# PSYCHOLOGICAL AND PHYSIOLOGIACAL CORRELATES OF EMOTION REGULATION

**by**

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**Abstract**

The principal aim of this thesis is to examine how emotion regulation and mindfulness are related to cardiovascular activity and the implications of these relationships for the understanding of aggression. Studies one and two aimed to detail the relationship of mindfulness to psychopathic traits and emotion regulation. Results of these studies collectively imply that mindfulness shares certain features with primary psychopathic traits, including reduced physiological responding to aversive stimuli. Study three aimed to investigate whether slow-paced breathing, associated with an increase in vagal output and thus decrease in heart rate, may exert effects on emotion regulation. Participation in a paced breathing course improved emotion regulation and increased trait mindfulness in a sample of male offenders. Study four aimed to explore how cardiovascular activity and psychopathic traits relate to female perpetrated intimate partner violence. Increased vagal activity, was found to be positively linked to proactive aggression and partner violence. Study five aimed to extend the results of Study four to a sample of male offenders. The results showed that high vagal activity is related to low empathy and good performance on the Stroop task. Collectively, these findings have implications for the use of mindfulness based treatments and the understanding of aggression.

*~ To my wife, Hai ~*

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## Dissemination

Large elements of the fourth experimental chapter, corresponding to Study 2, have now been published in the journal Mindfulness. The work has been co-authored by the candidate's supervisors (Dr Ian Mitchell and Dr Louise Dixon) and co-worker (Dr Steven Gillespie). However, the candidate was the principal researcher with respect to designing and executing the study, undertaking the data analyses, and writing the paper. The full reference is: Brzozowski A., Gillespie S. M., Dixon L., Mitchell I. J. (2018). Mindfulness dampens cardiac responses to motion scenes of violence. *Mindfulness*, 9(2), 575-584. DOI: 10.1007/s12671-017-0799-6.

Parts of the General Introduction were published in a special review on forensic neuroscience. This work has been authored by Dr Steven Gillespie, and co-authored by the candidate and Dr Ian Mitchell. The full reference is: Gillespie, S. M., Brzozowski, A., & Mitchell, I. J. (2018). Self-regulation and aggressive antisocial behaviour: Insights from amygdala-prefrontal and heart-brain interactions. *Psychology, Crime & Law, 24*(3), 243-257. DOI: 10.1080/1068316X.2017.141481.

Large parts of the sixth experimental chapter, corresponding to Study 4, have now been accepted for publication in the Journal of Interpersonal Violence. As with Chapter 4, the work has been co-authored by the candidate's supervisors (Dr Ian Mitchell and Dr Louise Dixon) and co-worker (Dr Steven Gillespie). The candidate was the principal researcher with respect to executing the study, undertaking the data analyses, and writing the paper.

## Table of Contents

## List of Illustrations

**List of Tables**

# CHAPTER 1: INTRODUCTION

## 1.1. Aims of the thesis

Regulation of emotions is recognised as being an important facet with respect to good mental wellbeing (Gross & Muñoz, 1995; Gross & John, 2003; Thayer & Lane, 2009; Smith, Thayer, Khalsa, & Lane, 2017; Quoidbach, Berry, Hansenne, & Mikolajczak, 2010). Conversely, failure to adequately regulate emotions is associated with mental health issues and tendencies to behave antisocially (Gross & Muñoz, 1995; Martin & Dahlen, 2005; Barlow, Allen, & Choate 2016; Gross & John, 2003; Beauregard, 2007; Gillespie, Mitchell, Fisher, & Beech, 2012; Davidson, Putnam, & Larson, 2000; Roberton, Daffern, & Bucks, 2014; Long, Felton, Lilienfeld, & Lejuez, 2014). The latter can be characterised by impulsive acts and the expression of aggression (Davidson et al., 2000; Roberton et al., 2014; Long et al., 2014; García-Forero, Gallardo-Pujol, Maydeu-Olivares, & Andrés-Pueyo, 2009).

In recent years, there have been attempts to use techniques associated with mindfulness to improve regulation of emotions and other aspects of self-regulation (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Tang & Leve, 2016; Arch & Craske, 2006; Goldin & Gross, 2010). Mindfulness can be described as the cultivation of awareness to the present moment and non-judgemental acceptance of mental processes, including emotions (Bishop et al., 2004). Mindfulness techniques could therefore form the basis of therapeutic approaches to reducing antisocial tendencies (Borders, Earleywine, & Jajodia, 2010; Heppner et al., 2008; Singh, Wahler, Adkins, & Myers, 2003; Velotti et al., 2016).

Emotion regulation, mindfulness and aggressive behaviour may all be related to cardiovascular function (Smith et al., 2017; Raine, 2002; Ditto, Eclache, & Goldman, 2006; Carlson, Speca, Faris, & Patel, 2007). High resting heart rates are associated with impulsivity and certain affective disorders, including anxiety, depression, and bipolar disorder (Latvala et al., 2016; Krueger, Schedlowski, & Meyer, 2005). Conversely, low resting heart rates are linked with certain types of offending (Latvala, Kuja-Halkola, Almqvist, Larsson, & Lichtenstein, 2015; Raine, 1996; Raine, 2002; Raine, 2015). Techniques which are designed to promote a mindful state may reduce the resting heart rate (rHR) overtime (Carlson, Speca, Faris, & Patel, 2007; Bell, 2015). Furthermore, mindfulness was previously found to attenuate physiological arousal (Lin, Fisher, Roberts, & Moser, 2016; Brown, Goodman, & Inzlicht, 2012). This raises the paradoxical position that mindfulness could be associated with aggression and offending via a relationship with low rHR or attenuated heart rate responding.

A commonly accepted model which aims to account for the striking relationship between low rHR and offending has emphasised how the rHR rate might reflect low autonomic arousal (Raine, 2002; Raine, Venables, & Mednick, 1997; Raine, 1996; Raine & Venables, 1984). This is assumed to be an aversive state which causes affected individuals to engage in impulsive sensation seeking (Raine, 2002; Portnoy, Raine, Chen, Pardini, Loeber, & Jennings, 2014). Such impulsive and reckless acts might also be associated with poor regulation of emotions (Davidson et al., 2000; Roberton et a., 2014; Herts, McLaughlin, & Hatzenbuehler, 2012). Consequently, expressions of aggression seen in individuals with low rHR would be expected to be of an impulsive type rather than premeditated (Long et al., 2014; Scott, Stepp, & Pilkonis, 2014).

An alternative view at the relationship of rHR and offending would focus on the possibility that certain crimes are premeditated. Low rHR is strongly associated with increased activity of the vagus. Previously published studies have linked this with good emotion regulation and executive function (Smith et al., 2017; Hovland et al., 2012;

Mezzacappa, Kindlon, Saul, & Earls, 1998). This paradoxically suggests that offenders with low rHR's adequately regulate emotions and are well able to plan their activities.

Low levels of arousal, impulsivity and aggression are all associated with psychopathic traits such as meanness or disinhibition (Portnoy & Farrington, 2015; Kyranides, Fanti, Sikki, & Patrick, 2017; Patrick, Fowles, & Krueger, 2009; Douglas, Bore, & Munro, 2012). However, the fearless and unemotional traits which are so characteristic of psychopathic individuals might also be expected to be related to low emotional volatility and imperturbability (Kyranides et al., 2017; Patrick et al., 2009; Vidal, Skeem, & Camp, 2010), and to proactive aggression (Patrick et al., 2009; Cima & Raine, 2009). This arrangement suggests that low rHR may lead to offending behaviours via traits associated with psychopathy.

This thesis sets out to explore the above. Specifically, the relationships between emotion regulation, mindfulness, psychopathic traits, cardiovascular function and aggression are investigated. The initial series of experiments explored how the trait of mindfulness is related to psychopathic and aggressive traits, and to cardiovascular control. The second series of experiments examined the relationship between low rHR, traits associated with offending, and executive function.

**1.2. Organisation of thesis**

The remainder of this first chapter presents a literature review which outlines how emotion regulation is related to some specific biological and psychological characteristics, including cardiovascular physiology, mindfulness, psychopathic traits, aggressiveness, and executive function. The review of literature is then followed by a general methods section and then a series of experimental study chapters. The thesis closes with a discussion of the findings. To ensure clarity some of the less informative correlational analyses performed have not been included in the results section of the experimental chapters. However, for completeness they are presented in Appendix number one.

**1.3 Emotions and emotion regulation**

The concept of emotions refers to subjective experiences and feelings, for example pain, fear and happiness. Early formulations of the concept saw emotions as being distinct from cognitions and sensory perception. However, it is now appreciated that emotions are potently intertwined with cognitions, physiology and the expression of behaviours (Sah, Faber, De Armentia, & Power, 2003).

Evolution has shaped emotions to serve psychobiological adaptation in environmentally relevant situations, such as threat or procreation (Ekman, 1992). Emotions typically have a quick onset, are short-lived and carry characteristics which are specific to the subjective experience, such as facial expression. Emotionally driven behaviour is typically accompanied by physiological reactions. For example, the demands of emotionally induced behaviours can include increased blood flow in specific organs. To facilitate these physiological needs underlying these behaviours, the heart rate will either slow or rise. These emotional characteristics can facilitate immediate organisation of behaviour and increase the chance of survival.

Emotions, irrespective of their diverse types, can be classified as either positive or negative with the term valenced being used to describe this. Lang (1995) argues that this bi-dimensional model of emotions represents two opponent motivational systems. The appetitive motivational system corresponds to the positive emotions; conversely the aversive system corresponds to the negative emotions. The level of activation of either system is referred to as arousal. For example, increased arousal of the aversive motivational system will typically be accompanied by a strong negative emotion (e.g. fear), which may be followed by a behaviour (e.g. active escaping). These motivational systems compete for physiological outputs and are related to heart rate variability, as explained below.

Gross (1998) has argued that in less developed societies strong emotional impulses were potentially adaptive as they promoted survival. However, in modern societies, emotional volatility is generally considered to be less desirable and successful control over emotional and behavioural impulsivity is promoted. Therefore, current social norms regard elevated impulsivity as being associated with maladaptive tendencies such as the expression of aggression (Cross, Copping, & Campbell, 2011).

The ability to control emotional impulses has been frequently associated with emotion regulation. The latter can be described as the ability to modify one’s personal experience of emotion or perception of an emotional event (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Gross, 1998). Psychopathologies such as depression, anxiety, stress (Gross & Muñoz, 1995; Martin & Dahlen, 2005; Sinha, 2008; Barlow et al., 2016; Gross & John, 2003) and substance abuse (Fox, Axelrod, Paliwal, Sleeper, & Sinha, 2007; Fox, Hong, & Sinha, 2008; Xin et al., 2014; Verdejo-García, Bechara, Recknor, & Pérez-García, 2007), as well as offending (Roberton et al., 2014) can often be perceived as originating from a poor ability to effectively regulate emotions.

The popular work of Gross (Gross & Levenson, 1993; Gross & Muñoz, 1995; Gross, 1998; Gross & John, 2003; Sheppes et al., 2014) explains the possible theoretical processes underlying emotion regulation. These processes can influence emotional experience by implementing purposeful cognitive control. The author argues that regulation is guided by five different strategies: situation selection, situation modification, attention deployment, cognitive change, and response modulation. The first refers to approaching or avoiding certain emotion-evoking situations. The second includes active modification of environmental cues to change the impact of a currently experienced situation. Attention deployment consists of strategies that serve to alter the focus of attention toward particular cues. Examples of such processes include distraction, concentration, and rumination. During cognitive change, the capacity to deal with the situation is evaluated and modified by classical defence mechanisms (i.e. denial, isolation, and intellectualisation). Finally, response modulation can refer to controlled changes of physiological, experiential, or behavioural responding.

Two of the most commonly cited emotion regulation strategies are reappraisal and suppression (Gross, 1998; Gross & John, 2003; Goldin, McRae, Ramel, & Gross, 2008). These strategies refer to mechanisms of cognitive change and response modulation, as explained in the previous paragraph. Reappraisal is a process of change in cognitive interpretation of an emotion-evoking situation, whereas suppression is a process of inhibition of emotion-related responses, including physiological arousal. Emotion regulation is negatively linked with aggression. However, this relationship might depend on the type of emotion regulation strategy. According to Gross and John (2003) suppression is related to higher negative affect, and poorer interpersonal functioning and well-being, compared with reappraisal. Accordingly, in a review of studies, suppression has been associated with increases in depressive symptoms over time (Aldao et al., 2010). Therefore, controversially, it may be that suppression, but not reappraisal, is related to emotional lability.

More recent research emphasized successful emotion regulation may be dependent on flexible alternation between available strategies and on the context to which the strategy is applied (Kashdan & Rottenberg, 2010; Bonanno, 2005; Opitz, Gross, & Urry, 2012). This account highlights the premise that effective emotion regulation is a very complex phenomenon. To elucidate the determinants of choosing a specific strategy, Gross and colleagues (Sheppes et al., 2014) investigated the concomitants of applying distraction, an attention regulation strategy, and reappraisal. Their major findings highlighted the process of strategy selection is partly reliant on the intensity of emotion, complexity of the strategy, and short or long-term goal orientation. Furthermore, the authors proposed that the extent to which individuals can flexibly shift between different strategies is dependent on the amount of cognitive resources available at a given moment and that executive control processes are recruited to regulate emotions.

Difficulties in emotion regulation can potentially lead to acts of violence (Davidson et al., 2000). It had been proposed (Gillespie et al., 2012; Day, 2009) that prison-based psychological interventions would benefit from addressing poor emotion regulation, and that respiratory pattern biofeedback, which shares certain features with mindfulness techniques, may exert such benefits (Gillespie et al., 2012). As will be outlined in the following sections, emotion regulation, mindfulness and respiratory biofeedback hold various contextual similarities and this arrangement may facilitate the use of psychological interventions in various problem groups.

### 1.4 The neurobiology of emotion regulation

From a neurobiological perspective, the higher brain structures involved in emotion regulation are the amygdala and the prefrontal cortex (PFC), along with the anterior cingulate cortex (ACC). The amygdala is not a single structure but rather a complex consisting of several discrete nuclei, each of which forms a specific set of connections with other brain structures, and by virtue of this, performs a set of distinctive functions (Sah et al., 2003). Similarly, the PFC can be subdivided into a series of substructures which differ in their function. Some of these substructures are the ventromedial PFC (VMPFC), the orbitofrontal cortex (OFC), and the dorsolateral PFC (DLPFC). The amygdala makes extensive reciprocal connections with the prefrontal cortex. The descending projections from the PFC can be seen as keeping the amygdala in check. Reduced PFC function thus results in increased amygdala activity and the increased potential for the expression of prepotent responses. This arrangement can be observed in individuals diagnosed with borderline personality disorder, characterised by high levels of impulsive and aggressive behaviour (New et al., 2007).

The amygdala is located in the medial parts of the temporal lobe. Broadly speaking, the amygdala can be subdivided into two major components, the basolateral amygdala and the centromedial amygdala (Sah et al., 2003). It has been estimated that the basolateral acts as the major input territory for the amygdala. On the other hand, the centromedial is more characterised by its outputs. Parts of the basolateral complex include the lateral amygdala nuclei and the basal nuclei. The basal nucleus receives particularly strong afferent inputs from the PFC. However, inputs to the lateral nuclei from the thalamus and high level sensory cortical areas were also described. Changes in the strength of these sensory synapses, effected by the process of long term potentiation, are thought to underlie the role of the amygdala in emotional conditioned responses (Cardinal, Parkinson, Hall, & Everitt, 2002).

Much of our understanding of the functional and anatomical organisation of the amygdala has been derived from experimental studies using rodents and sub-human primates. The amygdala is thought to be involved in attributing the value or emotional significance of cortical and subcortical sensory inputs. This is particularly apparent with respect to processing fear related information, though the amygdala also plays an equivalent role with respect to positively valenced stimuli (Rosen & Donley 2006; Weiskrantz, 1956). The central amygdala nuclei are most strongly implicated in the generation of fear responses. However, the basolateral nuclei receive a dopamine input which is involved in the act of attributing salience to stimuli during classical conditioning, a learning process by which a neutral stimulus can become biologically significant. This process is implicated in emotional responding (Cardinal et al., 2002). Importantly, the VMPFC and the ACC can be seen in functional terms as inhibiting the amygdala (Stein et al., 2007). Consequently, failure of the VMPFC causes the amygdala to be released from inhibition and a tendency for behaviours associated with poor emotion regulation can be observed.

Emotional responses in which the amygdala is involved are associated with changes in heart rate and can be accompanied by marked behavioural reactions such as freezing and startle responses. Many of these behavioural and physiological reactions are associated with projections from the central nucleus of the amygdala to structures in the brainstem (see figure 1.1). These brainstem structures include the periaqueductal gray, which is implicated in changes of cardiovascular activity; the parabrachial nucleus, associated with processing of pain; and the nucleus of the solitary tract, which is coupled with the vagal system (Sah et al., 2003). These brainstem structures project to the periphery. This linkage is mediated by the autonomic nervous system (ANS). The role that the ANS plays in modulation of the heart rate and how it relays information back to the cerebral area will be explained in section 1.5.

