paradigms is being facilitated by new and advance methods of analysing dyadic interactions. These approaches allow researchers to go beyond investigating two interacting individuals separately, but rather to ask questions about how the interactants themselves or their particular way of communicating and interacting influence each other, e.g. in terms of physiological responses (Hasson & Frith, 2016; Paananen et al., 2018) or neural activity patterns (Špiláková, Shaw, Czekóová, & Brázdil, 2019). These new analyses techniques will open up new and exciting avenues for affective researchers, or social psychologists and neuroscientists in general, to investigate affective and other psychological processes as they emerge in interactive settings. For instance, behavioural dynamic causal modelling (bDCM) offers a way of probing how behavioural inputs into a neural network modulate activity within the network's volumes of interest, and give rise to certain behaviours (Shaw et al., 2019). Crucially, this approach can be extended to include two interacting brains, thereby allowing us to determine whether Person A's neural activations leading to behaviour A can help us predict Person B's neural activation patterns and subsequent behaviour B. For instance, a study by Shaw et al. (2018) applied bDCM to a second-person paradigm in which participants engaged in an iterated Ultimatum Game. In order for both players to achieve higher gains, they have to balance fairness whilst attempting to maximise their wins. Selfish behaviour directed at achieving maximal gains by just one player is likely to result in the responding interactant rejecting the offer, thus none of the players receives any wins for this round. Importantly, players were involved in reciprocal turn-taking, i.e. decisions from Player A served as input for Player B, who then made a decision which served as a new input for Player A. The authors demonstrated how neural activation patterns from one player, indicative of the degree to which they reciprocated their partner's prior behaviour, could be used to predict the responses in the responding player with 85.6% accuracy. Interestingly, this model that included both interactants predicted Responders reactions more accurately than models only including brain and behavioural responses from one player, i.e. the Responder, alone. Thus, taking the interaction between the dyad into account resulted in a better fitting model which is likely due to interactive processes beyond each individual's inputs being taken into consideration.

Indeed, there have been recent developments to devise DCM approaches which are specifically designed to address questions of dyadic nature. Bilek (2020) proposes the hyperscanning DCM (hDCM) as another approach to modelling dyadic interactions. The authors show how the hDCM was applied to a dyadic joint-attention task, which demonstrated more accurate predictions of participants' neural responses when one person's neural response patterns were used as a predictor of the other person's neural response patterns. Importantly, similar to Shaw et al. (2018), Bilek (2020) highlights how these two-brain DCM models better predicted each individual's response patterns compared to single-brain DCM models. Again, this offers further support for the need of analyses methods which examine two interacting humans as a joint unit and emphasises Bolis and Schilbach (2020) plea for dyadic interaction analyses which reveal processes, such as distinct neural activation patterns, which only emerge in during true interactions and can only be captured by analytic approaches which examine two brains, or two physiological systems, in unison. The authors argue for the unity of opposites in Psychology, highlighting the need for a dialectical approach which investigates the individual and the social as inherently united and inseparable. Thus, analysis approaches for dyadic interactions need to be able to explore processes in the individual, and how they are influenced by social factors, as well as examining the social process between people and how this context-specific interaction allows new processes to emerge. Of course, it should not be trivialised that intra-personal ER is a particularly complex process involving widespread numerous neural activations across various neural networks (Morawetz et al., 2020). Thus, the complexity of inter-personal ER is increased further by modulations of each individual interactant – e.g. by their age (Livingstone & Isaacowitz, 2021), gender (Christensen et al., 2020), the current situation (Kobylińska & Kusev, 2019), or their inherent ER abilities (Morawetz et al., 2017), as well as by the situation-specific modulations emerging from the interaction within the dyad. Thus, as we amass further knowledge about the psychophysiological and neural underpinnings of inter-personal ER for both Targets and Regulators, we will be able to devise neural models, which can be tested using advanced techniques, such as bDCM or hDCM. Therefore, in certain cases there may still be a need to examine inter-personal ER in these para-social paradigms, however, these findings should be interpreted with caution. These findings can be used to plan paradigms, construct models, and improve analysis methods which will result in a more accurate picture of true interactive, inter-personal ER.

5.2.3. What Mechanisms Underlie Inter-Personal ER?

A key question the thesis set out to investigate was how inter-personal ER exerts its effects particularly when down-regulating negative affect. Previous findings have shown inter-personal ER to be effective in reducing self-reported negative feelings; i.e. aspects of the affective subsystem which can be accessed consciously by most healthy people. In particular, even minor benefits of receiving intrinsic inter-personal ER from a close friend (Christensen et al., 2020; Morawetz et al., 2021) or a romantic partner (Levy-Gigi & Shamay-Tsoory, 2017) seem to be able to produce noticeable decreases in negative affect in the regulating Target. Although the experiments presented within this thesis relied on dyads consisting of two strangers, and were unable to replicate these findings for the rating responses, the overall evidence on the efficacy of inter-personal ER in general, as well as stranger-directed specifically, is inconclusive. Coan et al. (2006) demonstrated beneficial regulatory effects for women regulating with the help of a stranger relative to regulating on their own. However, despite these beneficial effects, the women also demonstrated some physiological and neural responses akin to threat responses when regulating with a stranger. Similarly, Morawetz et al. (2021) reported some beneficial effects of down-regulating negative affect with the help of a stranger, however, these benefits were also associated with heightened activations within the amygdala, which were also interpreted as threat responses. Interestingly, both studies assume regulatory benefits to exist for strangers, however, they may be a balanced trade-off between these benefits and threat responses associated with assessing a novel interactant. The experiments presented within this thesis suggest a beneficial effect for stranger-directed inter-personal ER when electrodermal responses are considered, although this benefit was not reflected in participants' self-reports. Thus, inter-personal ER is complex and likely to be modulated by social factors, such as the social proximity of the interactants, rather than assuming ineffective inter-personal ER for strangers per se. Moreover, similar studies with Targets regulating with the help of a close other as well as a stranger are needed to determine the true limits of stranger-directed inter-personal ER. Indeed, in clinical settings, the therapeutic relationship which the therapist fosters with the patient is considered to be an essential ingredient in the success of the therapy (Li, 2021; Norcross, 2010) – thus, to increase the probability of therapeutic success, the therapist has to build rapport with the client and develop a trusted relationship in a relatively short amount of time and often based on less frequent contact as would be expected for regular friendships and relationships (Fröding & Peterson, 2012). Therefore, when attempting to understand the intricate inter-personal influences on inter-personal ER, these relational dynamics should be considered and manipulated systematically in future investigations.