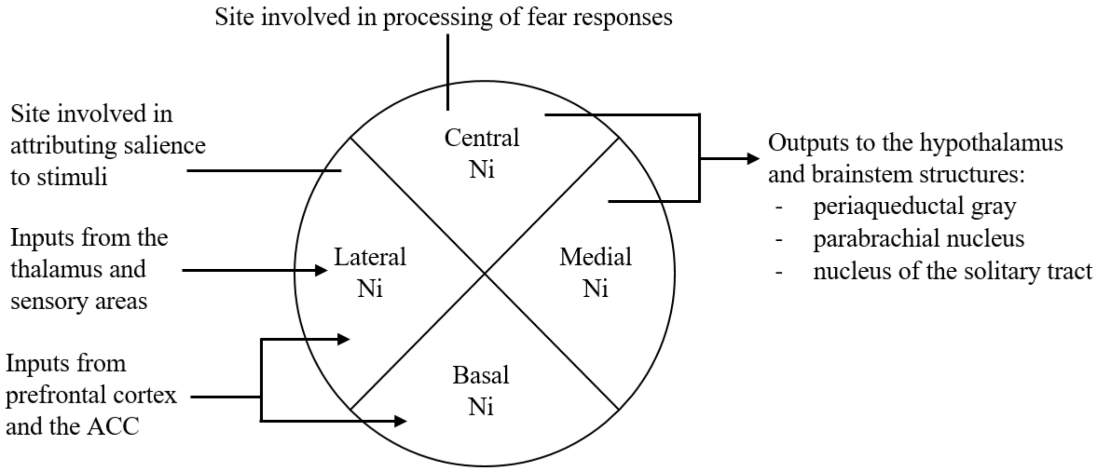



Figure 1.1: Connections and functions of the amygdala nuclei

*Note. Ni – nuclei; ACC – anterior cingulate cortex. Adapted from "Broken Brains" (2014) by I. J. Mitchell.*

Cognitive processes play a substantial role in the process of regulating emotions as discussed in section 1.3 (Ochsner & Gross, 2005; Sheppes et al., 2014). Previous research has associated the functioning of the PFC with a wide range of cognitive processes, including those that are believed to be implicated in emotion regulation (Kohn et al., 2014; Ochsner & Gross, 2005; Cabeza & Nyberg, 2000). Some of these processes may reflect the well-established roles that the PFC plays in executive functions. Executive function refers to a collection of high level cognitive processes, including working memory, planning, attentional set shifting and the inhibition of impulsive responses (Aron, Robbins, & Poldrack, 2004; Bari & Robbins, 2013). For example, greater working memory capacity may be related to successful downregulation of negative emotions (Schmeichel & Demaree, 2010). Moreover, the ability to effectively shift attention may be related to reduced levels of anxiety (Johnson, 2009). Therefore, emotion regulation and executive function appear to be strongly interlinked (Hofmann, Schmeichel, & Baddeley, 2012; Sheppes et al., 2014).

Impairment of the VMPFC is associated with impulsivity, as can be detected using the Porteus maze, and deficits on the IOWA gambling task. This may reflect the VMPFC's role in interpreting the physiological changes that accompany emotional reactions. The VMPFC is continuous with the adjacent OFC. Damage to the OFC can be accompanied by major personality changes, as in the case of Phineas Gage, a railway engineer whose OFC was penetrated by a steel pole in a horrific accident. The OFC, particularly its medial area, is believed to play a significant role in the evaluation of social and emotional cues (Coccaro, Sripada, Yanowitch, & Phan, 2011). By contrast, the DLPFC plays fundamental roles in high level cognitive actions including abstract reasoning, planning and working memory (Royall et al. 2002; Goldman-Rakic, 1995). Activation of the DLPFC is commonly observed during a n-back paradigm (Jaeggi et al., 2003). The quality of functional and structural connectivity between the PFC substructures and the amygdalar nuclei has a key impact on emotional responding (Ochsner & Gross, 2005; Banks, Eddy, Angstadt, Nathan, & Phan, 2007; Öhman, 2005).

Strongly related to the PFC, but not strictly part of it, is the anterior cingulate cortex (ACC). There are extensive connections between the ACC and regions of the PFC, including the DLPFC and the VMPFC (Beckmann, Johansen-Berg, & Rushworth, 2009; Margulies et al., 2007). The cingulate can be thought of as a relatively primitive form of cerebral cortex which lines substantial parts of the medial surface of the cerebral hemispheres. The cingulum is routinely subdivided into the ACC and the posterior cingulate (Devinsky, Morrell, & Vogt, 1995). The ACC in turn can often be considered to be composed of a dorsal cognitive part and a ventral affective portion. The ACC is thought to be involved in error detection and imaging studies have shown it to be active during Stroop tasks (Yuan & Raz, 2014). Heightened ACC activation has previously been observed to inhibit amygdala responses (Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Petersen & Posner, 2012; Wadlinger & Isaacowitz, 2011; Ochsner & Gross, 2005; Bush, Luu, & Posner, 2000). Projections from the DLPFC to the ACC may represent a route by which the former can moderate amygdala activity (Kohn et al., 2014; Beckmann et al., 2009; Margulies et al., 2007)

It has been recently proposed by Kohn et al., (2014) that certain non-prefrontal cortical regions may be involved in final steps of the emotion regulation process. These regions included the superior temporal gyrus, associated with language processes, the pre-supplementary motor area, related to control of movement, and the angular gyrus, related to various social processed and imagery. Furthermore, Kohn et al., (2014) propossed that the anterior middle cingulate gyrus may act as a hub for assimilating information from the various regions implicated in emotion regulation.

Emotional responses are typically accompanied by physiological reactions in the periphery. The ANS can act as a mediator between the cerebral areas discussed in this section and the body’s internal organs. The potential anatomical organisation of how information might be conveyed from the brain to the heart and back will be introduced in section 1.5.

## 1.5 Cardiovascular control, the autonomic nervous system and brain function

Emotional responses are typically accompanied by physiological changes as explained in sections 1.3 and 1.4. These changes are mediated by the autonomic nervous system (ANS), that is, the elements of the nervous system which form extensive neural links between the internal organs, including the heart, and the brain. The neural connections from the viscera provide the brain with vital information about the physiological state of the body. Based on this data, the brain can send information back to the viscera and adjust the activity of target organs to current demands. For example, an imminent risk of being physically harmed may be accompanied by changes in cardiovascular system. This may be followed by increased blood flow to the muscles to increase the chance of survival through either ’fight’ or ‘flight’. These physiological changes can be associated with complex behaviours which accompany emotional and cognitive responses. However, the precise neuroanatomical pathways of this heart-brain-behaviour arrangement are still to be fully elucidated.

Organs, including the heart, usually receive dual innervation from the ANS. The ANS can be divided into two divisions, the sympathetic division and the parasympathetic division (Berntson et al., 1997). When the former operates, it tends to lead to increased expenditure of energy whereas the increase activity in the latter is linked with relaxation and conservation of resources.

The heart rate at rest is predominantly controlled via the vagus nerve of the parasympathetic nervous system. The vagal input to the heart descends from the nucleus ambiguous of the medulla oblongata located in the brainstem. The descending vagal preganglionic fibres travel to the heart where short postganglionic fibres innervate the sinoatrial node (Critchley, 2005). The sinoatrial node can be described as a group of cells able to produce electrical impulses causing the heart to contract. The slowing of contractions is achieved by release of acetylcholine from the vagal pre and postganglionic synapses. This effect can be diminished with increased activity of the noradrenaline based sympathetic innervations to the heart. Therefore, the rate of the heart is dictated by the interplay of the two subsystems of the ANS.

Various researchers, most notably Julian Thayer and Hugo Critchley (Smith et al., 2017; Critchley & Harrison 2013), have championed research concerning autonomic influences on emotion, cognition and behaviour. Their work forms the cornerstone of models of the neural networks by which the heart and brain are interconnected.

Briefly, according to these models, efferent information from the heart concerning its physiological state is conveyed to the nucleus of the solitary tract (NTS) of the brainstem by the vagus. The NTS is also involved in control of breathing. The NTS in turn sends efferents to the nucleus ambiguous which gives rise to the vagal parasympathetic input to the heart. Other brainstem structures to which the NTS is reciprocally connected include the periaqueductal gray (PAG), and the parabrachial nucleus. The NTS also projects to the hypothalamus, a limbic structure which plays a critical role in maintaining homeostasis. The PAG, parabrachial nucleus and the hypothalamus relay visceral related information to the basal forebrain and to the amygdala. Equivalent information is also sent to the thalamus from where it is relayed to parts of the cerebral cortex, including the PFC. As discussed in section 1.4, the PFC and the amygdala make strong contributions to the process of the generation and regulation of emotions. Activity in all the mentioned brain structures contributes to the strength of the descending vagal control over the rate of the heart.

The anatomical arrangement outlined in the preceding paragraph results in a situation whereby prefrontal functioning is affected by the heart rate and this in turn can be influenced by the pattern of breathing. Breathing out results in minor increases in the frequency of vagal nerve discharges (Yasuma & Hayano, 2004; Grossman & Kollai, 1993). Consequently, expiration is associated with a short duration slowing of the heart rate. This physiological phenomenon is referred to as the respiratory sinus arrhythmia. A slow-paced pattern of breathing is associated with a stronger vagal nerve response and thus an exaggerated slowing of the heart rate (Grossman & Taylor, 2007). This increases the variability in the interbeat intervals, or heart rate variability (HRV). HRV and HR, not surprisingly, are closely connected to each other, with the values of these two parameters typically being highly negatively correlated. Thus, emotional reactions which result in increased heart rate simultaneously cause a concurrent decrease in HRV.

Previous research emphasized that low HRV is associated with negative psychological characteristics (Kemp & Quintana, 2013; Thayer & Lane, 2009), including depression (Carney et al., 2001; Gorman & Sloan, 2000), phobic anxiety (Kawachi, Sparrow, Vokonas, & Weiss, 1995; Friedman & Thayer, 1997), and stress (Vrijkotte, Van Doornen, & De Geus, 2000; Hall et al., 2004). Conversely, elevated levels of HRV had been positively linked with good emotion regulation (Hovland et al., 2012; Mezzacappa et al., 1998; Ruiz-Padial, Sollers, Vila, & Thayer, 2003; Thayer & Lane, 2009; Thayer & Lane, 2000; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012; Thayer, Hansen, Saus-Rose, & Johnsen, 2009), and good physical fitness (Buchheit & Gindre, 2006; Oliveira, Barker, Wilkinson, Abbott, & Williams, 2017).

Various studies have emphasized how HRV biofeedback techniques can effectively reduce symptoms of depression (Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009; Karavidas et al., 2007; Nolan et al., 2005), anxiety (Paul & Garg, 2012; Renier, 2008; Bradley et al., 2010), stress (Nolan et al., 2005), and anger (Renier, 2008). Furthermore, HRV biofeedback exercises may lead to long-lasting improvements in baseline HRV values (Wheat & Larkin, 2010; Zucker et al., 2009; Nolan et al., 2005, Paul & Garg, 2012, Renier, 2008). For example, Zucker et al. (2009) showed that a four-week-long HRV biofeedback intervention lowered scores for depression and increased baseline HRV values in a sample of community based individuals receiving treatment for substance misuse disorders.

HRV has previously been associated with executive functions. Several studies have indicated that higher HRV may be related to better performance on tasks that assess updating and attentional shifting (Hansen, Johnsen, & Thayer, 2009; Hansen, Johnsen, & Thayer, 2003;

Hovland et al., 2012; Stenfors, Hanson, Theorell, & Osika, 2016). This suggests that activity in dorsal and lateral cortical areas could be related to HRV. However, HRV has also been associated with inhibition of dominant responses (Zahn et al., 2016; Gillie, Vasey, & Thayer, 2014). This arrangement suggests the involvement of ventral and medial parts of the PFC. Interestingly, a study by Chang et al., (2013) indicated that the connectivity between the DLPFC, ACC, limbic and brainstem structures is heightened during states of elevated HRV. This accordingly suggests that executive working memory and Stroop task-related inhibition are influenced by HRV. This account is supported by previously published studies (Albinet, Abou-Dest, André, & Audiffren, 2016; Jennings, Allen, Gianaros, Thayer, & Manuck, 2015; Hansen et al., 2009; Hansen et al., 2003). However, the link between HRV and executive functions may be weakened if demographic covariates are taken into consideration (Kimhy et al., 2013; Stenfors et al., 2016). These studies collectively highlight the need for further research in the relationships.

As mentioned in the paragraphs above, the central and the autonomic nervous system can actively participate in the regulation of cardiovascular activity. It is well established that exposure to salient stimuli is associated with phasic changes in cardiovascular activity. Various studies (Bradley, Keil, & Lang, 2012; Bradley, 2009; Stanger, Kavussanu, Willoughby, & Ring, 2012; Azevedo et al., 2005; Lang & Bradley, 2010; Palomba, Angrilli, & Mini, 1997) have demonstrated that heart rate initially decelerates prominently in response to emotionally valenced static images. The heart rate returns to pre-exposure values after several seconds, irrespective of the duration of static images. The initial cardiac deceleration can be interpreted as an attentional startle response. The deceleration is greater when negative images are viewed, in comparison to pleasant and neutral images (Azevedo et al., 2005; Bradley, 2009; Palomba et al., 1997). Conversely, Bradley (2009) emphasized that less threatening scenes do not require excessive attentional processing, which consequently results in milder cardiac deceleration. Therefore, cardiac deceleration can be seen as representing a physiological measure of emotional valence and arousal (Lang, 1995; Palomba et al., 1997).

The cardiac deceleration, in addition to being influenced by the valence and arousal of the stimulus, is related to the proximity of the stimulus and to some personality traits. Thus, the deceleration is generally evident when a threat is distant. For example, together with the slowing of the heart, freezing was observed when individuals were exposed to distressing static and motion images (Azevedo et al., 2005, Facchinetti, Imbiriba, Azevedo, Vargas, & Volchan, 2006; Vila et al., 2007). Conversely, as the danger reaches a threshold of imminent confrontation, or the person exposed to the stimuli has high level of anxiety, or a specific phobia, a subsequent rise in cardiac activity is observed (Pittig, Arch, Lam, & Craske, 2013; Thayer et al., 2000; Palomba, Sarlo, Angrilli, Mini, & Stegagno, 2000; Fredrikson, 1981). This latter response would be accompanied by active avoidance, such as escaping the situation.

### 1.6 Mindfulness and emotion regulation

Recent work has explored the potential relationships between emotion regulation and mindfulness. The detailed relationship between these psychological characteristics is in need of exploration.

Mindfulness, as previously noted, can be described as the cultivation of awareness to the present moment and non-judgemental acceptance of mental processes, including emotions (Shapiro, Carlson, Astin, & Freedman, 2006; Bishop et al., 2004). Thus, mindfulness can be defined by two components, namely attentional self-regulation, and a specific mental approach to personal experience. The attentional component of mindfulness refers to attending to one’s immediate experience by focusing on the here and now and observing internal and external stimuli. This is assumed to help to develop a greater insight into personal experience of the present. The concept of being non-judgemental is characterized by acceptance, curiosity, and openness. Such a state would be associated with enabling experiences to fade away, and a capacity to be non-striving towards instant positive reward.

Mindfulness, however, can be regarded as having more than two components. Baer et al., (2008) developed a five-factor model of mindfulness. These factors are observing, describing, acting with awareness, non-judging, non-reacting. The observe factor refers to attending to personal sensations, such as emotions, cognitions, emotions, and sights. Describe denotes labelling personal events with words. Acting with awareness means attending to the present without getting distracted. Non-judge refers to taking a relaxed approach toward thoughts and feelings. Non-react denotes allowing thoughts and feelings flow, without getting caught up in them.

Mindfulness has been incorporated into various psychological therapies, including Cognitive Behaviour Therapy (Singh, Lancioni, Wahler, Winton, & Singh, 2008), Dialectical Behaviour Therapy (Robins & Chapman, 2004), and Mindfulness Based Stress Reduction (Kabat-Zinn, 2003). These therapies are reputed to be effective in reducing symptoms of depression and anxiety (Hofman, Sawyer, Witt, & Oh, 2010; Grossman, Niemann, Schmidt, & Walach 2004) and may contribute to treatment of substance misuse disorders (Zgierska et al., 2010; Bowen et al., 2006; Bowen et al., 2014). More recently mindfulness has been used as an adjunct to therapeutic approaches to the treatment of some offender groups (Malouf, Youman, Stuewig, Witt, & Tangney, 2017; Baker, Young, & Wolfe, 2016). Accordingly, there has been a drive to practice mindfulness techniques in order for individuals to increase their trait mindfulness. Indeed, research has demonstrated that a relatively stable psychological trait-like quality manifests with practicing mindfulness overtime (Thompson & Waltz, 2007).