Furthermore, Chapter 3 demonstrated that psychophysiological mechanisms, as evidenced by the EDA measures, likely underlie these inter-personal ER processes. The Social Baseline Theory (Beckes & Sbarra, 2022) posits that the presence of others can decrease physiological signs of stress automatically. Indeed, beneficial physiological effects of inter-personal ER appear to emerge even in the absence of conscious awareness from the participants, as is evidenced by the discrepancy between the rating responses and EDA measures. Therefore, these physiological results extend the aforementioned findings of the benefits of inter-personal ER, which were previously primarily based on rating responses. Nonetheless, the current investigation highlighted that effortful inter-personal regulation, as evidenced by PFC activation observed in Chapter 4, can also modulate physiological arousal. Moreover, Chapter 4 offered some initial insights into the neural processes which support intrinsic and extrinsic inter-personal ER. Importantly, neural activation patterns presented in Chapter 4 suggest that (1) intrinsic inter-personal ER is likely to engage the same widespread neural networks as intrinsic intra-persona ER, and (2) inter-personal ER is facilitated by shared neural networks between the Regulator and the Target. In order to regulate their emotions inter- or intra-personally, Targets likely engage in an embodied simulation of their desired affective goal state, which is supported by activations within somatic and motor cortices during the ER task and corresponds with numerous previous accounts of embodied affect and social cognition (Halberstadt et al., 2009; Kiverstein & Miller, 2015; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Reeck et al., 2016). Moreover, this embodiment perspective is in line with findings from empathy research, which shows that empathic responses to others are facilitated by shared neural representations between the person experiencing and the person observing the emotion (Singer & Lamm, 2009). Interestingly, the high convergence in neural activation patterns between Targets implementing ER and Regulators choosing an ER strategy for Targets, supports this perspective of empathic embodied processes underlying extrinsic inter-personal ER. Nonetheless, one fundamental question which remains to be addressed in the future, is what role the brain regions associated with socio-cognitive processes, such as the dmPFC, TPJ and the precuneus (Kanske et al., 2015; Van Overwalle, 2009), which were also observed within the current ER paradigm, play during inter-personal ER in both the Regulators and Targets. These socio-cognitive regions do display connections to emotion-generative regions, such as the IFG/vlPFC, amygdala and ventral striatum (Berboth, Windischberger, Kohn, & Morawetz, 2021; Morawetz et al., 2020; Reeck et al., 2016), however, it is unclear whether they exert their regulatory effects directly on these emotion-generative regions, or whether these socio-cognitive processing hubs are in fact not directly involved in the ER process.

5.2.4. How Is Inter-Personal ER Influenced by Individual Differences?

Another aim of the thesis was to determine which factors modulate inter-personal ER and whether certain person characteristics render this form of ER as more or less effective for certain groups of people. Understanding how inter-personal ER might not be effective for certain groups and how it might need to be modified to increase its beneficial effect would be particularly impactful for clinical settings, as psychopathology has been associated extensively with emotional dysregulation (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Christensen et al., 2020; Fitzpatrick & Kuo, 2015; Gross & Jazaieri, 2014; Heller & Casey, 2016). Interestingly, most of the person characteristics, such as current mood (Quirin, Kazen, & Kuhl, 2009) and autism phenotype (Hurley, Losh, Parlier, Reznick, & Piven, 2007) in the laboratory EDA presented in Chapter 3 did not suggest any individual difference to modulate the efficacy of inter-personal ER. Similarly, response inhibition used as a proxy for cognitive control as measured by the Stroop task (Jostmann & Koole, 2007) in the online experiments of Chapter 3 also offered no support for inter-personal ER being influenced by someone's general ability to exert cognitive control. Furthermore, there was no evidence to suggest that the autistic traits measured with the Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and trait action orientation (Kuhl, 1994), which are described in Chapter 4, modulated inter-personal ER efficacy for Targets. However, there was one person characteristic which was related with ER in the EDA experiment, and might warrant further investigation in the future. The findings suggested that alexithymia was related to ER (Vorst & Bermond, 2001). In the EDA experiment, participants expressing higher levels of alexithymic traits tended to overestimate their abilities to down-regulate their emotions. These participants provided lower ratings of arousal following regulation, however, these estimations of their regulatory success were not supported by the EDA measures, which remained high. Alexithymia is primarily associated with difficulties in understanding and verbalising one's affective experiences (Bermond, Bierman, Cladder, Moormann, & Vorst, 2010; Goerlich, 2018), and has been shown to underlie affective difficulties in autism (Bird et al., 2010; Poquérusse, Pastore, Dellantonio, & Esposito, 2018). In fact, alexithymia is a transdiagnostic condition (Goerlich, 2018; Valdespino, Antezana, Ghane, & Richey, 2017), future investigations into the links between alexithymia and (inter-personal) ER might expose fruitful avenues for the development of therapeutic and transdiagnostic interventions for emotional dysregulation (e.g., Bornemann & Singer, 2017).