Some researchers (Chambers, Gullone, & Allen, 2009; Goldin & Gross, 2010; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007; Kabat-Zinn, 2003; Bishop et al., 2004, Keng, Smoski, & Robins, 2011) argue that mindfulness may hold contextual similarities with emotion regulation strategies. Thus, mindfulness based techniques have been previously used to elevate levels of emotion regulation (Baer et al., 2006; Arch & Craske, 2006; Goldin & Gross, 2010). Elevated levels of both emotion regulation and mindfulness seem to link with positive psychological wellbeing (Gross & John, 2003; Gross & Muñoz, 1995; Brown & Ryan, 2003; Garland et al., 2010; Jain et al., 2007). Similarly, poor emotion regulation (Gross & Muñoz, 1995; Martin & Dahlen, 2005) and low levels of mindfulness (Brown & Ryan, 2003; Goyal et al., 2014) have previously been related to negative psychological characteristics, such as depression, anxiety, and stress. Moreover, high trait mindfulness has been related to elevated levels of self-esteem (Brown & Ryan, 2003), high positive affect (Garland et al., 2010; Jain et al., 2007; Davidson et al., 2003), and empathy (Lamothe, Rondeau, Malboeuf-Hurtubise, Duval, & Sultan, 2016).

The contextual similarities between mindfulness and emotion regulation may be linked to certain higher order cognitive mechanisms. Some researchers (Tang & Leve, 2016; Bishop et al., 2004) have emphasized that mindfulness is associated with improved regulatory mechanisms of attention and emotion. More specifically, elevated levels of trait mindfulness may entail sustained concentration, fluent shifting of focus, and inhibition of excessive elaboration of thoughts, emotions, and sensations (Desbordes et al., 2012; Hayes & Feldman, 2004; Jain et al., 2007; Jha, Krompinger, & Baime, 2007; Morrison & Jha, 2015; Tang & Posner, 2009). The well-established model of attention by Petersen and Posner (2012) suggests that attention can be broken down into three components. These are alerting, orienting and executive processes. There is evidence for a link with mindfulness and all three components (Jha et al., 2007). As it was explained in sections 1.3 and 1.4 attentional processes play a significant role in the regulation of emotions (Ochsner & Gross, 2005; Sheppes et al., 2014). This indicates that both emotion regulation and mindfulness may exert effects via higher order brain functions.

However, Chambers et al. (2009) argue that mindfulness may be incompatible with certain emotion regulation strategies, such as reappraisal and suppression. This is because reappraisal may be associated with experiential avoidance of emotional experiences, whereas mindfulness is closely linked with acceptance of emotions. Similarly, suppression may be related to rejection of emotions, whereas mindfulness cultivates noncritical awareness of emotions. Classic emotion regulation strategies championed by Gross and colleagues seem to be focused on manipulation of emotional states when they arise. This appears to be inherently different to the idea of non-judgemental attentiveness promoted by mindfulness theorists (Kabat-Zinn, 2003).

Various emotion regulation strategies may be differentially related to aggression as explained in section 1.3. Mindfulness was found to have a negative relationship with aggression (Borders et al., 2010; Heppner et al., 2008). This potential arrangement may result from reduced both angry rumination and hostile attribution bias observed in mindful individuals. Consequently, mindfulness techniques have been suggested as forming the therapeutic underpinning of treatments for certain types of offender (Gillespie et al., 2012; Singh et al., 2008). However, similar to emotion regulation, the various facets of mindfulness may be differently related to maladaptive traits. For example, the facets nonjudging and nonreacting to inner experience may signify detachment from emotional experience, which can be associated with certain psychopathic traits (Skeem, Johansson, Andershed, Kerr, & Louden, 2007; Levenson, Kiehl, & Fitzpatrick, 1995). Therefore, the detailed relationship of emotion regulation, mindfulness, and antisocial tendencies could vary amongst the various subscales of these traits.

As stated in section 1.3, all types of emotions can be categorised on a two-dimensional spectrum of valence and arousal (Lang, 1995). Furthermore, emotional responses are typically accompanied by physiological reactions. Various studies indicate that mindfulness affects these aspects of emotional responding. Thus, mindfulness increases scores for self report valence toward more positive emotional states (Remmers, Topolinski, & Koole, 2016; Cameron & Fredrickson, 2015; Ho, Sun, Ting, Chan, & Lee, 2015; Taylor et al., 2011; Goldin & Gross, 2010) but attenuates physiological arousal, irrespective of whether an emotion is negative or positive (Lin et al., 2016; Brown et al., 2012). This diminished emotional responding may reflect reduced amygdalar activation in response to affective cues (Taylor et al., 2011; Lutz et al., 2013).

The contextual similarities between mindfulness and emotion regulation may reflect the activity of certain brain structures. Imaging studies have suggested that the ACC in particular becomes active during mindfulness meditation, whereas trait mindfulness has been related to neural activity in circuits interconnecting the PFC, ACC and amygdala (Tang, Hölzel, & Posner, 2015; Tang & Leve, 2016). These brain systems are most strongly implicated in regulation of emotions (Kohn et al., 2014; Ochsner & Gross, 2005; Etkin, Egner, & Kalisch, 2011; Petersen & Posner, 2012; Bush et al., 2000). As discussed in section 1.4, the heightened ACC activity can lead to inhibition of amygdala responses which are in certain circumstances linked to negative emotionality. This neurological arrangement may be implicated in positive psychological effects frequently associated with increased trait mindfulness.

The way in which mindfulness impacts upon brain function, however, is influenced by the practitioner's experience with meditation. In a review of studies Tang et al., (2015) noted that novice meditators showed increased task related activation of the dorsomedial, dorsolateral, ventrolateral, and orbitofrontal prefrontal cortical (PFC) areas, and increased resting activity in the anterior cingulate cortex (ACC) and the posterior cingulate cortex (PCC). Conversely, experienced meditators, compared to controls, showed less activation in the PCC, and the ventrolateral, dorsolateral, and medial PFC (Lutz, Brühl, Scheerer, Jäncke, & Herwig, 2016b; Tang et al., 2015). However, the activity of the ACC is increased both in experts as it is in novice meditators (Tang & Leve, 2016; Tang et al., 2015). A putative explanation for these different patterns of activity is that novice meditators actively recruit "top-down" cognitive processes associated with increased mental effort. Conversely, experts rely more on "bottom-up" processes which are linked with automatization of responses (Chiesa, Serretti, & Jakobsen, 2013).

Interestingly, decreased activation in the medial PFC and the PCC, which can be observed in expert meditators, has previously been related to diminished self-referential processing. This diminished processing supports self-detachment rather than affective or subjective interpretation of personal experience (Lutz et al., 2016a; Brewer et al., 2011; Hölzel et al., 2011; Farb et al., 2007; Gusnard, Akbudak, Shulman, & Raichle, 2001). In mindful individuals, self-detachment may serve an adaptive role, whereby a more present centered approach allows for effective adaptation to constantly changing circumstances (Shapiro et al., 2006). However, elevated psychopathic tendencies can also be related to various forms of self-detachment, including emotional (Patrick, 2014; Hancock, Woodworth,

& Porter, 2013). In the case of psychopathic traits self-detachment can be considered as socially maladaptive and may be linked to the reduced ability to perceive emotional cues (Patrick, 2014). This chain of reasoning suggests that some features of mindfulness may be associated with certain undesirable tendencies as suggested in the paragraph above.

Mindfulness practices frequently involve the regulation of breathing such that the individual adopts a pattern of slow regular breathing and pays closer attention to the respiratory pattern. This raises the possibility that mindfulness could exert some of its psychological positive effects via an action on HRV. Indeed, previous studies (Arch & Craske, 2006; Goldin & Gross, 2010; Broderick, 2005; Praissman, 2008) have emphasized the procedural similarities between mindfulness and breathing biofeedback techniques, as both focus attention to the pattern of breathing. The study by Arch & Craske, (2006) showed how a 15 minutes mindful breathing session enhanced emotion regulation in response to emotionally valenced pictures in a group of undergraduate students. Thus, the participants in the breathing group rated neutral images as more positive and were more willing to view negative pictures than participants in an unfocused attention group.

In another study, Farb, Segal, and Anderson (2012) showed that mindfulness breathing exercises activated the areas of the brain that are involved in interoceptive awareness, that is, the awareness of the internal state of physiological arousal. The accuracy of perceptions of internal physiological states may consequently be associated with mindfulness levels. The areas of the brain that are known to be involved in interoceptive awareness are the insula and medial prefrontal cortices. Previous studies have shown increased activity in these brain regions to be related to meditation practices, such as mindfulness (Brewer, et al., 2011; Farb et al., 2007; Kilpatrick et al., 2011; Lazar et al., 2006).

## 1.7 Aggression

Deficiencies in the ability to regulate emotions can often be linked with the emergence of aggressive behaviour. Equally, elevated emotion regulation had been associated with high levels of trait mindfulness. Therefore, elevated trait mindfulness may be related to reduced tendencies to aggress.

Aggression can be defined as purposeful behaviour aimed at harming another person either physically or psychologically. The term violence is commonly used to describe physically injurious acts of aggression (Flannery, Vazsonyi, & Waldman, 2007). Therefore, aggression can be thought of as a broad term to describe harmful behaviour, whereas violence is a narrower term used to describe aggressive acts that result in bodily injury.

Aggressive behaviours constitute a serious problem to modern societies as they are disruptive and harmful to both the victim and perpetrator. Over 1.3 million violent incidents were reported in England and Wales during year ending December 2016 (Office for National Statistics, 2016). The current section aims to outline some psychological and biological models of aggressive behaviour. Two types of aggression will be described and related to psychological characteristics.

There are many psychological models of aggression. These include, Lorenz's etiological model (Lorenz, 2005; Eley, Lichtenstein, & Moffitt, 2003) which purports natural selection acts to promote aggression because it increases the possibility of gene survival. This inherent biological model sees aggression as being adaptive as it helps to obtain resources necessary for survival. On the other hand, the frustration – aggression theory indicates that aggression is preceded by frustration caused by failure to achieve ones' personal targets (Dollard, Miller, Doob, Mowrer, & Sears, 1939; Pawliczek et al., 2013). According to this model the occurrence of aggression depends on the persons' cognitions and other mediating factors, including environmental stimuli (Baron & Richardson 1994; Berkowitz, 1993). A third model, based on social learning theory, proposes that aggressive acts are acquired via learning processes (Bandura, 1978). This model posits that modelling an aggressive behaviour will become more probable when consequences of the modelled behaviour are rewarded. Furthermore, skills that can limit aggressive behaviour can be acquired through learning (Bandura, 2001). Such skills may include cognitive regulation of emotions or mindfulness.

Aggressive behaviours can be classified into two major subtypes, proactive and reactive (Cima, Raine, Meesters, & Popma, 2013; Polman, de Castro, Koops, van Boxtel, & Merk, 2007). The former can emerge without any obvious antecedent. This form of aggression typically requires the presence of a plan (Ellis, Weiss, & Lochman, 2009; Stanford, Houston, Villemarette-Pittman, & Greve, 2003). Proactive aggression has also been termed instrumental because it is often aimed at obtaining a preferred outcome or to coerce others. By contrast, reactive aggression results from interpretation of someone's intentions as being hostile and provocative (Dodge et al., 2015; Kempes, Matthys, De Vries, & Van Engeland, 2005). Reactive aggression can sometimes be considered to be impulsive as the person inflicting the act appears to have little or no foresight into the behaviour. Proactive and reactive aggression differentially relate to conduct problems. The former is more related to criminal, including violent, behaviour than the latter (Vitaro, Gendreau, Tremblay, & Oligny, 1998; Brendgen, Vitaro, Tremblay, & Lavoie, 2001; Raine et al., 2006). Conversely, reactive aggression, as opposed to proactive aggression, can be linked to difficulties in emotion regulation (Card & Little, 2006; Marsee & Frick, 2007; Shields & Cicchetti, 1998).

The differential expression of the two subtypes of aggression may be associated with various personality traits. Two of the most pertinent are psychopathic traits and anxiety.

### 1.7.1 Aggression and psychopathic traits

The concept of psychopathy is intertwined with problems with emotion regulation and aggression. Psychopathy refers to as a severe personality disorder characterised by high levels of criminality and aggression. The modern concept was propagated by Hervey Cleckley in his influential book, The Mask of Sanity (Cleckley, 1955). This work contains descriptions of psychiatric patients who were said to be superficially charming and intelligent, but manipulative, aggressive and devoid of human emotions. The prevalence of psychopathy in UK based prisons is approximated at 7.5% (Coid et al., 2009). Though hard to accurately estimate, it is thought that the prevalence of psychopathy in the general population is much lower.

The archetypal psychopath is widely assumed to be characterised by callous, unemotional and manipulative traits. These features have been said to be features of primary psychopaths. By contrast, secondary psychopaths are thought to be emotionally volatile and impulsive (Cornell et al., 1996). Primary psychopathy is associated with reactive aggression and uniquely with proactive aggression. Conversely, secondary psychopaths are more strongly associated with reactive aggression, but less with proactive aggression, and may be accompanied by poor impulse control and increased anxious feelings (Cima et al., 2013; Patrick et al., 2009; Skeem et al., 2007).

Individuals who possess marked psychopathic characteristics but have avoided imprisonment are sometimes labelled successful psychopaths (Gao & Raine, 2010). The claim that psychopathic traits can be observed in the general population has received growing attention. Research has shown that, in non-clinical samples, scores for psychopathic tendencies form negative relationships with scores for socially desirable characteristics (Marcus, John, & Edens, 2004).

Research that focuses on non-clinical samples treats psychopathy as a multifactorial trait rather than a severe personality disorder. The idea of trait continuity has been further supported by neurological studies which indicate that brain abnormalities in non-offending individuals with high psychopathic traits seem to mirror those of clinical samples (Seara-Cardoso & Viding, 2015). Hence, although psychopathy seems to be a predominant feature in prison populations, it is observable in the general population in the continuous form of a psychological multifactorial trait. This implies that non-offending individuals with high scores on psychopathic traits may have emotion regulation problems.

Perhaps the most cited psychopathy assessment tool is the Psychopathy Checklist – Revised. (PCL-R) (Hare, 2003). This instrument is commonly used to determine whether an individual can be diagnosed as a psychopath. The PCL-R treats psychopathy as a multifactorial construct consisting of two main factors, each composed of two facets. The first factor is thus further divided into an interpersonal facet and an affective facet. The second factor is divided into lifestyle and antisocial features of the disorder. Higher scores on Factor 1, in contrast with Factor 2, are associated with lower levels of anxiety, fewer symptoms of mental disorder, and better interpersonal skills, such as assertiveness (Skeem et al., 2007, Hale, Goldstein, Abramowitz, Calamari, & Kosson, 2004; Visser, Ashton, & Pozzebon, 2012). Similar results have also been shown in relation to self-report measures of psychopathy in offender and non-offender samples (Gillespie et al., 2015). This suggests that primary psychopathic traits, contrary to secondary psychopathic traits, may be linked with better emotion regulation.

Psychopathy has been linked with high levels of offending and aggressive behaviour. However, the relationship of psychopathic traits to aggression is complex. Certain psychopathic traits have previously been more strongly linked with either premeditated or impulsive aggression (Cornell et al., 1996; Patrick et al., 2009). For example, meanness, characterised by callousness and a lack of empathy, is more closely related to premeditated aggression, whereas disinhibition, characterized by lack of foresight and impulsivity, is more often linked with impulsive aggression. Boldness, however, is characterised by emotional resiliency and venturesomeness, a carefully planned form of stimulation seeking behaviour can also be associated with an increased level of fearlessness and proactive aggression (Patrick et al., 2009).

It has been well evidenced that heightened psychopathic traits are linked with neurological deficits in processing of emotions. These problems include difficulties in the recognition of facial emotional expressions in others, in particular the expressions of fear (Blair et al., 2004). This impairment potentially leaves the affected individual to persist with fear evoking behaviours even when the victim shows behavioural signs of distress.

Another deficit linked to psychopathic tendencies is the inability to form an association between a neutral stimulus and an aversive stimulus, that is, to learn via aversive conditioning (Flor, Birbaumer, Hermann, Ziegler, & Patrick, 2002; Birbaumer et al., 2005). Consequently, individuals with elevated psychopathic traits are unable to form an association between negative feelings and socially undesirable responses. These problems appear to be strongly associated with processing of fear responses that are mediated via the amygdala nucleus as detailed in Chapter 1.4. Indeed, there is preliminary evidence that suggests high scores on psychopathic tendencies are related to reduced amygdala volume (Tiihonen et al., 2000) and attenuated amygdala responses to fear (Marsh et al., 2008, Jones, Laurens, Herba, Barker, & Viding, 2009) and words of various valence levels (Kiehl et al., 2001).

The generation of emotions appears to simultaneously evoke a series of physiological responses as discussed in sections 1.3 and 1.4. These can include skin conductance responses, startle responses, and cardiovascular activity changes (Bradley et al., 1993). Skin conductance responses are related to short bursts in sympathetic activity typically evoked in a laboratory condition by aversive stimuli. In a frequently cited study, psychopathic offenders, compared to healthy non-offenders, were seen to generate substantially weaker skin conductance responses during an aversive conditioning paradigm (Flor et al., 2002; Birbaumer et al., 2005). Consistent with this pattern, individuals with psychopathy showed deficient skin conductance responding to emotional pictures of various magnitudes of valence (Herpertz et al., 2001). A similar blunting of physiological responding was observed for startle blink magnitude (Benning, Patrick, & Iacono, 2005; Herpertz et al., 2001). These findings suggest that psychopathy is related to arousal deficits, especially when responding to emotion evoking stimuli.