As the majority of person characteristics were unrelated to participants' abilities to implement inter-personal ER when they were directed by a stranger, future studies investigating potential modulators of inter-personal ER should turn their attention towards social factors. For instance, social proximity, as discussed previous sections above appears to be a key modulator of inter-personal ER. However, more research explicitly manipulating social proximity during inter-personal ER are needed to make definite claims regarding the modulatory effects of the relationship between the regulating dyad. Morawetz et al. (2021) examined inter-personal ER by asking participants to regulate their emotions with the guidance of a friend or a stranger. In the friend condition, a photograph of their friend was presented alongside a sentence of reappraisal to be used with the image, e.g. "Remember, this is not real". Similarly, in the stranger condition, participants were provided with a sentence to help them regulate their emotions which was presented with a photo of a stranger. Findings suggested that participants benefitted the most from receiving guidance from their friend, although it is important to note, that stranger-directed ER was rated as more effective than regulating on their own. In the experiments presented within this thesis, there was no evidence to suggest participants felt similarly, i.e. that they experienced the guidance from the stranger as more effective than self-regulating. However, physiological indices suggest that stranger-directed inter-personal ER was more effective in reducing negative affect. Future studies should investigate such a manipulation of social proximity in a second-person paradigm to formally assess how intrinsic intra-personal ER compares to intrinsic inter-personal ER when we are guided by close others versus a stranger.

Other studies have only investigated close dyads, thus without the inclusion of a stranger-directed ER condition, decisive conclusions about social proximity cannot be made. For instance, a study assessing the regulatory benefits of daughters regulating their emotions prior to a stressful public speaking task with the help of their mothers, showed that daughters with poor mother-daughter relationships exhibited the highest levels of arousal prior to the task and the lowest benefits following the task, i.e. after receiving inter-personal support (Lougheed et al., 2016). Although social proximity could be assessed in this paradigm, this study might suggest another crucial avenue which can be explored to identify social factors that influence inter-personal ER efficacy. The quality of the relationship is likely to also influence the success of inter-personal ER. Relationship quality has been shown to influence well-being more than the actual frequency of interactions between people (Wazid & Shahnawaz, 2017). Thus, future inter-personal ER studies can measure relationship quality using questionnaires, such as the scale for Positive-Negative Relationship Quality (Rogge, Fincham, Crasta, & Maniaci, 2017), or measure physiological synchrony between interactants, which is considered a useful proxy for relational quality between interacting people and can be used to assess dynamic changes in relationship quality across several sessions (Karvonen et al., 2016; Paananen et al., 2018). Similarly, the actual or perceived presence of the other person is likely to modulate the benefits of receiving inter-personal ER (Biocca, Harms, & Burgoon, 2003). The presence of romantic partners throughout the day has been shown to reduce physiological indices of arousal in couples (Han et al., 2021). Participants exposed to mild electric shocks rated the experience as less aversive and showed decreased activations within the amygdala and thalamus when they were able to communicate with a therapist who assured them of their presence (Mulej Bratec et al., 2020). Moreover, Gonzalez, Coppola, Allen, and Coan (2021) propose that physiological expenditures and prefrontal activation in the dlPFC and vmPFC associated with cognitive control are reduced in the presence of others. Thus, the perceived presence of the other might be a key modulator of inter-personal ER efficacy and could be assessed easily in future studies by varying whether participants regulate their emotions within close proximity or whether they are separated and placed in different rooms.

5.3. General Conclusion

The current paradigm provides a useful approach for examining the efficacy of inter-personal ER by utilising a within-subjects approach to assess both inter- and intra-personal regulation. Moreover, the addition of choice elements within the trials provides insights into more naturalistic and flexible regulatory behaviours, which resemble naturalistic behaviours more closely. The Frame condition also allowed for explicit regulation to be compared with implicit regulation, and the latter appeared to be particularly useful in decreasing highly negative emotions. The use of multiple methods for the assessment of the efficacy of inter-personal ER revealed divergent findings for the various affective sub-systems, thereby stressing the importance of multi-method assessments of affect. Taken together, the findings across Chapters 3 and 4 suggest that inter-personal ER might have differential effects for the various affective sub-systems. There was evidence to suggest that inter-personal ER is more effective in reducing physiological responses to negative images, however, there were no differential benefits between inter- and intra-personal ER when rating responses were considered. Furthermore, inter-personal ER appears to be modulated by the relational factors between the interacting dyad. Previous studies revealing beneficial effects of inter- over intra-personal ER based on rating responses, relied on close dyads, whereas these findings for rating responses could not be replicated with strangers. Nonetheless, it is important to note that some benefits of stranger-directed inter-personal ER, albeit attenuated, have previously been reported elsewhere and were also seen in the current datasets. Thus, it appears that decreasing negative emotions with the help of others is effective in eliciting affective changes, however, maximal benefits require a close social proximity between the interactants. Further, most individual differences other than alexithymia were unrelated to inter-personal ER success, thus possibly suggesting that social factors, such as the aforementioned social proximity, to be more critical in modulating inter-personal ER processes.