An alternative explanation to deficits linked with psychopathy has been proposed by Newman and colleagues (Lorenz & Newman, 2002; Newman, Curtin, Bertsch, & Baskin-Sommers, 2010). According to this model the characteristic low levels of anxiety and fear seen in psychopathy are related to exaggerated attentional processing. In this view psychopaths excessively focus on their primary goals and so simultaneously fail to process information peripheral to their focus of attention. It has been suggested that the exaggerated focus is linked with enhanced activation of the PFC regions implicated in attentional processing (Larson et al., 2013). This study demonstrated that psychopathic offenders, relative to non-psychopathic offenders, recruited the PFC to a greater extent and that the strength of this activation was inversely related to amygdala activation in response to threat-related stimuli. Results of these studies imply that the exaggerated attention, as seen in low-anxious psychopaths, affects the capacity to recruit the amygdala when the need to process emotion arises. However, this alternative explanation of the underlying mechanisms of psychopathic disorder remains under scrutiny (Blair & Mitchell, 2009).

### 1.7.2 Aggression and anxiety

It was argued in sections 1.3 and 1.6 that mindfulness and emotion regulation may protect individuals from committing acts of aggression and are inversely related to anxiety. High trait anxiety, however, has previously been assumed to protect individuals from perpetration of aggressive behaviour. According to DeWall, Buckner, Lambert, Cohen, and Fincham (2010) more socially anxious students, predominantly female, have less positive attitudes towards behaving aggressively against their intimate partners. Moreover, they are less prone to behave aggressively towards an unknown person. This may stem from elevated concerns about negative social evaluation, commonly present in social anxiety disorder.

However, recent studies have shown that anxiety can be positively related to high levels of aggression. Consequently, attempts to increase anxiety in offenders may paradoxically result in them becoming more aggressive. In a study by Spielberger, Gorsuch, Lushene, Vagg and Jacobs (1983), prison inmates were found to have higher mean trait anxiety scores compared to a sample of working adults. Moreover, high anxiety and disruptive behaviour disorders (e.g. conduct disorder) co-occur regularly in children and adolescent samples (Bubier & Drabick, 2009). These authors propose that the reactive type of aggression is strongly bounded with heightened anxiety. This conclusion is in keeping with secondary psychopathic traits being linked to impulsivity, anxiety, and high levels of reactive aggression.

A third model of the relationship between anxiety and aggression stresses that both high and low levels of anxiety can be related to aggression. In a study by Ben-Porath, and Taylor (2002), male participants were assigned to an experimental or a control group and given either diazepam (an anxiolytic drug) or a placebo. Both groups were provoked to evoke aggressive behaviour. Participants in the diazepam condition administered maximum electric shocks of maximum voltage more often than participant in the control condition. Therefore, it may be that both high and low levels of anxiety can predispose or potentiate aggressive behaviours. Indeed, this pattern was previously observed in rodents selectively bred for low and high anxiety-related behaviours (Neumann, Veenema, & Beiderbeck, 2010). Thus, the male rodents that were selected for high anxiety-related behaviours and those that were low in anxiety-related behaviours showed elevated aggression compared with non-selected rats. This is also in keeping with primary psychopaths being low-anxious and aggressive. However, such an arrangement undermines the proposition that high levels of emotion regulation and mindfulness are linked with reduced aggressiveness.

### 1.7.3 Neurobiology of reactive aggression

The neurobiology of trait aggressiveness appears to be underpinned by brain structures related to emotion regulation, with much attention being paid to the role of the amygdala (Davidson et al., 2000). Reviews (Rosell & Siever, 2015; Siever, 2008; Nelson & Trainor, 2007; Coccaro et al., 2011) of morphological and functional brain imaging studies have suggested that there may be amygdala abnormalities in individuals prone to reactive aggression. These reviews have indicated that trait reactive aggression is related to reduced volume in the amygdala, lower resting activity, and phasic increases in activity in response to both aggressive tasks and images of neutral and fearful faces. A preliminary study by Gopal et al., (2013) suggested that in psychiatric patients the reduction in amygdala volume may be specific to the left dorsal nuclei.

The amygdala has extensive reciprocal connections with the prefrontal cortical areas, as discussed in section 1.4. Early imaging studies emphasized that VMPFC metabolic activity is related to aggression (Soloff, Meltzer, Greer, Constantine, & Kelly, 2000). However, recent studies postulated that impulsivity reflects impaired functional connections between OFC and amygdala (Coccaro et al., 2011; Winstanley, Theobald, Cardinal, & Robbins; 2004). This view receives tentative support from imaging studies which have suggested that reductions in the volume of the left OFC gray matter and right ACC are associated with aggressive traits (Gansler et al., 2009; Antonucci et al., 2006; Boes, Tranel, Anderson, & Nopoulos, 2008; Ducharme et al., 2011). Furthermore, imaging studies have reported the typically observed negative correlation between OFC and amygdala activation during viewing of fearful faces was non-existent in impulsive, aggressive individuals (Coccaro, McCloskey, Fitzgerald, & Phan, 2007).

The PFC has also been shown to be differentially activated in impulsive individuals. Thus New et al., (2009) showed that resting glucose metabolic rate was lower in the OFC of impulsive participants compared to controls. However, the activity of the OFC and the amygdala increased in the impulsive group following a provocation whereas as it decreased in the control participants. Simultaneously, increased activity in the dorsal areas of the PFC was observed for the control group only. These differences suggest that impulsive individuals have impaired top-down cognitive control of emotions.

The neurobiological mechanisms underlying proactive aggression are less well established than those for reactive aggression. Perhaps the most influential view is encompassed in the violence inhibition model (VIM) of Blair (2001). In this model, the reactive and proactive types of aggression can be characterised by different patterns of neurocognitive functioning. Proactive aggression is associated with the diminished ability to attribute salience to stimuli during fear conditioning. Evidence in support of this model can be seen in the research by Lozier, Cardinale, VanMeter, and Marsh (2014). This group studied conduct problem adolescents who had various intensities of callous and unemotional traits. The investigation involved analysing amygdala responses to facial expressions of different emotions. The findings suggested that activation of the right amygdala was positively related to externalizing behaviour/reactive aggression and inversely related to CU/proactive aggressive traits. Further insights into the mechanisms of proactive aggression, however, can potentially be gained by studying the interrelationships between proactive aggression, the cardiovascular system, and the brain.

### 1.7.4 Cardiovascular activity and aggression

There is a well-evidenced view that low resting heart rate (rHR) is a major predictor of offending (Ortiz & Raine 2004; Lorber, 2004; Portnoy & Farrington, 2015; Raine, 2015; Raine et al., 1997). A recent Swedish study (Latvala et al., 2015), which followed approximately 700,000 men for 35 years has emphatically supported this robust relationship by demonstrating that there is a quasi-linear relationship of rHR with violent and non-violent crimes but not sex offences, as well as with non-intentional injuries. The causes of this association, however, remain unclear. Raine (2002) has theorized that in aggressive individuals low rHR most likely reflects withdrawal of sympathetic activity. This potential arrangement has led Raine and colleagues (Raine, 1996; Raine et al. 1997; Raine & Venables, 1984) to postulate that the autonomic underarousal would be aversive and consequently drive affected individuals to partake in risky, impulsive activities in order to increase autonomic arousal. It is these activities that have a strong tendency to be related to criminal acts. However, there appears to be limited evidence to support this model.

An alternative approach to understanding the relationship between low rHR and offending entails focussing on the corollaries of low rHR with brain function. Low rHR typically results from high vagal activity and this is in turn reflected in high (HRV) as discussed in section 1.5. This accordingly implies that low rHR is predictive of good prefrontal functioning and good emotional control. This conclusion is counterintuitive given the strong relationship between low rHR and offending, including violent offenses.

This relationship may, however, be better understood by consideration of the different types of aggressive behaviour. Previous studies of children (Raine, Fung, Portnoy, Choy, & Spring, 2014; Scarpa, Haden, & Tanaka, 2010) have emphasized the existence of a link between resting cardiovascular activity and the two subtypes of aggression. Both of these studies investigated parent-reported aggression in children. Raine et al. (2014) argued that low rHR is related to proactive aggression, impulsive features of psychopathy, and total child psychopathy. Scarpa et al. (2010) found that high resting HRV is associated with proactive aggression, whereas low HRV is associated with reactive aggression. The link between cardiovascular activity, higher brain function, emotion regulation, and the two subtypes of aggression needs further investigation. Of particular interest would be investigating these relationships with the use of self-report questionnaires and physiological measures in adult samples.

Psychopathic traits are also associated with characteristic cardiovascular responses which may be associated with their tendency to offend. Hansen, Johnsen, Thornton, Waage, and Thayer (2007) found that in a group of incarcerated offenders a deceitful, manipulative interpersonal style, and unempathic traits were significantly related to low rHR and high HRV. A meta-analysis of studies by Portnoy and Farrington (2015) supports a link between low rHR and psychopathy. This relationship, however, was not found in an earlier meta-analysis (Lorber, 2004). However, Portnoy and Farrington (2015) argued that the prior meta-analysis did not use adequate procedures to draw accurate conclusions on the relationships of rHR and maladaptive traits. For example, Lorber (2004) coded effect sizes as $d = 0$ for seven studies investigating the relationship between rHR and psychopathy which did not provide adequate statistics to calculate the effect size. These potential flaws were addressed in the more recent meta-analysis which concluded that there is a relationship between psychopathy and physiology. This implies that psychopathic traits might be linked to unusual ANS function.

Interestingly, in the study by Levenston, Patrick, Bradley, and Lang (2000), psychopathic offenders, relative to non-psychopathic individuals, showed a greater deceleration (that is a phasic shift) of heart rate in response to emotionally valenced pictures. This result is intriguing as the same group of psychopaths, as assessed with the Psychopathy Checklist – Revised (PCL-R), showed less startle potentiation whilst viewing the unpleasant pictures. Levenston et al. argued that psychopaths focused more attention on the images and that caused a greater drop in heart rate. As it will be explained in the following sections, phasic shifts in heart rate may be linked with attentional engagement towards some stimuli. These observations collectively suggest that psychopathy may be related to dysfunction in both attentional and emotional processes, mediated by cortical and limbic structures respectively.

Further insights into the relationship between low rHR and offending can be gained by considering the nature of sensation seeking. As mentioned in the opening paragraph of this section, the frequently cited model of aggression suggests that underarousal is aversive and likely leads to impulsive sensation seeking. However, premeditated/instrumental acts of aggression, unlike reactive aggression, are pre-planned. Moreover, sensation seeking can be subdivided into impulsive acts and relatively well-planned forms of behaviour, that is, venturesome acts (Eysenck & Eysenck, 1978). Venturesome individuals are thought to be well aware of the risk inclined in their activities. Examples of such risky activities are rock climbing or parachuting. Researchers interested in the concept of psychopathy associated venturesomeness with boldness, a psychopathic trait characterised by high social dominance and emotional stability (Patrick et al., 2009). Venturesomeness, but not impulsivity, has been positively associated with cerebrospinal fluid testosterone levels, a putative biological marker of aggression (Coccaro, Beresford, Minar, Kaskow, & Geracioti, 2007; Montoya, Terburg, Bos, & van Honk, 2012).

A previously published study investigated how heart rate responses can link with different types of male partner violence perpetrators (Gottman, Jacobson, Rushe, & Shortt, 1995). The study found that the heart rate of the batterers either decelerated or accelerated in response to a marital interaction. For those of whom the heart rate decelerated were named vagal reactors because of the typically observed inverse relationship between heart rate and vagal activity (Jacobson, Gottman, & Shortt, 1995). The vagal reactors were found to be generally more aggressive than the group for which the heart rate accelerated. Findings of a different study suggest that batterers characterised by high rates of aggression, such as the vagal reactors, use more instrumental or proactive aggression to assert their authority and to control their partners (Babcock, Jacobson, Gottman, & Yerington, 2000). Conversely, partner violent individuals which were characterised by high borderline traits, frequently associated with poor emotion regulation, exhibited a pattern of expressive or reactive aggression. These studies collectively suggest that proactive aggressive individuals for whom vagal activity increases during conflict may not benefit from interventions which are aimed at increasing emotion regulation by elevating vagal activity. Importantly, the fundamental knowledge of how emotion regulation is linked to vagal activity in offenders is lacking and this thesis provides some explanations for this link.

### 1.8 Executive function, emotion regulation and aggression

Poor executive functioning and offending are often assumed to be positively related. This relationship, although intuitivly plausible, lacks strong empirical evidence (Krämer, Kopyciok, Richter, Rodriguez-Fornells, & Münte, 2011).

Executive functions, as stated above, can be defined as an umbrella term for self-generated mechanisms that organise the implementation of complex cognitive processes, which ultimately may affect the expression of behaviour. These mechanisms allow for formulation of plans via various processes, including impulse inhibition, working memory, and attentional set shifting. Working memory is associated with processes of updating and temporary storage of ongoing information for relevance to the task. Inhibition delineates the ability to stop, break, or pause a more dominant response. Shifting refers to the ability to switch attention between tasks, operations, or sets (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000).

There are clear links between impulsivity and the lack of inhibitory control, a facet of executive functions. However, the links are less clear between aggression and other forms of executive functioning, such as working memory or attention. Furthermore, low rHR is positively associated with offending, including aggressive acts, and negatively related to HRV. The latter has previously been linked with good executive function. This accordingly implies that aggressive offenders may not have executive function deficits. Indeed, primary psychopathic traits were previously associated with unimpaired executive functions (Ross, Benning, & Adams, 2007; Hansen et al., 2007; Lantrip, Towns, Roth, & Giancola, 2016).

Executive processes can be assessed by various tasks, including the n-back, Stroop, and Porteus mazes. The quality of performance on these tasks appears to be related to the volume (Yuan & Raz, 2014) and activity (Jaeggi, 2003; Bush et al., 2000) of certain cerebral structures, especially those located in the PFC. Tests of executive function may not be able to perfectly account for the anatomical complexity of the PFC. However, the correlations between the various tasks are low, which suggests a degree of anatomical specificity. Therefore, performance on the tests may be assumed to approximately resemble the structure and activity of specific prefrontal brain structures.

According to a review by Yuan and Raz (2014), activity in specific prefrontal areas can be associated with performance on executive function tasks. The author argued that the inferior frontal gyrus (IFG) and ACC were observed to become active during a Stroop task, which requires participants to name the colour of a word irrespective of the words meaning. This ability is frequently associated with inhibition of task-irrelevant information. The lateral PFC (LPFC) was found to relate to working memory tasks, such as the n-back paradigm which requires the individual to remember specific information for a short period of time. However, previous reviews argued the dorsolateral part of the PFC is more specific to working memory (Royall et al. 2002; Goldman-Rakic, 1995; Jaeggi et al., 2003). The lateral orbitofrontal area is thought to be associated with inhibition of socially inappropriate behaviour and with risk assessment (Royall et al. 2002). Performance on the Porteus mazes is linked with processes of planning and behavioural inhibition (Tuvbald, May, Jackson, Raine,

& Baker, 2017). This test has previously been found to index the activity of ventral parts of the PFC (Kirsch et al., 2006).

Executive processes have been subdivided into non-emotional or "cool" processes and affective or "hot" processes (Dolcos & McCarthy, 2006; Rubia, 2011). The former processes are believed to be mediated via a dorsal neural pathway, that is the DLPFC, the LPFC, and the dorsal ACC, (Bush et al., 2002; Snowden, Gray, Pugh, & Atkinson, 2013). By contrast, the latter processes are related to the more ventral structures of the PFC including the OFC. This dichotomisation of executive processes can be illustrated with cognitive tests. For example, the Stroop task is related to "cool" inhibition whereas "hot" behavioural inhibition can be assessed with the Porteus mazes.

It was discussed in section 1.4 that the DLPFC and the ACC are implicated in regulation of emotions (Ochsner & Gross, 2005). The DLPFC connects with the dorsal ACC (dACC), whereas the ventral ACC is more strongly connected with the OFC (Beckmann et al., 2009; Marguiles et al., 2007). Accordingly, the colour-word Stroop has been associated with activity in the dACC, whereas the emotional Stroop has been associated with ventral ACC (Bush et al., 2000). Support for this anatomical distinction has been evidenced by studies investigating risk behaviour in adolescent samples (Botdorf, Rosenbaum, Patrianakos, Steinberg, & Chein, 2017; Figner, Mackinlay, Wilkening, & Weber, 2009). For example, Botdorf et al., 2017 found that performance on the emotional Stroop, but not on the cognitive variant, was correlated with risk taking. These studies suggest that the "cool" Stroop task-related inhibition and working memory may be unimpaired in certain subgroups of aggressive individuals.

It is often assumed that aggressive individuals have impaired executive function. However, as discussed in previous sections, the expression of aggression can be manifested in not one but various neurocognitive based profiles. These profiles may be differently related to cerebral function and consequently to performance on executive function tasks. More specifically, the impulsive, reactive type of aggression linked with secondary psychopathic traits can be characterised by decreased executive performance. Conversely, proactive aggression and primary psychopathic traits can be characterised by unaffected executive functions. This potential arrangement has been observed in several previously performed studies (Snowden et al., 2013; Dinn & Harris, 2000; Dolan & Anderson, 2002; Ellis et al., 2009; Giancola, Moss, Martin, Kirisci, & Tarter, 1996; Syngelaki, Moore, Savage, Fairchild, & Van Goozen, 2006; Dean et al., 2013). These studies collectively suggest that the impulsive/secondary psychopathy profile can be characterised by strongly decreased performance on tests assessing OFC function, whereas the DLPFC and ACC function in some instances appears to be relatively spared. Furthermore, a limited amount of evidence suggests that the proactive/primary psychopathy profile may be associated with improved executive function (Hansen et al., 2007; Ellis et al., 2009; Maes & Brazil, 2013). This positive association may be particularly pertinent for individuals that can be described as successful psychopaths (Gao & Raine, 2010).

As stated above, inhibition, a core feature of executive function, can be characterised as the ability to stop, break, or pause outright action. This global suppression of motor action is related to endogenous self-control mechanisms rather than exogenous control, that is, related to external factors (Aron, Robbins, & Poldrack, 2014). A failure to impose inhibitory control over behaviour or cognitions can be regarded synonymous with impulsivity. However, impulsivity can be split into two factors, the first being the tendency to act without planning ahead, whereas the second can be described as compulsive repetitiveness, that is, the tendency to constantly repeat a behaviour despite its inappropriateness (Bari & Robbins, 2013). The former factor appears to be closely related to reactive forms of aggressive behaviour. This suggests that reactive aggression can be associated with executive function impairment (Ellis et al., 2009). This proposition is supported by studies discussed in section 1.7.3, which highlighted the association of reduced OFC-amygdala connectivity with impulsive characteristics.

Impulsivity can also be studied from the perspective of neurochemistry. Previous research has emphasized the inverse relationship between the levels of neurotransmitter serotonin and aggression (Coccaro et al., 2011; Siever, 2008; Rosell & Siever, 2015, Krakowski, 2003). There is evidence to suggest that the expression of certain serotonin receptor subtypes modulates both impulsivity and aggression both in humans and rodents (Lesch & Merschdorf, 2000; Krakowski, 2003; Rosell & Siever, 2015). A review of studies suggested that serotonin modulates activity in areas of the PFC, including the OFC and ACC (Coccaro, Fanning, Phan, & Lee, 2015).

Some investigators of the relationship of serotonin and impulsivity in humans have manipulated tryptophan levels. Tryptophan, an essential amino acid, is the precursor of serotonin. Its levels can be reduced, and consequently those of serotonin, by placing an individual on a tryptophan depletion diet. Research concerning effects of tryptophan manipulation on aggression is still inconclusive. However, the current evidence indicates that increasing tryptophan levels may enhance positive and limit negative social behaviour (Steenbergen, Jongkees, Sellaro, & Colzato, 2016). There is also a literature which suggests that boosting serotonin levels by the administration of selective serotonin reuptake inhibitors (SSRIs) is associated with reduced levels of aggression (Siever et al., 2008).

Serotonin is implicated in the basal activity of many cerebral areas, including the PFC and ACC (Coccaro et al., 2011). Activity in these brain structures can influence the ability to regulate emotions as discussed in section 1.4, and may influence performance on executive functioning tasks (Robbins & Arnsten, 2009). Laboratory induced tryptophan depletion led to reductions in the right orbito-inferior prefrontal activation during a motor response inhibition task (Rubia, 2005). However, no significant effect on task performance was observed. Similarly, a study by Evers et al. (2006) found no effect of tryptophan depletion on executive performance (Evers et al., 2006). Authors of the latter article suggested that tryptophan depletion related performance may be modulated by various psychological characteristics. These characteristics may include aggression, as demonstrated by the studies described in the previous paragraph.

Interestingly, the relationship between acute depletion of tryptophan and increased impulsivity has been associated with lower HRV (Booij et al., 2006). Conversely, high HRV has been associated with improved performance on executive working memory tasks and Stroop task-related inhibition as discussed in section 1.5.

**1.9 Aim and hypotheses**

The principle aims of this thesis were to examine the central issue of how emotion regulation and mindfulness are related to cardiovascular activity and the implications of these relationships for our understanding of aggressive behaviour.

From the preceding literature review it can be seen that there are two seemingly robust conclusions that can be drawn concerning emotion regulation and aggression. Firstly, that a high degree of mindfulness is coupled with good emotion regulation and that this is associated with good psychological well being. Secondly, that low rHR is associated with aggression, and is a characteristic of many offender samples.

Both of these conclusions, however, lead to potentially paradoxically sequelae. In relation to the first conclusion, good emotion regulation can be seen in individuals with high primary psychopathic traits. High levels of these psychopathic traits are generally assumed to be maladaptive and linked to both aggression and offending. The promoting of mindfulness in such individuals might counter intuitively be expected to result in negative outcomes.

In relation to the second conclusion, rHR is typically highly correlated with HRV but in a negative direction. HRV is associated with strong prefrontal functioning, a prerequisite for good executive function. Thus, low rHR would be expected to be associated with good executive function, including the inhibition of prepotent responses and good emotion regulation. However, this is at variance with the general perceptions of offenders as being impulsive and having poor emotion regulation.

The experiments reported in the following experimental chapters are intended to address these related concepts. The two principle hypotheses tested are that; high levels of mindfulness are positively related to primary psychopathic traits and enable effective dampening of emotional and physiological responses to affective stimuli, and that mindfulness and emotion regulation can be increased by undertaking a HRV biofeedback while paradoxically high HRV is associated with aggressive traits and good executive functioning.

The next section will outline some of the psychometric measures and executive function tasks used in this thesis. The section will finish by discussing electrocardiography and some indexes of cardiovascular activity.

# CHAPTER 2: GENERAL METHODS

The typical experimental approach used in the design of the experiments reported in this thesis was a combination of psychometric measures (including the use of personality inventories to assess emotion regulation, mindfulness and psychopathic traits), assessments of cardiovascular activity (including measures of rHR and HRV), and tests of executive function. The following sections give details of these measures.

## 2.1 Psychometric measures

A range of personality inventories were used in the experimental studies to assess the levels of a series of psychological traits. The details of these are listed below.

### 2.1.1. Measures of emotions and emotion regulation

*Emotion Regulation Questionnaire [ERQ]*

The ERQ (Gross & John, 2003) contains two subscales, namely reappraisal and suppression. Respondents are asked to rate 10 sentences on a seven-points Likert scale. Reappraisal a process linked to change in cognitive interpretation of a potentially emotion-evoking situation. Suppression is a process associated with inhibition of emotion-related responses to a situation. Gross and John (2003) report alpha reliability for reappraisal is $\alpha$=.79, and for suppression $\alpha$=.73.

*Short Positive and Negative Affect Schedule [Short PANAS]*

The Short PANAS (Mackinnon et al., 1999) contains 10 items. This questionnaire consists of two scales. One scale measures Positive Affect (PA) and the other Negative Affect (NA). The participant is asked to rank 10 different emotions on a scale from one to five. The participants’ responses represent his emotional state. Cronbach’s alpha reported by Mackinnon et al., (1999) was α=.78 for PA and α=.87 for NA.

*Self-Report Emotion Questionnaire*

The self-report emotion questionnaire (Gross & Levenson, 1995) measures sixteen positive and negative emotions elicited in response to any video content. Respondents indicate the strength of each emotion on a Likert scale from 1 to 8. This scale was previously used in a large study assessing over 250 films (Gross & Levenson, 1995).

*Valence and arousal*

Lang (1995) proposed all emotions can be explained on a two-dimensional spectrum of valence and arousal. In keeping with this view, valence is measured on a scale from -10 (negative) to +10 (positive) and arousal is measured from 0 (not aroused) to +10 (highly aroused). This model was validated by a large emotional picture library and has proven to be reliable (Gross & Levenson, 1995).

### 2.1.2. Measures of mindfulness

*The Five Facet Mindfulness Questionnaire [FFMQ]*

The FFMQ treats mindfulness as a multidimensional construct. In total, there are 39 questions loading onto five subscales (Baer et al., 2008) observing measures the perception of subjective experiences. Describing refers to verbalisation of subjective experiences. Acting with awareness denotes concentration of undivided attention to the present moment. Nonjudging measures a nonevaluative approach to individual experiences. Nonreacting represents a fluent flow of thoughts and feelings. The authors (Baer et al., 2008) report alpha reliabilities for the FFMQ subscales ranged between different samples from α=.67 to α=.92.

*Five Facet Mindfulness Questionnaire Short Version [FFMQ-SF]*

The FFMQ-SF (Bohlmeijer, Klooster, Fledderus, Veehof, & Baer, 2011) is a 24-item short questionnaire that treats mindfulness as a multidimensional construct. This scale is formed of five factors, similar to the described above extended version of the questionnaire. Bohlmeijer et al., (2011) report alpha reliabilities for these scales are α=.75, α=.73, α=.85, α=.85, and α=.87 respectively.

*Mindful Attention Awareness Scale [MAAS]*

The MAAS is a self-report, single factor questionnaire. It measures the presence or absence of concentration on the present internal and external experiences, that the authors (Brown & Ryan, 2003) believe to be the true essence of trait mindfulness. An example of one of the 15 questions asked is: "I rush through activities without being really attentive to them". Internal consistency of this scale in an American psychology student sample (N=313) was α=.84. In the current study reliability was α=.79.

### 2.1.3. Measures of psychopathy

*Levenson Self Report Psychopathy scale [LSRP]*

The LSRP inventory is intended for use in assessing psychopathic personality traits in non-offending samples. It consists of two subscales, the first is a 16-item scale for assessing primary psychopathic traits, while the second is a 10-item scale for assessing secondary psychopathic traits. The primary subscale (LSRP-I) focuses on the selfish and uncaring characteristics associated with Factor 1 of the Psychopathy Checklist – Revised [PCL-R] by Hare (1991), and the secondary subscale (LSRP-II) assessed the behavioural and lifestyle factors associated with Factor 2, such as boredom and impulsivity. Good internal consistency has been reported for the LSRP with a Cronbach's alpha of α=.82 for the primary subscale and α=.63 for the secondary subscale (Levenson et al., 1995).

*Triarchic Psychopathy Measure [TriPM]*

The TriPM constructed by Patrick (2010) is a 58-item instrument with 3 subscales. The TriPM offers advantages over the LSRP in that its subscales boldness which measures social dominance and emotional resilience, meanness which assesses callousness, and the disinhibition subscale which records impulsivity. Although phenotypically distinct, boldness and meanness share common features of fearlessness. Boldness is associated with venturesomeness, a well-calculated form of adventure seeking, and may be characteristic of the so called "successful psychopaths". Meanness is linked with deficits in empathic thinking and destructive excitement seeking. Contrary to boldness, disinhibition is characterised by high levels of impulsive sensation seeking and impairment in foresight. The authors report good internal consistency for the subscales ranging from α= .80 to α=.83 and good construct reliability of α=.85 (Sica et al., 2015; Stanley, Wygant, & Sellbom, 2013).

### 2.1.4. Measures of aggression and anger

*Conflict Tactics Scale – 2 [CTS2]*

The CTS2 is a 78-item questionnaire that measures prevalence and chronicity of IPV perpetration and victimization. The CTS2 includes 5 subscales, namely the negotiation, psychological aggression, physical assault, sexual coercion and injury scales. Items on all but the negotiation scale are classified as either minor or severe actions. For example, "I slapped my partner" comprises a minor assault, whereas "I beat up my partner" is classed as a severe assault. The CTS2 generates a lot of data about the distinct types of IPV. However, the primary focus of studies utilising the CTS2 was to understand of the concomitants of intimate partner physical assault. Therefore, scores for the remaining subscales were not reported in the current studies. The authors of the CTS2 measure report good internal consistency for the physical assault scale with a Cronbach's alpha of α=.86 (Straus, Hamby, Boney-McCoy, & Sugarman, 1996).

*Proactive reactive aggression questionnaire [RPQ]*

The RPQ (Raine et al., 2006) consists of 23 items measuring reactive and proactive aggression. The two types of aggression differ in terms of their motivational drive. The former occurs in response to provocation or strong angry feelings, whereas the latter is goal orientated and premeditated. The authors report internal reliabilities for these scales as α=.86 and α=.84 respectively.

*State Trait Anger Expression Inventory [STAXI-2]*

The STAXI-2 (Spielberger, 1999) is a comprehensive anger assessment questionnaire. This questionnaire can be used to assess various state and trait components of anger as well as the expression and control of anger. The current study utilised four subscales of the STAXI-2, namely anger expression out (AX/O), anger expression in (AX/I), anger control out (AX/CO), and anger control in (AX/CI). Each of these subscales comprises eight questions answered on a four point Likert scale. The AX/O measures the frequency of verbal and behavioural expression of anger. The AX/I evaluates how often the person inverts anger on himself. The AX/CO measures how often the person succeeds to control anger. The AX/CI assesses how often the person attempts to calm himself down. According to Lievaart, Franken, & Hovens, (2016), alpha reliability for these scales are α=.80, α=.71, α=.87, and α=.89 respectively.

### 2.1.5. Measures of emotion dysregulation

*Depression Anxiety Stress Scales [DASS-21]*

The DASS-21 (Henry & Crawford, 2005) is a 21-item questionnaire that measures the intensity of three psychological constructs, namely depression, anxiety, and stress.

Respondents are asked to rate a series of statements on a four-point scale from zero to three. The authors reported alpha reliability for anxiety equals α=.82, depression α=.88, and stress α=.90.

*Millon Clinical Multiaxial Inventory – III [MCMI-III]*

The MCMI-III (Millon, Millon, Davis, & Grossman, 2009) is a comprehensive personality inventory containing 27 scales. The borderline scale includes 16 statements to which the respondent can either agree or disagree. This measure was devised to assess traits in relation to the Diagnostic and Statistical manual of Mental Disorder, 4th Edition [DSM-IV] (American Psychiatric Association, 1994) criteria for the diagnosis of borderline personality disorder [BPD]. Cronbach's alpha for the borderline scale reported by Rossi, van der Ark, and Sloore (2007). is α=.82.

*State Trait Anxiety Inventory [STAI]*

The STAI (Spielberger et al., 1983) is a 40-item inventory with 20 items assessing trait anxiety [STAI-T] and 20 for state anxiety [STAI-S]. Trait anxiety reflects anxiety as a personality trait whereas state anxiety refers to transient feelings of anxiety. In the current study, only trait anxiety was assessed as the current studies were more focused on the more enduring trait characteristics. Participants rate the extent to which each item applies to them on a four-point Likert scale. Reported Cronbach's alpha scores for the STAI are in the range of α=.86 to α=.95 (Spielberger et al., 1983).

*Sensation Seeking [$I_7$]*

The I7 (Eysenck, Pearson, Easting, & Allsopp, 1985) consists of 54 items assessing three components, namely impulsiveness, venturesomeness, and empathy. Impulsiveness can be related to poor impulse control whereas venturesomeness is linked with well-considered forms of stimulation seeking behaviours (Cross, Copping, & Campbell, 2011). Empathy can be defined as the ability to understand others. However, the use of this scale was not clearly defined by Eysenck et al. (1985). Responses to the items are given on a dichotomous “yes” or “no” scale. Reliability of the subscales are α=.84, α=.85, and α=.69 respectively.

### 2.1.7 Executive functioning tasks

*The Stroop Colour – Word task [Stroop]*

In this task, there are two types of stimuli, namely incongruent and congruent. The former represents trials that consist of names of colours printed in a colour that does not denote the name. The latter signifies trials in which ink colour and word are the same (Stroop, 1935). An extended version of the test includes control trials which consist of coloured shapes. The participants are asked to name the colour of each consequent stimuli. Proportion of correct trials and mean latency of correct trials are obtained for each set of trials. In this instance, latency refers to the time taken to initiate a response to a trial where the trial consists of a single stimulus. Each test session consists of randomly sampled 84 trials presented by a laptop. Performance on this task may be jointly related to the ability to selectively allocate attention and to inhibit prepotent responses (Kane & Engle, 2003; Lamers, Roelofs, & Rabeling-Keus, 2010). The dorsal ACC is known to be involved in Stroop-effect performance (Bush et al., 2002).

*The N-back task [N-back]*

The n-back continuous performance task is considered to be a test of working memory, that is, the ability to temporarily store and manage information. This test requires the participant to indicate whether the current stimulus matches the one from n-steps earlier in the sequence. Performance on the n-back has frequently been associated with functioning of the DLPFC (Jaeggi et al., 2003; Smith & Jonides, 1999; Owen, McMillan, Laird, & Bullmore, 2005). This appears to be particularly pertinent for non-verbal versions of the task (Owen et al., 2005). The current version has been designed by Jaegi et al., (2003) who demonstrated a simultaneous increase in task difficulty and activity in the DLPFC and some other brain regions. In the current study, the dependent variable was calculated for a 2-back and a 3-back version of the task.

*The Porteus Maze Test [Porteus maze]*

The Porteus maze test (Porteus, 1965) of impulsivity is administered using pen and paper. Participants are asked to complete a series of labyrinths without crossing walls, cutting corners, lifting the pencil, or going the wrong direction. A composite score of mistakes makes up a “Q-score” of impulsivity. Previous studies used the Porteus mazes to assess OFC impairment associated with psychopathic tendencies (Snowden et al., 2013). Imaging studies suggested performance on this test is sensitive to functioning of the ventromedial prefrontal cortex (Kirsch et al., 2006).