Moreover, a key consideration of the experiments within this thesis concerned the degree to which the investigations could be considered as true social interactions. Social Psychology and Neuroscience often investigates socio-cognitive processes in participants who passively observe social scenarios and are asked to make inferences for instance about the actors beliefs, intentions or personality traits (Schurz et al., 2021; Singer & Lamm, 2009) Schilbach et al. (2013) criticise the dominant approach in social neuroscience which investigates socio-cognitive processes in people in isolation rather than in real dynamic interactions. Thus, the use of a second-person paradigm increased the ecological validity of the study by investigating inter-personal ER in a real-time dyadic task. The findings offered limited support for approaches assuming reduced PFC activations during inter-personal ER (e.g. Beckes & Coan, 2011) – in fact, neural activation patterns between the inter- and intra-personal conditions were very similar to one another. Target-specific activation patterns during intrinsic inter- and intra-personal ER, as well as Regulator-specific extrinsic inter-personal ER could be examined. This revealed significant similarities between the brain responses of Targets implementing intrinsic inter- and intra-personal ER. This suggests that intrinsic ER is implemented in the same way within Targets regardless of whether they are engaging in self- or Regulator-directed regulation. Furthermore, the similarities between brain responses in Targets implementing intrinsic ER and Regulators recommending extrinsic ER, suggests that we might engage in embodied simulations of the desired affective goal state in order to provide effective extrinsic ER to others. Future second-person inter-personal ER paradigms will be able to assess synchrony within the interactants to determine how the relationship between interactants changes over time and influences ER efficacy. They should also assess truly interactive settings, i.e. intra-personal emotion generation and regulation within Regulators, as this is likely to influence how both participants approach the regulatory attempts. Furthermore, advanced analyses of dyadic responses, such as bDCM and hDCM will enable us to predict responses in interacting dyads, which might be useful to tailor interventions within therapeutic, educational, developmental or organisational settings. Moreover, these effective connectivity analyses will help elucidate the specific involvement of socio-cognitive processes on the inter-personal ER process, as activations within these typical socio-cognitive brain regions, such as the TPJ and precuneus, were observed during both inter- and intra-personal ER within the current paradigm.

References

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review, 30*(2), 217-237. doi:10.1016/j.cpr.2009.11.004

Alghamdi, M., Regenbrecht, H., Hoermann, S., & Swain, N. (2017). Mild stress stimuli built into a non-immersive virtual environment can elicit actual stress responses. *Behaviour & Information Technology, 36*(9), 913-934.

Amir, N., Beard, C., Taylor, C. T., Klumpp, H., Elias, J., Burns, M., & Chen, X. (2009). Attention training in individuals with generalized social phobia: A randomized controlled trial. *Journal of consulting and clinical psychology, 77*(5), 961.

Bahl, N., & Ouimet, A. J. (2022). Smiling won't necessarily make you feel better: Response-focused emotion regulation strategies have little impact on cognitive, behavioural, physiological, and subjective outcomes. *Journal of Behavior Therapy and Experimental Psychiatry, 74*, 101695.

Barańczuk, U. (2019). The five factor model of personality and emotion regulation: A meta-analysis. *Personality and Individual Differences, 139*, 217-227.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, malesand females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31*(1), 5-17.

Barrett, L. F. (2006). Solving the Emotion Paradox: Categorization and the Experience of Emotion. *Personality and Social Psychology Review, 10*(1), 20-46. doi:10.1207/s15327957pspr1001_2

Barrett, L. F. (2012). Emotions Are Real. *Emotion, 12*(3), 413-429. doi:10.1037/a0027555

Barthel, A. L., Hay, A., Doan, S. N., & Hofmann, S. G. (2018). Interpersonal emotion regulation: A review of social and developmental components. *Behaviour Change, 35*(4), 203-216.

Bartolomeo, L. A., Culbreth, A. J., Ossenfort, K. L., & Strauss, G. P. (2020). Neurophysiological evidence for emotion regulation impairment in schizophrenia: The role of visual attention and cognitive effort. *Journal of abnormal psychology, 129*(6), 670.

Beckes, L., & Coan, J. A. (2011). Social baseline theory: The role of social proximity in emotion and economy of action. *Social and Personality Psychology Compass, 5*(12), 976-988.

Beckes, L., & Sbarra, D. A. (2022). Social baseline theory: State of the science and new directions. *Current Opinion in Psychology, 43*, 36-41.

Benfer, N., Bardeen, J. R., & Clauss, K. (2018). Experimental manipulation of emotion regulation self-efficacy: Effects on emotion regulation ability, perceived effort in the service of regulation, and affective reactivity. *Journal of contextual behavioral science, 10*, 108-114.

Berboth, S., Windischberger, C., Kohn, N., & Morawetz, C. (2021). Test-retest reliability of emotion regulation networks using fMRI at ultra-high magnetic field. *Neuroimage, 232*, 117917.

Bermond, B., Bierman, D. J., Cladder, M. A., Moormann, P. P., & Vorst, H. C. (2010). The cognitive and affective alexithymia dimensions in the regulation of sympathetic responses. *International Journal of Psychophysiology, 75*(3), 227-233.

Bernat, E. M., Cadwallader, M., Seo, D., Vizueta, N., & Patrick, C. J. (2011). Effects of instructed emotion regulation on valence, arousal, and attentional measures of affective processing. *Developmental neuropsychology, 36*(4), 493-518.

Bevilacqua, D., Davidesco, I., Wan, L., Chaloner, K., Rowland, J., Ding, M., . . . Dikker, S. (2019). Brain-to-brain synchrony and learning outcomes vary by student–teacher dynamics: Evidence from a real-world classroom electroencephalography study. *Journal of Cognitive Neuroscience, 31*(3), 401-411.

Bilek, E. (2020). Directed coupling in multi-brain networks underlies generalized synchrony during social exchange.

Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators & virtual environments, 12*(5), 456-480.

Bird, G., Silani, G., Brindley, R., White, S., Frith, U., & Singer, T. (2010). Empathic brain responses in insula are modulated by levels of alexithymia but not autism. *Brain, 133*(5), 1515-1525.

Blackford, J. U., Buckholtz, J. W., Avery, S. N., & Zald, D. H. (2010). A unique role for the human amygdala in novelty detection. *Neuroimage, 50*(3), 1188-1193.