## 2.4 Electrocardiography

Electrocardiography is the process of recording the activity of the heart with an electrocardiogram (ECG). This device detects electrical changes on the skin resulting from the activity of the heart. Each heartbeat can be graphically illustrated with a series of waves which form a trace. These waves correspond with the distinct electrophysiological stages of the heartbeat. The “QRS” complex represents ventricular depolarization and is the most visually obvious part of the trace. A typical “R” wave forms the highest part the complex. The time distances between the pivots of the “R” waves are commonly used to calculate parameters of cardiovascular activity, including the heart rate and vagally mediated HRV.

In all of the current studies the ECG trace was recorded using a wrist-worn Biocom 4000 USB device (Biocom Technologies, Poulsbo, Washington, USA; Russoniello, Pougtachev, Zhirnov, & Mahar, 2010; Porto & Junqueira, 2009) with silver/silver-chloride electrodes and a sampling rate of up to 1024Hz. This device records cardiac activity over a 5-minute long epoch. Recorded traces were scanned for artefacts using the Biocom Heart Rhythm Scanner Professional Edition software installed on a Samsung laptop. The quality of each trace was reviewed and where possible artefacts were corrected with the use of an automated software-based algorithm. A trace was rejected if signal noise prevented accurate visual localisation of the "R" wave, artefacts were too difficult to correct, or when the software deemed the recording to be poor quality.

To standardise the ECG testing procedure several steps were undertaken. Each participant was asked to sit still, rest hands on their thighs, keep their eyes open and breathe normally. Before testing began the skin was prepared by gentle rubbing with an abrasive skin cream and then wiped with alcohol. To improve the quality of signal a conductive cream was applied on the electrodes prior to their positioning.

Testing location varied depending on whether the participants were imprisoned. Non-offenders were tested individually in a quiet research testing cubicle, whereas incarcerated offenders were tested individually in therapy rooms located in the prisons.

### 2.5 Assessment of heart rate variability

Autonomic nervous system mediation of heart rate can be measured with an electrocardiogram. Typically, a short-term ECG assessment will last several minutes. This is because a large amount of data is required to calculate indexes of HRV. The methods of HRV calculation are typically divided into time and frequency domain analysis (Task Force of the

European Society of Cardiology, 1996; Berntson et al., 1997). Time domain measures are estimated by applying various mathematical procedures to the differences between successive "R" waves as explained in section 2.4. Similarly, frequency components are derived with the use of a mathematical algorithm that distributes the variance spectrum of the interbeat intervals as a function of frequency. Vagal domination increases inter-beat interval fluctuations of the heart and consequently gives higher HRV values.

Examples of time domain measures include the standard deviation of successive interbeat intervals (SDNN) and the root mean square of successive beat differences (rMSSD). The SDNN and rMSSD are reliable and widely accepted measures of vagal cranial activity (Task Force of the European Society of Cardiology, 1996). There is a strong positive correlation between these indexes and both typically have a negative correlation with heart rate (Levy, 1990). The SDNN and rMSSD measures can be used to investigate short and long term vagal influences over the heart. However, their values increase with the duration of the recording. Therefore, statistical procedures should include HRV recordings of identical lengths.

The frequency domain measures include high frequency (HF) and low frequency (LF) component. The HF component is believed to be mediated primarily by the vagus. Some experimental designs use the LF component as a measure of sympathetic nervous system activity. However, there is evidence to suggest that LF values are mainly determined by the parasympathetic nervous system (Reyes del Paso, Langewitz, Mulder, Roon, & Duschek, 2013).

Heart rate and consequently the measurement of HRV is influenced by mechanisms other than vagal activity and the respiratory rate (Grossman & Taylor, 2007). These confounding effects include the baroreflex (Critchley & Harrison, 2013; Berntson et al., 1997), thermoregulation (Fleisher et al., 1996), and residual inspiratory vagal activity (Grossman & Kollai, 1993). Arguably the most significant confound originates from the baroreflex.

The baroreceptors are responsive to a spontaneous change in blood pressure. The change in blood pressure can originate from environmental demands, such as physical activity. To regulate the pressure and maintain homeostasis, baroreceptors relay information to the NTS which modulates vagal activity and inhibits nuclei controlling the activity of the sympathetic nervous system (Smith et al., 2017). This modulation of the vagus can lower or increase the heart rate and influence HRV.

## 2.6 Ethics statement

The design and work associated with performing the research described in this thesis adhere to the Code of Ethics and Conduct of The British Psychological Society. Ethical approval was gained from the following committees: The University of Birmingham Science, Technology, Engineering and Mathematics (STEM) Ethical Review Committee, and The University of Birmingham Committee for Ethical Review.

Prior to participation each participant was asked to read and sign a consent form which contained information about the purpose of the study, testing procedure, benefits and risks of participation, process of withdrawal, data collection, and confidentiality. The form also included contact information for the researchers, and medical and psychological support services. For the laboratory and prison based studies, participants were given a copy of the consent form to keep. For the web based studies consent forms were available to access anytime online. The participants could decline participation and withdraw from the study whenever they wished to do so. Upon completion or termination each participant was given a debrief form which contained detailed information about the study.

# CHAPTER 3 (STUDY 1): THE RELATIONSHIP OF EMOTION REGULATION, MINDFULNESS, AND PSYCHOPATHIC TRAITS IN FEMALE UNDERGRADUATES

## 3.1 Introduction

In the general introduction to this thesis it was argued that there may be contextual similarities between mindfulness and emotion regulation, such that both can be associated with inhibition of excessive elaboration of emotions. Certain emotion regulation strategies, such as suppression, were previously related to increased aggressive traits which are frequently found in individuals with elevated psychopathic characteristics. Therefore, it could be that psychopathy may be paradoxically positively associated with certain aspects of mindfulness and emotion regulation. For example, both individuals with psychopathic traits and mindful individuals were previously characterised by their propensity to detach from emotional experiences. Previous studies also suggest that that mindfulness is associated with increased activity in the ACC. This brain structure was previously found to inhibit amygdalar activity. Such inhibition processes may also underlie certain primary psychopathic characteristics, including proactive aggression and reduced emotionality, and underlies emotion regulatory processes. This first experimental chapter set out to investigate the possibility that mindfulness, psychopathic traits, and emotion regulation are related to each other.

Emotion regulation can be defined as a process through which individuals modulate their emotional experience (Aldao et al., 2010; Gross, 1998). Gross (1998) argues that there are several ER strategies, which include reappraisal and suppression. Similarly, mindfulness, associated with self-regulation of attention and acceptance of subjective experiences (Kabat-Zinn, 2003; Bishop et al., 2004) has various subcomponents. There appear to be contextual similarities between emotion regulation and mindfulness. However, the positive association between reappraisal, suppression and mindfulness has been questioned here and in previous research. Moreover, a subset of psychopathic tendencies includes characteristics which may paradoxically have a positive relationship with emotion regulation and mindfulness. However, this apparent relationship may be more appropriate to certain ER and mindfulness components than to others. The thrust of this study is to investigate the relationship of the different components of emotion regulation with mindfulness and how the two latter characteristics relate to psychopathic traits.

The frequently cited work by Gross (1998) details some of the possible processes underlying emotion regulation. These can be grouped into antecedent-focused and expression-focused strategies, examples of which are reappraisal and suppression respectively. Reappraisal is linked with cognitive re-evaluation of personal emotional experiences. Suppression is associated with various forms of inhibition of emotional expressions. These emotion regulation strategies are commonly executed once the emotion arises. More recent research (Gross & John, 2003) emphasized that reappraisal is related to a greater experience of positive emotions. Conversely, suppression is linked with a stronger experience of negative feelings. This suggests that reappraisal is a more efficient emotion regulation strategy compared with suppression.

Mindfulness is frequently defined by two core components, namely cultivation of awareness to the present moment and non-judgemental acceptance of mental processes (Shapiro et al., 2006; Bishop et al., 2004). However, a frequently cited concept of mindfulness consists of a five facet structure (Baer et al., 2008). These factors are observing, describing, acting with awareness, non-judging, non-reacting. The observe factor refers to attending to personal sensations, such as emotions, cognitions, and sights. Describe denotes labelling personal events with words. Acting with awareness means attending to the present without getting distracted. Non-judge refers to taking a relaxed approach toward thoughts and feelings. Non-react denotes allowing thoughts and feelings flow, without getting caught up in them. Four of the components, excluding acting with awareness, were previously found to increase with meditation experience (Baer et al., 2008).

Psychopathy refers to a severe personality disorder which is characterised by callous and unemotional traits and is associated with severe patterns of aggressive behaviour and offending. Psychopathic traits, however, can be seen as existing on a continuum and thus observable in non-forensic samples (Marcus et al., 2004). Psychopathic traits are typically assumed to be characterised by fearlessness, callousness and unemotionality. However, these three traits are key aspects of primary psychopathy and can be associated with certain level of social success (Gao & Raine, 2010). By contrast, secondary psychopathy is associated with impulsivity, emotional dysregulation and increased antisocial tendencies (Skeem et al., 2007; Levenson et al., 1995). Although primary psychopathy and secondary psychopathy typically coexist, they are believed to be driven by distinct neurobiological mechanisms (Lozier et al., 2014). This account highlights the need to statistically control the effects of one of these components when making inferences about the other.

Poor emotion regulation (Gross & Muñoz, 1995; Martin & Dahlen, 2005) and low levels of mindfulness (Brown & Ryan, 2003; Goyal et al., 2014) have previously been related to negative psychological characteristics, such as depression, anxiety, and stress. Conversely, elevated levels of both emotion regulation and mindfulness seem to link with positive psychological wellbeing (Gross & John, 2003; Gross & Muñoz, 1995; Brown & Ryan, 2003;

Garland et al., 2010; Jain et al., 2007). Mindfulness based techniques have been previously used to elevate levels of emotion regulation (Baer et al. 2006; Arch & Craske, 2006; Goldin & Gross, 2010). For example, in a group of undergraduate students, a 15 minutes mindful breathing session enhanced emotional control in response to slides portraying aversive images (Arch & Craske, 2006). The findings of these studies suggest there may be contextual similarities between emotion regulation and mindfulness.

However, Chambers et al. (2009) suggest that mindfulness may be antithetical to certain emotion regulation strategies, such as reappraisal and suppression. This is because reappraisal may be associated with experiential avoidance of emotional experiences, whereas mindfulness is believed to be closely linked with acceptance of emotions. Similarly, suppression may be related to rejection of emotions, whereas mindfulness cultivates noncritical awareness of emotions. Classic emotion regulation strategies advocated by Gross and colleague's (Gross, 1998) seem to be focused on manipulation of emotional states when they arise. This appears to be inherently different to the idea of nonjudgemental attentiveness promoted by mindfulness theorists (Kabat-Zinn, 2003). However, the detailed relationship between emotion regulation strategies and mindfulness needs exploration. The aim of this research was to investigate these relationships.

Single constructs of emotion regulation and mindfulness may be inversely related to aggressive behaviour. Poor emotional awareness and use of maladaptive emotion regulation strategies has been associated with increased aggression in offenders (Roberton et al., 2014). Moreover, difficulties with emotion regulation were associated with impulsive features of psychopathy (Long et al., 2014). Increased mindfulness may reduce angry rumination and hostile attribution bias (Borders et al., 2010; Heppner et al., 2008) and was previously found to correlate negatively with impulsivity (Peters, Erisman, Upton, Baer, & Roemer, 2011). The emotionally unstable characteristics of hostile attribution and impulsivity can be associated with secondary psychopathic traits (Skeem et al., 2007).

However, the negative link between emotion regulation, mindfulness and aggression may be more relevant to specific components of the constructs. According to Gross and John (2003) suppression is related to higher negative affect, and poorer interpersonal functioning and well-being, compared with reappraisal (Aldao et al., 2010; Gross & Levenson, 1993). Previous research found a negative link between difficulties in emotion regulation and primary psychopathic traits (Long et al., 2014) whereby fearlessness and callousness are associated with better emotion regulation. This effect may reflect greater inhibition of amygdala responses by higher cortical centres (Ochsner & Gross 2005). This interpretation is in keeping with the work of Lozier et al. (2014) which found that individuals with high callous and unemotional traits have dampened amygdala responses to facial expressions. Collectively, these studies suggest that suppression may be positively associated with both primary and secondary psychopathic features, whereas reappraisal may be positively related to primary psychopathic traits only.

Similarly, mindfulness components may be differently related to psychopathic traits. For example, nonjudging and nonreacting to inner experience facets of the FFMQ (Baer et al., 2008) may signify detachment from emotional experience. Internal sensations are believed to provide crucial information in the process of emotion regulation (Damasio, Everitt, & Bishop, 1996; Füstös, Gramann, Herbert, & Pollatos, 2012). Emotional detachment and reduced ability to utilise inner stimuli has previously been associated with increased psychopathic tendencies (Skeem et al., 2007; Nentjes, Meijer, Bernstein, Arntz, & Medendorp, 2013; van Honk, Hermans, Putman, Montagne, & Schutter, 2002).

It has previously been proposed that a core deficit of psychopathy is related to abnormalities in certain processes of attention (Hiatt & Newman, 2006; Blair & Mitchell, 2009). A putative explanation of this deficit highlighted that psychopaths fail to shift attention towards information that is peripheral to their task (Lorenz & Newman, 2002; Newman et al., 2010). This propensity may be somehow related to mindfulness facet act with awareness, which was previously associated with decreased tendencies to become distracted (Jain et al., 2007). Altogether, these studies suggest that unemotional features of psychopathy may be positively related to mindfulness facets nonjudging, nonreacting, and act with awareness. The converse link can be expected with secondary psychopathy. This research aimed to investigate this possibility.

It was hypothesised that there are negative relationships between the two emotion regulation subscales: reappraisal and suppression, and the mindfulness facets: act with awareness, nonjudging, nonreacting. Furthermore, reappraisal will be positively linked with primary psychopathic traits and negatively with secondary psychopathic traits, whereas suppression will have a negative link with both psychopathic traits subscales. Mindfulness facets act with awareness, nonjudging, nonreacting are expected to have a positive relationship with primary psychopathic traits, and the converse link with secondary psychopathic traits.

**3.2 Method**

*Participants*

Participants were 234 female undergraduate psychology students. Mean age was 19.38, 90% respondents were British, and 95% considered themselves to live by Western cultural values. The majority were not employed (68.8%), while the rest were either in part-time work (29.2%) or employed 16 hours or over (three participants). 91.9% respondents were currently undertaking an undergraduate degree. Participants' racial background was mainly white (80.4%), then Asian (10.4%) and Black (3.1%). All questionnaires were filled out online in exchange for university credit.

*Materials*

Emotion regulation, mindfulness and psychopathic traits were assessed using the Emotion Regulation Questionnaire (ERQ), the Five Facet Mindfulness Questionnaire (FFMQ) and the Levenson Self Report Psychopathy (LSRP) inventories respectively, details of which are given in Chapter 2.1. In the current study, alpha reliabilities for the ERQ were $\alpha$=.88 for reappraisal and $\alpha$=.80 for suppression. For the FFMQ the alphas ranged from $\alpha$=.78 to $\alpha$=.93, whereas for the LSRP these values were $\alpha$=.88 and $\alpha$=.64 for the primary and secondary psychopathy scales respectively.

*Procedure*

To participate in the study participants logged onto a dedicated university website using their personalised accounts. Participants received on-screen instructions which ensured that informed consent was given. The questionnaires were then completed in a set order: FFMQ, ERQ, LSRP. After completion, a debrief section was displayed and respondent was granted credit. Ethical permission for the current research was given by the Science, Technology, Engineering and Mathematics (STEM) Ethical Review Committee of the University of Birmingham.

*Statistical analyses*

The initial sample consisted of female university students (N = 256). Investigation of responses revealed that 22 participants failed to give complete answers. These participants were excluded from further analysis. The remaining dataset (N = 234) was analysed with the

SPSS statistical analysis software. The Shapiro-Wilk test for normality of distribution was significant for all of the variables, excluding *observe*, *describe*, and *nonreact*. Therefore, nonparametric Spearman's correlations were performed to investigate the relationships between all variables measured.

In a subsequent analysis, partial correlations of primary and secondary psychopathic traits with emotion regulation and mindfulness subscales. Primary and secondary psychopathic traits were interchangeably entered as a statistical covariate to control for the phenotypic similarities between these traits. Therefore, the results reported here denote the unique relationships with primary and secondary psychopathic traits independent of the other.

Results of the partial correlations between the facets of mindfulness and subscales of psychopathic traits appeared to form inverse patterns. Therefore, it was decided to further investigate the relationship by calculating a sum of the mindfulness components and performing partial correlations between the resulting variable and the different components of psychopathic traits. Cronbach's alpha reliability statistic for the total mindfulness score was $\alpha$=.80 which suggests good internal consistency of the newly obtained variable.

**3.3 Results**

*Descriptive statistics*

The current scores for the emotion regulation and psychopathic traits subscales were broadly similar to normative values reported in samples of female undergraduates (Melka, Lancaster, Bryant, & Rodriguez, 2011) and mixed-gender undergraduate psychology students (Douglas et al., 2012) respectively. Scores for the mindfulness facets were slightly lower compared to previously published mixed-gender normative values (Baer et al., 2008). Table

3.1 contains the means, standard deviations, medians, and the corresponding interquartile ranges for all variables included in the current analysis.