Bolis, D., & Schilbach, L. (2020). 'I interact therefore I am': The self as a historical product of dialectical attunement. *Topoi, 39*(3), 521-534.

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. doi:10.1177/1745691613504116

Bornemann, B., & Singer, T. (2017). Taking time to feel our body: Steady increases in heartbeat perception accuracy and decreases in alexithymia over 9 months of contemplative mental training. *Psychophysiology, 54*(3), 469-482.

Bradley, R. T., McCraty, R., Atkinson, M., Tomasino, D., Daugherty, A., & Arguelles, L. (2010). Emotion self-regulation, psychophysiological coherence, and test anxiety: results from an experiment using electrophysiological measures. *Applied psychophysiology and biofeedback, 35*(4), 261-283.

Butler, E. A. (2017). Emotions are temporal interpersonal systems. *Current Opinion in Psychology, 17*, 129-134. doi:10.1016/j.copsyc.2017.07.005

Catani, M., Dell'Acqua, F., & De Schotten, M. T. (2013). A revised limbic system model for memory, emotion and behaviour. *Neuroscience & Biobehavioral Reviews, 37*(8), 1724-1737.

Christensen, K. A., van Dyk, I. S., Nelson, S. V., & Vasey, M. W. (2020). Using multilevel modeling to characterize interpersonal emotion regulation strategies and psychopathology in female friends. *Personality and Individual Differences, 165*, 110156.

Coan, J. A., Beckes, L., Gonzalez, M. Z., Maresh, E. L., Brown, C. L., & Hasselmo, K. (2017). Relationship status and perceived support in the social regulation of neural responses to threat. *Social Cognitive and Affective Neuroscience, 12*(10), 1574-1583.

Coan, J. A., Schaefer, H. S., & Davidson, R. J. (2006). Lending a hand: Social regulation of the neural response to threat. *Psychological science, 17*(12), 1032-1039.

Colombo, D., Fernández-Álvarez, J., Suso-Ribera, C., Cipresso, P., Valev, H., Leufkens, T., . . . Botella, C. (2020). The need for change: Understanding emotion regulation antecedents and consequences using ecological momentary assessment. *Emotion, 20*(1), 30.

Crowell, S. E., Puzia, M. E., & Yaptangco, M. (2015). The ontogeny of chronic distress: Emotion dysregulation across the life span and its implications for psychological and physical health. *Current Opinion in Psychology, 3*, 91-99.

De Bruin, L., Van Elk, M., & Newen, A. (2012). Reconceptualizing second-person interaction. *Frontiers in Human Neuroscience, 6*, 151.

De Castella, K., Goldin, P., Jazaieri, H., Ziv, M., Dweck, C. S., & Gross, J. J. (2013). Beliefs about emotion: Links to emotion regulation, well-being, and psychological distress. *Basic and Applied Social Psychology, 35*(6), 497-505.

De Vignemont, F., & Singer, T. (2006). The empathic brain: how, when and why? *Trends in Cognitive Sciences, 10*(10), 435-441.

Dixon-Gordon, K. L., Bernecker, S. L., & Christensen, K. (2015). Recent innovations in the field of interpersonal emotion regulation. *Current Opinion in Psychology, 3*, 36-42.

English, T., & Eldesouky, L. (2020). We're not alone: Understanding the social consequences of intrinsic emotion regulation. *Emotion, 20*(1), 43.

Fitzpatrick, S., & Kuo, J. R. (2015). A comprehensive examination of delayed emotional recovery in borderline personality disorder. *Journal of Behavior Therapy and Experimental Psychiatry, 47*, 51-59. doi:10.1016/j.jbtep.2014.11.004

Ford, B. Q., & Gross, J. J. (2019). Why beliefs about emotion matter: An emotion-regulation perspective. *Current Directions in Psychological Science, 28*(1), 74-81.

Fotopoulou, A., & Tsakiris, M. (2017). Mentalizing homeostasis: the social origins of interoceptive inference–replies to Commentaries. *Neuropsychoanalysis, 19*(1), 71-76.

Fox, A. S., Oler, J. A., Tromp, D. P., Fudge, J. L., & Kalin, N. H. (2015). Extending the amygdala in theories of threat processing. *Trends in neurosciences, 38*(5), 319-329.

Frank, D., Dewitt, M., Hudgens-Haney, M., Schaeffer, D., Ball, B., Schwarz, N., . . . Sabatinelli, D. (2014). Emotion regulation: quantitative meta-analysis of functional activation and deactivation. *Neuroscience & Biobehavioral Reviews, 45*, 202-211.

Fröding, B., & Peterson, M. (2012). Why virtual friendship is no genuine friendship. *Ethics and Information Technology, 14*(3), 201-207.

Gee, D. G. (2016). Sensitive periods of emotion regulation: influences of parental care on frontoamygdala circuitry and plasticity.

Goerlich, K. S. (2018). The Multifaceted Nature of Alexithymia - A Neuroscientific Perspective. *Frontiers in Psychology, 9*. doi:ARTN 1614

10.3389/fpsyg.2018.01614

Goldin, P. R., McRae, K., Ramel, W., & Gross, J. J. (2008). The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. *Biological Psychiatry, 63*(6), 577-586. doi:10.1016/j.biopsych.2007.05.031

Gonzalez, M. Z., Coppola, A. M., Allen, J. P., & Coan, J. A. (2021). Yielding to social presence as a bioenergetic strategy: preliminary evidence using fMRI. *Current Research in Ecological and Social Psychology*, 100010.

Gross, J. J. (1998a). Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology, 74*(1), 224-237. doi:10.1037/0022-3514.74.1.224

Gross, J. J. (1998b). The emerging field of emotion regulation: An integrative review. *Review of general psychology, 2*(3), 271-299.

Gross, J. J. (2015). Emotion Regulation: Current Status and Future Prospects. *Psychological Inquiry, 26*(1), 1-26. doi:10.1080/1047840x.2014.940781

Gross, J. J., & Jazaieri, H. (2014). Emotion, Emotion Regulation, and Psychopathology:An Affective Science Perspective. *Clinical Psychological Science, 2*(4), 387-401. doi:10.1177/2167702614536164

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

Halberstadt, J., Winkielman, P., Niedenthal, P. M., & Dalle, N. (2009). Emotional conception: How embodied emotion concepts guide perception and facial action. *Psychological science, 20*(10), 1254-1261.

Hallam, G. P., Webb, T. L., Sheeran, P., Miles, E., Niven, K., Wilkinson, I. D., . . . Farrow, T. F. D. (2014). The neural correlates of regulating another person's emotions: an exploratory fMRI study. *Frontiers in Human Neuroscience, 8*. doi:10.3389/fnhum.2014.00376

Han, S. C., Schacter, H. L., Timmons, A. C., Kim, Y., Sichko, S., Pettit, C., . . . Margolin, G. (2021). Romantic partner presence and physiological responses in daily life: Attachment style as a moderator. *Biological Psychology, 161*, 108082.

Hasson, U., & Frith, C. D. (2016). Mirroring and beyond: coupled dynamics as a generalized framework for modelling social interactions. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1693), 20150366.

Heinrich, L. M., & Gullone, E. (2006). The clinical significance of loneliness: A literature review. *Clinical Psychology Review, 26*(6), 695-718.

Heller, A. S., & Casey, B. (2016). The neurodynamics of emotion: delineating typical and atypical emotional processes during adolescence. *Developmental Science, 19*(1), 3-18. doi:10.1111/desc.12373

Hoemann, K., & Feldman Barrett, L. (2019). Concepts dissolve artificial boundaries in the study of emotion and cognition, uniting body, brain, and mind. *Cognition and emotion, 33*(1), 67-76.

Hollenstein, T., Tighe, A. B., & Lougheed, J. P. (2017). Emotional development in the context of mother–child relationships. *Current Opinion in Psychology, 17*, 140-144.

Hurley, R. S. E., Losh, M., Parlier, M., Reznick, J. S., & Piven, J. (2007). The Broad Autism Phenotype Questionnaire. *Journal of Autism and Developmental Disorders, 37*(9), 1679-1690. doi:10.1007/s10803-006-0299-3

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), 1301-1333. doi:10.1111/j.1467-6494.2004.00298.x

Jostmann, N. B., & Koole, S. L. (2007). On the regulation of cognitive control: Action orientation moderates the impact of high demands in Stroop interference tasks. *Journal of Experimental Psychology: General, 136*(4), 593.

Kanske, P., Böckler, A., Trautwein, F.-M., & Singer, T. (2015). Dissecting the social brain: Introducing the EmpaToM to reveal distinct neural networks and brain–behavior relations for empathy and Theory of Mind. *Neuroimage, 122*, 6-19.

Karvonen, A., Kykyri, V. L., Kaartinen, J., Penttonen, M., & Seikkula, J. (2016). Sympathetic nervous system synchrony in couple therapy. *Journal of marital and family therapy, 42*(3), 383-395.

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review, 30*(7), 865-878.

Kiel, E. J., & Kalomiris, A. E. (2015). Current themes in understanding children's emotion regulation as developing from within the parent–child relationship. *Current Opinion in Psychology, 3*, 11-16.

Kiverstein, J., & Miller, M. (2015). The embodied brain: towards a radical embodied cognitive neuroscience. *Frontiers in Human Neuroscience, 9*, 237.

Kobylińska, D., & Kusev, P. (2019). Flexible emotion regulation: How situational demands and individual differences influence the effectiveness of regulatory strategies. *Frontiers in Psychology, 10*, 72.

Kohn, N., Eickhoff, S. B., Scheller, M., Laird, A. R., Fox, P. T., & Habel, U. (2014). Neural network of cognitive emotion regulation - An ALE meta-analysis and MACM analysis. *Neuroimage, 87*, 345-355. doi:10.1016/j.neuroimage.2013.11.001

Kuhl, J. (1994). Action versus state orientation: Psychometric properties of the Action Control Scale (ACS-90). *Volition and personality: Action versus state orientation, 47*(56).

LaBar, K. S., Gitelman, D. R., Mesulam, M.-M., & Parrish, T. B. (2001). Impact of signal-to-noise on functional MRI of the human amygdala. *Neuroreport, 12*(16), 3461-3464.

Lamm, C., & Majdandžić, J. (2015). The role of shared neural activations, mirror neurons, and morality in empathy–A critical comment. *Neuroscience Research, 90*, 15-24.

Lang, F. R., Staudinger, U. M., & Carstensen, L. L. (1998). Perspectives on socioemotional selectivity in late life: How personality and social context do (and do not) make a difference. *Journals of Gerontology Series B-Psychological Sciences and Social Sciences, 53*(1), P21-P30. doi:DOI 10.1093/geronb/53B.1.P21

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International affective picture system (IAPS): affective ratings of pictures and instruction manual. University of Florida, Gainesville*. Retrieved from

Lee, H., Heller, A. S., Van Reekum, C. M., Nelson, B., & Davidson, R. J. (2012). Amygdala–prefrontal coupling underlies individual differences in emotion regulation. *Neuroimage, 62*(3), 1575-1581.