Table 3.1: Descriptive statistics for variables used in the current study

| | *M* | *SD* | *Med* | *Ran* |
|---|---|---|---|---|
| Reappraisal | 27.76 | 6.44 | 29 | 33 |
| Suppression | 14.12 | 5.05 | 14 | 24 |
| Observe | 22.94 | 6.49 | 22 | 31 |
| Describe | 26.14 | 6.30 | 26 | 30 |
| Aware | 24.74 | 5.90 | 25 | 31 |
| Nonjudge | 25.06 | 7.93 | 25 | 32 |
| Nonreact | 18.45 | 4.66 | 18 | 25 |
| Primary Psy. Traits | 29.23 | 7.91 | 28 | 37 |
| Secondary Psy. Traits | 21.21 | 4.22 | 21 | 22 |

*Note. Psy. – psychopathic; Med – median; Ran – range.*

***Spearman's Rank-Order Correlations***

*Emotion Regulation and Mindfulness*

Results of the correlation analysis indicated positive correlations between the *reappraisal* aspect of emotion regulation and the following mindfulness facets: *observe* ($r_s$ = .163, $p$ = .013), *describe* ($r_s$ = .161, $p$ = .014), *nonreact* ($r_s$ = .380, $p$ < .001). Significant negative correlations were observed for *suppression* component of emotion regulation and the following mindfulness facets: *describe* ($r_s$ = -.362, $p$ < .001), *act with awareness* ($r_s$ = -.268, $p$ < .001), *nonjudge* ($r_s$ = -.197, $p$ = .002).

*Emotion Regulation and Psychopathic Traits*

The emotion regulation factor of *reappraisal* had a negative correlation with *secondary psychopathic traits* ($r_s$ = -.206, $p$ = .002). Conversely, emotion regulation *suppression* was positively correlated with both *primary psychopathic traits* characterised by callous, unemotional traits ($r_s$ = .261, $p$ < .001), and *secondary psychopathic traits* characterised by emotion dysregulation and impulsive features ($r_s$ = .313, $p$ < .001). The remaining components were not significantly correlated.

*Psychopathic Traits and Mindfulness*

There was a negative relationship between *primary psychopathic traits* and *act with awareness* ($r_s$ = -.162, $p$ = .013). Furthermore, *secondary psychopathic traits* had negative correlations with *describe* ($r_s$ = -.186, $p$ = .004), *act with awareness* ($r_s$ = -.471, $p$ < .001), and *nonjudge* ($r_s$ = -.336, $p$ < .001). The remaining components were not significantly correlated.

The remaining rank-order correlations and intercorrelations between the subscale components can be found in Table 3.2 beneath.

Table 3.2: Non-parametric Spearman's correlations between the emotion regulation, mindfulness and psychopathic traits

| | Rea. | Sup. | Obs. | Des. | Aware | NJ | NR | Pri. psych. | Sec. psych. |
|---|---|---|---|---|---|---|---|---|---|
| Rea. | 1 | .022<br>.728 | .163*<br>.013 | .161*<br>.014 | .077<br>.239 | .011<br>.871 | .380**<br>.000 | -.095<br>.147 | -.206**<br>.002 |
| Sup. | | 1 | .104<br>.114 | -.362**<br>.000 | -.268**<br>.000 | -.197**<br>.002 | .103<br>.116 | .261**<br>.000 | .313**<br>.000 |
| Obs. | | | 1 | .087<br>.182 | -.351**<br>.000 | -.432**<br>.000 | .351**<br>.000 | .070<br>.289 | .092<br>.162 |
| Des. | | | | 1 | .162*<br>.013 | .105<br>.111 | .095<br>.146 | -.121<br>.065 | -.186**<br>.004 |
| Aware | | | | | 1 | .481**<br>.000 | -.113<br>.085 | -.162*<br>.013 | -.471**<br>.000 |
| NJ | | | | | | 1 | -.143*<br>.029 | -.097<br>.139 | -.336**<br>.000 |
| NR | | | | | | | 1 | .068<br>.300 | -.053<br>.423 |
| Pri. psych. | | | | | | | | 1 | .500**<br>.000 |

*Note. Rea. – reappraisal, Sup. – suppression, Obs. – observe, Des. – describe, Aware – act with awareness, NJ – nonjudge, NR – nonreact, Pri. Psych. – primary psychopathic traits, Sec. psych. – secondary psychopathic traits.*

***Partial Correlations Controlling for the Effects of Psychopathic Traits***

*Emotion Regulation and Psychopathic Traits*

The partial correlation between *reappraisal* and *primary psychopathic traits* was not significant ($r_{partial}$ = -.033, $p$ = .616). Furthermore, the previously obtained relationship between *reappraisal* and *secondary psychopathic traits* lost significance ($r_{partial}$ = -.102, $p$ = .121) when effects of *primary psychopathic traits* were partialed out. However, the positive correlations between *suppression* and *primary psychopathic traits* ($r_{partial}$ =.157, $p$ = .016), and *suppression* and *secondary psychopathic traits* ($r_{partial}$ = .216, $p$ = .001) remained significant after controlling for the effects of one or the other psychopathic component. This implies that both primary and secondary psychopathic traits are unrelated to reappraisal but are positively related to suppression.

*Primary Psychopathic Traits and Mindfulness*

There were no significant correlations between *primary psychopathic traits* and the mindfulness facets: *observe* ($r_{partial}$ = .015, $p$ = .825), *describe* ($r_{partial}$ = -.006, $p$ = .932), *act with awareness* ($r_{partial}$ = .110, $p$ = .095), *nonjudge* ($r_{partial}$ = .094, $p$ = .151), and *nonreact* ($r_{partial}$ = .109, $p$ = .097) when *secondary psychopathic traits* were entered as a covariate. Therefore, the previously observed rank-order correlation between *primary psychopathic traits* and *act with awareness* was no longer significant.

*Secondary Psychopathic Traits and Mindfulness*

Conversely, *secondary psychopathic traits* were negatively correlated with *act with awareness* ($r_{partial}$ = -.486, $p$ < .001) *and nonjudge* ($r_{partial}$ = -.344, $p$ < .001) when effects of *primary psychopathic traits* were partialed out. The previously significant correlation of *secondary psychopathic traits* and *describe* became insignificant ($r_{partial}$ = -.114, $p$ = .083). Similarly, *secondary psychopathic traits* did not correlate with *observe* ($r_{partial}$ = .076, $p$ =

.249), and *nonreact* ($r_{partial}$ = -.100, $p$ = .130). This suggests that secondary psychopathic traits are negatively related to mindfulness.

*Psychopathic Traits and Total Mindfulness Score*

When scores for *secondary psychopathic traits* were held constant, *primary psychopathy* had a positive correlation with the total score of mindfulness ($r_{partial}$ = .137, $p$ = .037). Conversely, *secondary psychopathic traits* and the total mindfulness score correlated negatively ($r_{partial}$ = -.426, $p$ < .000) when *primary psychopathic traits* were entered as a covariate.

**3.4 Discussion**

Emotion regulation and mindfulness appear to share contextual similarities. However, it has been previously proposed that certain characteristics of those traits may be antithetical (Chambers et al., 2009). Furthermore, it may be generally expected that emotion regulation and mindfulness have a negative link with psychopathic tendencies. Contrasting with the latter proposal, previous research found that fearless and unemotional characteristics of psychopathic traits were linked with reduced difficulties in emotion regulation (Long et al., 2014).

It was hypothesised that emotion regulation subscales and the mindfulness facets act with awareness, nonjudge, nonreact are negatively related. Contrary to the current hypothesis, reappraisal had a positive link with nonreact. However, suppression did have negative correlations with act with awareness and nonjudge. It is concluded, therefore, that mindfulness is incompatible with suppression but not reappraisal.

It was also hypothesised that reappraisal will be positively associated with primary psychopathic traits and negatively with secondary psychopathic traits. However, neither of these putative relationships was supported. Nonetheless, the hypothesis that suppression will be positively related to both psychopathic traits was supported. If these relationships extend to individuals with high psychopathic traits who have offended it implies that their main way of regulating emotions is by a process of inhibition of expression.

Another hypothesis stated that the mindfulness facets act with awareness, nonjudge, nonreact are positively related to primary psychopathic traits but negatively to secondary psychopathic traits. When secondary psychopathic traits were used as a covariate, primary psychopathic traits did not correlate with mindfulness facets. Conversely, secondary psychopathic traits were negatively correlated with act with awareness and nonjudge when effects of primary psychopathic traits were partialed out. Interestingly, the two subscales of psychopathic traits appeared to form inverse patterns with mindfulness. It is concluded that the separate components of mindfulness have negative relationships with secondary but not primary psychopathic traits.

The inverse patterns between psychopathic traits subscales and mindfulness factors were investigated further. The subscales of FFMQ were summed and the resulting variable formed a total score of mindfulness. This latter variable was positively correlated with primary psychopathy and negatively with secondary psychopathy when the effect of one or the other was partialed out. Summing the different factors of the FFMQ is not a common practice and may be limited by still to be identified confounds. However, the finding could be of importance for future studies where mindfulness is a single construct trait.

Gross & John (2003) argued that the expression-focused emotion regulation strategies reappraisal and suppression may be differently related to certain psychological characteristics. The current results indicate that on the whole, reappraisal had positive links with mindfulness while the inverse relationship was found between suppression and mindfulness. The detailed relationship between emotion regulation and mindfulness varied amongst the specific facets of these traits (Gross & John, 2003; Baer et al., 2008). Theorists have emphasized that two factors are most relevant for mindfulness, namely the ability to focus undivided attention on subjective experience (aware) and the ability to remain uncritical of personal experience (nonjudge) (Bishop et al., 2004). Interestingly, suppression was negatively linked to these two facets, whereas no relationship was found for reappraisal. This account supports the current hypotheses that mindfulness is a feature which is the converse of suppression. The current results leave open the possibility that mindfulness may be linked with antecedent-focused emotion regulation strategies.

The current study found that suppression was positively linked to primary and secondary psychopathic traits. This further supports the proposition that suppression is linked with negative psychological characteristics (Gross & John, 2003). The current findings suggest that certain psychopathic traits may be associated with increased ability to withhold expression of emotions. Surprisingly, such ability may be considered adaptive in certain cultures (Butler, Lee, & Gross, 2007). Previous studies suggested that fearless and callous traits of psychopathy may be linked to improved emotion regulation (Long et al., 2014). However, the current study found no evidence for a link between primary psychopathic traits and the ability to reappraise. This may be because primary psychopathic traits are associated with unemotional responding, which could render certain emotion regulation strategies useless. Conversely, reappraisal was negatively related to secondary psychopathic traits. This suggests individuals whom score high on the latter may have impaired emotion regulation characterised by the reduced ability to cognitively re-evaluate personal experience.

The mindfulness facet act with awareness is associated with superior attentional skills (Bishop et al., 2004). This ability has previously been linked with decreased tendencies to become distracted (Jain et al., 2007). Mindfulness is also characterised by the ability to remain indifferent and nonresponsive to inner sensations, which is typically viewed as the ability to nonjudge and nonreact (Baer et al., 2008). The current findings suggest that secondary psychopathic traits are inversely related to mindfulness facets act with awareness and nonjudge. This account suggests that secondary psychopaths are easily distracted and critical about subjective experiences, an interpretation that can be associated with emotional volatility (Cornell et al., 1996; Skeem et al., 2007). By contrast, primary psychopathic traits did not correlate with any of the mindfulness facets but formed a trend ($p < .10$) towards a positive association with facets act with awareness and nonreact. This suggest that primary psychopaths may have reduced tendencies to become distracted and may be nonresponsive to inner experiences. This may account for the diminished ability to shift attention towards information that is peripheral to their task (Lorenz & Newman, 2002) and reduced ability to utilise inner stimuli (van Honk et al., 2002; Blair, 2001).

When scores for mindfulness facets were summed, the resulting variable was positively associated with primary psychopathic traits. The latter were previously related to deficits in empathy (Ali, Amorim, & Chamorro-Premuzic, 2009; White, 2014). This suggests that mindfulness could be related to low empathy. This contradicts the notion put forward by Lamothe et al. (2016) as mentioned in Chapter 1. However, it could be that the individual facets of mindfulness are differentially related to empathy. The currently obtained results of partial correlations between mindfulness and psychopathy suggest that the components of mindfulness acting with awareness and non-reacting could have a negative and the remaining components positive relationship with empathy. This result, however, puts into question the utility of teaching mindfulness techniques to fearless and unemotional individuals.

In conclusion, the study demonstrated that the two major approaches to emotion regulation, namely suppression and reappraisal, were differentially related to psychopathic traits. Thus, suppression was positively correlated with both primary and secondary psychopathic traits. No correlation was found for the latter traits and reappraisal. The study further showed that the total mindfulness score was positively related to primary psychopathic traits but negatively with secondary psychopathic traits.

These findings may encourage reflection on some of the assumptions underlying therapeutic approaches to the treatment of aggressive offenders which focus on the development of better emotion regulation. The observed relationships between psychopathic traits and regulation of emotions by suppression suggest that this approach to emotion regulation maybe the default condition of many offenders. If so, therapeutic strategies may be better focussed on developing the aptitude for reappraisal. The findings further suggest that if mindfulness techniques are to be used in the treatment of aggressive offenders they should be limited to those offenders who show elevated levels of secondary but not primary psychopathic traits. It should be noted, however, that the current study involved female participants only. However, Baer (2008) found no significant sex differences on the FFMQ facets in a large sample which consisted of students, community members, highly educated individuals, and meditators.

In summary, the current study raises the controversial possibility that mindfulness is directly related to some psychopathic traits in that both concepts are related to reduced emotional responding. Consequently, it is of interest to determine whether mindfulness is related to the degree of physiological changes that accompany emotional responses. This issue is explored in the next study by examining how mindfulness is related to cardiovascular reactivity.

# CHAPTER 4 (STUDY 2): MINDFULNESS DAMPENS CARDIAC RESPONSEES TO MOTION SCENES OF VIOLENCE

## Dissemination

Large elements of this study are taken directly from a manuscript which was published in the journal Mindfulness. This manuscript was co-authored by the candidate's supervisors (Dr Ian Mitchell and Dr Louise Dixon) and co-worker (Dr Steven Gillespie). The candidate was the principal researcher with respect to designing and executing the study, undertaking the data analyses, and writing the paper. Dr Ian Mitchell collaborated with the design and writing of the study. Dr Louise Dixon collaborated with editing of the final manuscript. Dr Steven Gillespie collaborated with the design and writing of the study, and assisted with the data analyses.

## 4.1 Introduction

As discussed in the general introduction, there are similarities in the underlying biological and psychological mechanisms of trait mindfulness and primary psychopathic characteristics. Mindfulness is related to increased activity of the ACC, which in functional terms can be seen as inhibiting the amygdala. Reduced amygdala activation has also been linked to primary psychopathic characteristics, including proactive aggressive traits whereas increased amygdalar responsivity has been linked to reactive aggression. Therefore, amygdalar responses may be associated with holistic changes in psychological and physiological reactions to aversive cues. Previously published articles propose that the amygdala is implicated in the mediation of neurological information which travels to and from the heart. This suggests that trait mindfulness may be associated with changes to emotional and cardiovascular responses to stimuli containing aversive information.

In support of this reasoning the findings of the Chapter 3 controversially showed that trait mindfulness, when treated as a single factor, was positively related to primary psychopathic traits. In previously published work, primary psychopathic traits were related to more positive feelings and diminished physiological arousal in response to an anxiety evoking stimulus (Birbaumer et al., 2005). Accordingly, the current study investigated whether mindfulness elevates self-report emotions and dampens heart rate responding to a video clip containing graphic scenes of violence.

Mindfulness is defined by two components, namely attentional self-regulation and a specific mental approach to personal experience. The self-regulation of attention includes increased focus on personal experience of the present. The mental approach towards personal experience is characterized by acceptance, curiosity, and openness (Bishop et al., 2004). Elevated trait mindfulness has been linked with positive psychological characteristics (Keng et al., 2011), including higher levels of self-esteem (Brown & Ryan, 2003), increased positive affect (Garland et al., 2010; Jain et al., 2007; Davidson et al., 2003), and empathy (Lamothe et al., 2016). Practicing mindfulness has similarly been associated with reduced negative psychological characteristics such as anxiety, depression (Goyal et al., 2014), neuroticism (Giluk, 2009), and difficulties in emotion regulation (Baer et al., 2006). Furthermore, mindfulness based techniques are integrated in various psychological therapies, including Cognitive Behaviour Therapy (Singh et al., 2008), Dialectical Behaviour Therapy (Robins & Chapman, 2004), and Mindfulness Based Stress Reduction (Kabat-Zinn, 2003). A variety of studies have explored the theoretical mechanisms by which mindfulness exerts its positive effects. The current research was designed to expand the understanding of the mechanisms of mindfulness by relating trait mindfulness to cardiovascular processes.