Levy-Gigi, E., Bonanno, G. A., Shapiro, A. R., Richter-Levin, G., Keri, S., & Sheppes, G. (2016). Emotion Regulatory Flexibility Sheds Light on the Elusive Relationship Between Repeated Traumatic Exposure and Posttraumatic Stress Disorder Symptoms. *Clinical Psychological Science, 4*(1), 28-39. doi:10.1177/2167702615577783

Levy-Gigi, E., & Shamay-Tsoory, S. G. (2017). Help me if you can: Evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress. *Journal of Behavior Therapy and Experimental Psychiatry, 55*, 33-40. doi:10.1016/j.jbtep.2016.11.008

Li, X. (2021). The "dyadic dance": Exploring therapist–client dynamics and client symptom change using actor–partner interdependence modeling and multilevel mixture modeling. *Journal of Counseling Psychology*, No Pagination Specified-No Pagination Specified. doi:10.1037/cou0000599

Lindquist, K. A., & Barrett, L. F. (2012). A functional architecture of the human brain: emerging insights from the science of emotion. *Trends in Cognitive Sciences, 16*(11), 533-540. doi:10.1016/j.tics.2012.09.005

Linhartova, P., Latalova, A., Kosa, B., Kasparek, T., Schmahl, C., & Paret, C. (2019). fMRI neurofeedback in emotion regulation: A literature review. *Neuroimage, 193*, 75-92. doi:10.1016/j.neuroimage.2019.03.011

Livingstone, K. M., & Isaacowitz, D. M. (2021). Age and emotion regulation in daily life: Frequency, strategies, tactics, and effectiveness. *Emotion, 21*(1), 39.

Lougheed, J. P., Koval, P., & Hollenstein, T. (2016). Sharing the burden: The interpersonal regulation of emotional arousal in mother– daughter dyads. *Emotion, 16*(1), 83.

Moodie, C. A., Suri, G., Goerlitz, D. S., Mateen, M. A., Sheppes, G., McRae, K., . . . Gross, J. J. (2020). The neural bases of cognitive emotion regulation: The roles of strategy and intensity. *Cognitive, Affective, & Behavioral Neuroscience*, 1-21.

Morawetz, C., Berboth, S., & Bode, S. (2021). With a little help from my friends: the effect of social proximity on emotion regulation-related brain activity. *Neuroimage*, 117817.

Morawetz, C., Bode, S., Baudewig, J., & Heekeren, H. R. (2017). Effective amygdala-prefrontal connectivity predicts individual differences in successful emotion regulation. *Social Cognitive and Affective Neuroscience, 12*(4), 569-585.

Morawetz, C., Riedel, M. C., Salo, T., Berboth, S., Eickhoff, S., Laird, A. R., & Kohn, N. (2020). Multiple large-scale neural networks underlying emotion regulation. *Neuroscience & Biobehavioral Reviews*.

Mulej Bratec, S., Bertram, T., Starke, G., Brandl, F., Xie, X., & Sorg, C. (2020). Your presence soothes me: a neural process model of aversive emotion regulation via social buffering. *Social Cognitive and Affective Neuroscience, 15*(5), 561-570.

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review, 9*(3), 184-211.

Norcross, J. C. (2010). The therapeutic relationship. In *The heart and soul of change: Delivering what works in therapy, 2nd ed.* (pp. 113-141). Washington, DC, US: American Psychological Association.

Olsavsky, A. K., Telzer, E. H., Shapiro, M., Humphreys, K. L., Flannery, J., Goff, B., & Tottenham, N. (2013). Indiscriminate amygdala response to mothers and strangers after early maternal deprivation. *Biological Psychiatry, 74*(11), 853-860.

Paananen, K., Vaununmaa, R., Holma, J., Karvonen, A., Kykyri, V.-L., Tsatsishvili, V., . . . Seikkula, J. (2018). Electrodermal activity in couple therapy for intimate partner violence. *Contemporary Family Therapy, 40*(2), 138-152.

Papageorgiou, C., & Wells, A. (2000). Treatment of recurrent major depression with attention training. *Cognitive and Behavioral Practice, 7*(4), 407-413.

Pauw, L. S., Sauter, D. A., Van Kleef, G. A., & Fischer, A. H. (2019). Stop crying! The impact of situational demands on interpersonal emotion regulation. *Cognition and emotion, 33*(8), 1587-1598.

Plichta, M. M., Grimm, O., Morgen, K., Mier, D., Sauer, C., Haddad, L., . . . Schwarz, A. J. (2014). Amygdala habituation: a reliable fMRI phenotype. *Neuroimage, 103*, 383-390.

Poquérusse, J., Pastore, L., Dellantonio, S., & Esposito, G. (2018). Alexithymia and autism spectrum disorder: a complex relationship. *Frontiers in Psychology, 9*, 1196.

Pruessner, L., Barnow, S., Holt, D. V., Joormann, J., & Schulze, K. (2020). A cognitive control framework for understanding emotion regulation flexibility. *Emotion, 20*(1), 21.

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

Quesque, F., & Rossetti, Y. (2020). What do theory-of-mind tasks actually measure? Theory and practice. *Perspectives on Psychological Science, 15*(2), 384-396.

Quinones, A. R., Markwardt, S., & Botoseneanu, A. (2016). Multimorbidity Combinations and Disability in Older Adults. *Journals of Gerontology Series a-Biological Sciences and Medical Sciences, 71*(6), 823-830. doi:10.1093/gerona/glw035

Quirin, M., Kazen, M., & Kuhl, J. (2009). When nonsense sounds happy or helpless: the Implicit Positive and Negative Affect Test (IPANAT). *Journal of Personality and Social Psychology*(3), 500.

Redcay, E., & Schilbach, L. (2019). Using second-person neuroscience to elucidate the mechanisms of social interaction. *Nature Reviews Neuroscience, 20*(8), 495-505.

Reeck, C., Ames, D. R., & Ochsner, K. N. (2016). The social regulation of emotion: An integrative, cross-disciplinary model. *Trends in Cognitive Sciences, 20*(1), 47-63.

Rogge, R. D., Fincham, F. D., Crasta, D., & Maniaci, M. R. (2017). Positive and negative evaluation of relationships: Development and validation of the Positive–Negative Relationship Quality (PN-RQ) scale. *Psychological assessment, 29*(8), 1028.

Sahi, R. S., Ninova, E., & Silvers, J. A. (2020). With a little help from my friends: Selective social potentiation of emotion regulation. *Journal of Experimental Psychology: General.*

Samson, D., Apperly, I. A., Chiavarino, C., & Humphreys, G. W. (2004). Left temporoparietal junction is necessary for representing someone else's belief. *Nature neuroscience, 7*(5), 499-500.

Schilbach, L. (2016). Towards a second-person neuropsychiatry. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1686), 20150081.

Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., & Vogeley, K. (2013). Toward a second-person neuroscience 1. *Behavioral and brain sciences, 36*(4), 393-414.

Schurz, M., Radua, J., Tholen, M. G., Maliske, L., Margulies, D. S., Mars, R. B., . . . Kanske, P. (2021). Toward a hierarchical model of social cognition: A neuroimaging meta-analysis and integrative review of empathy and theory of mind. *Psychological Bulletin, 147*(3), 293.

Shamay-Tsoory, S. G., Aharon-Peretz, J., & Perry, D. (2009). Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. *Brain, 132*(3), 617-627.

Shaw, D., Czekóová, K., Gajdoš, M., Staněk, R., Špalek, J., & Brázdil, M. (2019). Social decision-making in the brain: Input-state-output modelling reveals patterns of effective connectivity underlying reciprocal choices. *Human Brain Mapping, 40*(2), 699-712.

Shaw, D. J., Czekóová, K., Staněk, R., Mareček, R., Urbánek, T., Špalek, J., . . . Brázdil, M. (2018). A dual-fMRI investigation of the iterated Ultimatum Game reveals that reciprocal behaviour is associated with neural alignment. *Scientific reports, 8*(1), 1-13.

Sheppes, G., & Levin, Z. (2013). Emotion regulation choice: selecting between cognitive regulation strategies to control emotion. *Frontiers in Human Neuroscience, 7*, 179.

Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., & Gross, J. J. (2014). Emotion Regulation Choice: A Conceptual Framework and Supporting Evidence. *Journal of Experimental Psychology-General, 143*(1), 163-181. doi:10.1037/a0030831

Singer, T., & Lamm, C. (2009). The social neuroscience of empathy. *Annals of the New York Academy of Sciences, 1156*(1), 81-96.

Špiláková, B., Shaw, D. J., Czekóová, K., & Brázdil, M. (2019). Dissecting social interaction: dual-fMRI reveals patterns of interpersonal brain-behavior relationships that dissociate among dimensions of social exchange. *Social Cognitive and Affective Neuroscience, 14*(2), 225-235.

Strauss, G. P., Ossenfort, K. L., & Whearty, K. M. (2016). Reappraisal and distraction emotion regulation strategies are associated with distinct patterns of visual attention and differing levels of cognitive demand. *PloS one, 11*(11), e0162290.

Tamir, M., & Ford, B. Q. (2012). When Feeling Bad Is Expected to Be Good: Emotion Regulation and Outcome Expectancies in Social Conflicts. *Emotion, 12*(4), 807-816. doi:10.1037/a0024443

Tang, H., Mai, X., Wang, S., Zhu, C., Krueger, F., & Liu, C. (2016). Interpersonal brain synchronization in the right temporo-parietal junction during face-to-face economic exchange. *Social Cognitive and Affective Neuroscience, 11*(1), 23-32.

Urry, H. L. (2010). Seeing, thinking, and feeling: emotion-regulating effects of gaze-directed cognitive reappraisal. *Emotion, 10*(1), 125.

Valdespino, A., Antezana, L., Ghane, M., & Richey, J. A. (2017). Alexithymia as a transdiagnostic precursor to empathy abnormalities: the functional role of the insula. *Frontiers in Psychology, 8*, 2234.

Valtorta, N. K., Kanaan, M., Gilbody, S., Ronzi, S., & Hanratty, B. (2016). Loneliness and social isolation as risk factors for coronary heart disease and stroke: systematic review and meta-analysis of longitudinal observational studies. *Heart, 102*(13), 1009-1016.

Van Overwalle, F. (2009). Social cognition and the brain: a meta-analysis. *Human Brain Mapping, 30*(3), 829-858.

Vorst, H. C. M., & Bermond, B. (2001). Validity and reliability of the Bermond-Vorst Alexithymia Questionnaire. *Personality and Individual Differences, 30*(3), 413-434. doi:Doi 10.1016/S0191-8869(00)00033-7

Wazid, S. W., & Shahnawaz, M. G. (2017). Relationship quality as mediator of forgiveness and psychological well-being among transgressors in romantic relationships. *Psychological Studies, 62*(2), 200-208.

Williams, W. C., Morelli, S. A., Ong, D. C., & Zaki, J. (2018). Interpersonal emotion regulation: Implications for affiliation, perceived support, relationships, and well-being. *Journal of Personality and Social Psychology, 115*(2), 224.

Zaki, J. (2020). Integrating empathy and interpersonal emotion regulation. *Annual Review of Psychology, 71*, 517-540.

Zaki, J., & Williams, W. C. (2013). Interpersonal Emotion Regulation. *Emotion, 13*(5), 803-810. doi:10.1037/a0033839