Some of the regulatory processes of attention and emotion are mediated in part by brain structures which are influenced by mindfulness training. For example, heightened ACC activation can inhibit amygdala responses which can be linked to negative emotionality (Etkin et al., 2006; Petersen & Posner, 2012; Wadlinger & Isaacowitz, 2011; Ochsner & Gross, 2005; Bush et al., 2000). Furthermore, decreased activation in the medial PFC and the PCC was related to diminished self-referential processing, which supports self-detachment, rather than affective or subjective interpretation of personal experience (Lutz et al., 2016a; Brewer et al., 2011; Hölzel et al., 2011; Farb et al., 2007; Gusnard et al., 2001).

Consistent with the findings of brain imaging studies, Tang and Leve (2016) suggested that mindfulness is associated with improved regulatory mechanisms of attention and emotion. All types of emotions can be rated on a Likert scale that ranges in *valence*, from more negative emotional states, to more positive emotional states. Irrespective of valence, the intensity of an emotion is referred to as *arousal* (Lang, 1995). Various studies indicate that mindfulness increases scores for valence toward more positive emotional states (Remmers et al., 2016; Cameron & Fredrickson, 2015; Ho et al., 2015; Taylor et al., 2011; Goldin & Gross, 2010). However, findings suggesting that mindfulness diminishes self report arousal are sparse (Shoham, Goldstein, Oren, Spivak, & Bernstein, 2017).

Nonetheless, previously published studies found mindfulness to attenuate physiological arousal in response to negative (Lin et al., 2016) and positive stimuli (Brown et al., 2012). This was represented by reductions in amplitude of event related brain potentials corresponding to visual stimuli. Increased scores for valence and attenuated physiological arousal were previously found to be related to high psychopathic tendencies (Birbaumer et al., 2005; Benning, 2005; Herpertz et al., 2001). This account suggests that there may be contextual similarities between mindfulness and certain psychopathic features.

Psychopathic tendencies and aggressive behaviour have previously been related to low resting rate of the heart and attenuated physiological responses (Portnoy & Farrington, 2015; Latvala et al., 2015; Birbaumer et al., 2005). Low resting heart rate can result from morphological changes in the heart following prolonged participation in physically demanding sports, such as cycling, swimming, and practicing marital arts. This phenomenon is referred to as athletes' heart syndrome (Rawlins, Bhan, & Sharma, 2009). Moreover, previously published articles suggest that athletic individuals may have high trait mindfulness (Bernier, Thienot, Codron, & Fournier, 2009; Gardner & Moore, 2004). Altogether, these studies suggest that athletic individuals may be characterised by attenuated heart rate responding associated with increased trait mindfulness, and that mindfulness may be associated with low resting heart rate.

Several studies (Bradley et al., 2012; Bradley, 2009; Stanger et al., 2012; Azevedo et al., 2005; Lang & Bradley, 2010; Palomba et al., 1997) have demonstrated that heart rate initially decelerates prominently in response to emotionally valenced static images. Irrespective of the duration of static images, the heart rate returns to pre-exposure values after several seconds. The initial cardiac deceleration can be interpreted as an attentional startle response. The deceleration is greater when negative images are viewed, compared with pleasant and neutral images (Azevedo et al., 2005; Bradley, 2009; Palomba et al., 1997). Therefore, cardiac deceleration can be seen as representing a physiological measure of emotional valence (Lang, 1995; Palomba et al., 1997). According to Lang and Bradley (2010), and Palomba et al. (1997), the heart rate deceleration in response to negative pictures (e.g., mutilation images) represents an adaptive mechanism as such stimuli may be related to potential threats to the organism, and is consequently important for survival. Moreover, Bradley (2009) emphasized that less threatening scenes do not require excessive attentional processing, which consequently results in milder cardiac deceleration.

Video clips may capture and sustain attention better than static photographs. Furthermore, the multiple scenes shown during a video clip possibly evoke multiple attentional startle responses. Consequently, heart rate obtained during the motion clip is expected to be lower than before the clip (Codispoti, Surcinelli, & Baldaro, 2008; Simons, Detenber, Roedema, & Reiss, 1999). The rate of the heart is largely dictated by the balance of activity of the two branches of the autonomic nervous system (ANS). The parasympathetic, vagally mediated division slows the heart while the sympathetic division speeds it up (Berntson et al., 1997; Levy, 1990; Task Force of the European Society of Cardiology, 1996). HRV, an index of vagal activity, is typically reciprocally related to heart rate (Berntson et al., 1997; Levy, 1990; Task Force of the European Society of Cardiology, 1996). Hence, when motion images are viewed, an increase in HRV and a decrease in sympathetic activity can be anticipated. Video clips have previously been used to successfully evoke specific emotions, including amusement, disgust, and sadness (Philippot, 1993; Gross & Levenson, 1995). However, the way in which valence and arousal interact with cardiac responses to video clips is still a matter of debate (Hagenaars, Roelofs, & Stins, 2013; Carvalho, Leite, Galdo-Álvarez, & Gonçalves, 2012).

When watching a positively valenced video the body tends to move. However, reductions in body movements are observed if the movie is negative or neutral. A positive correlation between reductions in body movements and heart rate was observed for negative video viewing (Hagenaars et al., 2013). This may reflect evolutionary adaptive responses to threatening stimuli whereby reducing body movements can minimize detection by predators (Eilam, 2005). These findings taken collectively suggest that the shift in heart rate can be utilized as an index of stimulus aversiveness.

The typical response to distressing images is bi-phasic with the heart initially decelerating and then in a few seconds returning to the pre-exposure level (Lang & Bradley, 2010). The cardiac deceleration, in addition to being influenced by the valence and arousal of the stimulus, is related to the proximity of the stimulus and some personality traits. Thus, the deceleration is generally evident when the threat is distant. As the danger reaches a threshold of imminent confrontation, or the person exposed to the stimulus has a high level of anxiety, or a specific phobia, a subsequent rise in cardiac activity is observed (Pittig et al., 2013; Thayer, Friedman, Borkovec, Johnsen, & Molina, 2000; Palomba et al., 2000; Fredrikson, 1981). However, the relationship of mindfulness with changes in cardiovascular activity during exposure to aversive stimuli remains poorly understood. In the current study, cardiovascular responses during exposure to a distressing video clip were recorded and analysed. Here the movie stimulus did not pose a direct threat and consequently it was predicted that the average heart rate would be lower during exposure compared to pre-exposure. It was predicted that the overall slowing effect on heart rate averaged across the five-minute presentation period would be influenced by levels of trait mindfulness. However, highly anxious individuals may exhibit a distress response whereby the average heart rate is higher during exposure, compared to before.

The current paper reports two studies. The first study investigated ratings of self-report emotions, valence, and arousal elicited during a 5-minute-long violent video clip. The obtained scores for valence and arousal were then related to trait mindfulness. It was hypothesized that mindfulness would be associated with higher responses for valence, but lower arousal ratings. The second study examined changes in heart rate in relation to the violent video clip and how trait mindfulness is linked to those changes. Contrasting the heart rate obtained before exposure from during exposure to a stimulus provided a measure of cardiac responding. Conversely, contrasting the exposure heart rate with the rate post-exposure gave a measure of cardiac recovery. The cardiac response to negative stimuli is in part influenced by anxiety levels of the participant (Pittig et al., 2013; Thayer et al., 2000). Therefore, trait anxiety was used as a statistical covariate in analyses concerning changes in cardiovascular activity. As noted in the above paragraphs, mindfulness increases scores for valence and attenuates arousal, whereas heart rate deceleration, typically mediated by increased activity of the vagus, can be used as an index of stimulus aversiveness. Therefore, it was hypothesized that there would be a negative relationship between mindfulness and both heart rate responding to, and recovery from, the emotional stimuli.

Two separate studies were conducted. The first was a group study which examined self-report emotions, valence, and arousal evoked during the projection of a 5-minute-long violent video clip. Trait mindfulness scores were obtained before exposure and later related to the measures of valence, and arousal. The second study was a laboratory based exploration of the relationships between cardiovascular responses to the violent video clip and trait mindfulness, and anxiety. Ethical approval for both studies was granted by the University of Birmingham Committee for Ethical Review. Informed consent was obtained from all individual participants included in the two studies. Participants received either course credit or a monetary reward of ten pounds for their participation.

### 4.2.1 Study 2A

**Method**

*Participants*

An undergraduate student sample of 49 participants (28 female and 21 male) aged from 18 to 21 (mean age = 18.86 and SD = .84) was recruited from a U.K. based university via the local research participation scheme in return for course credit. Both males and females were recruited to approximately match the distribution of genders in the general population.

*Procedure*

The sample was split in two and tested on two separate occasions. The study took place in a large teaching room with the participants sitting amongst each other. Upon arrival, everyone was asked to read and sign a consent form, provide demographic information, and provide responses to the MAAS questions. The demographic information included participants' age and nationality. Afterwards, the 5-minute-long violent video clip was projected on a large screen. After the clip ended, participants provided responses on how they felt during the movie. Debrief was provided by the experimenter at the end of the testing procedure.

*Measures*

In this study mindfulness was measured with the Mindfulness Attention Awareness Scale [MAAS] (Brown & Ryan 2003). This scale is useful when investigating person's trait mindfulness as a single component. Furthermore, the Self Report Emotion Questionnaire (Gross & Levenson, 1995) – a self-report scale was administered to measure emotions elicited by video content, and the measures of valence and arousal were used as instructed by Lang (1995). Emotions were elicited by a 5-minute-long clip containing scenes of graphic violence. The video clip consisted of scenes from popular Hollywood movies, that is "American

History X” (1998) and Inglorious Basterds (2009). The scenes depicted a human performing acts of violence with clear intention to cause fatal injury to the victim. The violent acts included fatal blows to the head, killing by gun shots, armed robbery, mutilation using physical force, and racially aggravated crimes. The content is rated as not to be watched by under eighteens. In the current study, alpha reliability for the MAAS was $\alpha$=.79. Details of the other self-report measures can be found in the general methods section (Chapter 2).

*Data analyses*

Descriptive statistics of scores for each emotion were visually examined to determine the type of emotional reaction evoked by the clip. The relationships between trait mindfulness, and self-report scores for valence, and arousal evoked by the clip were correlated with the use of the Pearson’s *r* statistic. This analysis served the understanding of how trait mindfulness influenced the interpretation of the clip content during viewing.

## Results

*Characterization of the sample*

Ratings of emotions experienced during the video were highest for tension and disgust. Table 4.1 shows the means, standard deviations and medians for results of all measures used in Study 2A. Ratings for valence were mid-range negative, whereas arousal ratings were in the lower part of the scale. Mean score for the MAAS was roughly the same as previously obtained from an undergraduate sample (Brown & Ryan, 2003). Medians are reported because some of the data was not normally distributed.

Table 4.1: Descriptive statistics for variables used in Study 2A

| | Mean | SD | Med |
|---|---|---|---|
| Amusement | 1.8 | 1.1 | 1 |
| Anger | 3.22 | 2.03 | 3 |
| Arousal | 2.1 | 1.65 | 1 |
| Confusion | 2.67 | 1.82 | 2 |
| Contempt | 2.2 | 1.78 | 1 |
| Contentment | 1.37 | 0.76 | 1 |
| Disgust | 5.1 | 2.02 | 5 |
| Embarrassment | 1.59 | 1.14 | 1 |
| Fear | 2.92 | 2.09 | 2 |
| Happiness | 1.14 | 0.41 | 1 |
| Interest | 3.27 | 1.89 | 3 |
| Pain | 3.24 | 2.17 | 3 |
| Relief | 1.16 | 0.43 | 1 |
| Sadness | 3.84 | 2.17 | 3 |
| Surprise | 3.16 | 2.02 | 3 |
| Tension | 5.14 | 1.87 | 5 |
| Valence | -3.98 | 3.71 | -5 |
| Arousal | 2.71 | 2.75 | 2 |
| MAAS | 3.67 | 0.64 | 3.6 |

*Note. SD – standard deviation; Med – median; range of the scales can be found in the General Methods section.*

*Correlations between mindfulness, self-report valence, and arousal*

Trait mindfulness was positively correlated with valence ($r$ = .370, $p$ = .009) but not with arousal levels ($r$ = -.070, $p$ = .634) experienced during the 5-minute-long clip.

### 4.2.2 Study 2B

## Method

*Participants*

The study was run using students who were physically active as there is some evidence to presume that such individuals are mindful (Cathcart, McGregor, & Groundwater, 2014) and have low resting heart rates (Rawlins, Bhan, & Sharma, 2009). A sample of ten females and 23 males were recruited by the researcher at their training facilities. One female terminated the study amid the distress caused by the clip. The final sample consisted of 32 participants, aged between 18 and 31 (mean age = 20.69 and SD = 2.80). Inclusion criteria were participation in organized physical activity classes at least four times a week. At the time of the study 30 participants reported being students and two were in full time employment. Individuals were rewarded with a payment of £10.

*Procedure*

This study had two parts. In the first part participants were asked to fill out the self-report questionnaires. The second part entailed collecting cardiovascular data immediately before, during, and immediately after a 5-minute-long violent video clip.

Physically active individuals were approached at their training facilities and the purpose of the study explained to them. Those who were willing to participate (N=33) gave informed consent the following week just prior to completing the personality inventories. After completion session arrangements were made for the participants to attend the second, laboratory based part of the study.

The cardiovascular parameters were assessed using the Biocom 4000 electrocardiogram (ECG). The assessment took place in a laboratory, where the lights were dimmed and no significant distractors were present. On the day of testing, participants were asked to refrain from both exercise and potential stimulants. Participants were asked to sit quietly for 5 minutes before cardiovascular assessment commenced which allowed the individual to acclimatize to the room environment. Next, the participants were instructed on the testing procedure. During the explanation, a silver/silver-chloride electrode was placed on each participant’s wrist. Elastic sweat bands were used to prevent movement of the electrodes.

The ECG trace was collected over three 5-minute-long time intervals; immediately before, during, and immediately after the violent video clip. Before exposure to the video clip the participants sat quietly whilst their cardiac activity was measured for 5 minutes. After the 5 minutes of testing the video clip was displayed on a laptop monitor and another 5 minutes testing interval started. For a more detailed description of the content of the clip please refer to Study 2A methodology section. The final 5 minutes of cardiovascular activity was obtained immediately after the clip ended. This collectively gave a continuous 15 minutes of ECG recording. At the end of the testing procedure, each participant was given feedback on the study and some basic information about the ECG results.

Recorded traces were scanned for artefacts using the Biocom Heart Rate Scanner – PE software installed on a Samsung laptop. The quality of each trace was visually checked for artefacts. Where possible artefacts were identified and replaced with interpolated R-R intervals with the use of an automated software-based algorithm. A trace was rejected if signal noise prevented accurate visual localisation of the “R” wave, artefacts were too difficult to correct, or when the software deemed the recording to be poor quality. For each 5-minute-long ECG trace the average heart rate, and root mean square of successive heartbeat interval differences (rMSSD), a reliable measure of HRV (Task Force of the European Society of Cardiology, 1996) were calculated with the use of the dedicated software.

*Measures*

Mindfulness was measured with the Mindfulness Attention Awareness Scale (MAAS). In addition, the trait subscale of the State Trait Anxiety Inventory (STAI) was used. In the current study, Cronbach's alphas were $\alpha$=.8 for the MAAS and $\alpha$=.91 for the trait component of the STAI. These self-report measures are described in detail in Chapter 2.1. The same 5-minute video clip described in the previous study was used here.

*Data analyses*

The main effects of the video manipulation on heart rate and HRV (rMSSD) were analysed with the repeated measures ANOVA within subject's effects. The differences in cardiovascular activity between the three time intervals were further analysed with the repeated measures planned contrasts statistic. Therefore, rHR was compared with heart rate during exposure. Similarly, heart rate during exposure was contrasted with heart rate after exposure. Corresponding contrasts were obtained for rMSSD before, during and after the violent clip. Effect sizes are expressed as partial eta squared [$\eta^2_p$] with the following recommended norms for interpretation: small=.01; medium=.06; large=.14. Next, to examine the effects of mindfulness and trait anxiety, for each participant the strength of shifts in cardiovascular activity were calculated. This was done by subtracting the values of time interval variables from each other. This resulted in forming of four new variables, two for shifts in heart rate and two for shifts in HRV. Two variables denoting the change from before to during the clip were given an idiom - *reactivity*, whereas the other two - *recovery*. Higher values indicate greater shifts in cardiovascular activity. These new variables, as well as rHR and HRV were later correlated with trait mindfulness, and anxiety with the Pearson's *r* statistic. Lastly, partial correlations between trait mindfulness and shifts in cardiovascular activity using trait anxiety as a covariate were performed. The same analysis was performed for trait anxiety and cardiovascular shifts when trait mindfulness was entered as a covariate. The rationale for controlling for these variables as covariates is explained in the introduction section.

## Results

*Characterization of the sample*

For the current sample of N = 32, mean rHR was comparable to normative values (*M* = 80bpm). Resting rMSSD (HRV) values were higher than the mixed-gender norms (rMSSD: *M* = 42, *SD* = 15) reported by Nunan, Sandercock, and Brodie (2010). Descriptive statistics for trait mindfulness (*M* = 3.86, *SD* = .69) and anxiety (*M* = 41.94, *SD* = 10.40) were roughly the same as previously published values (Brown & Ryan, 2003; Spielberger et al., 1983). Table 4.2 shows the means and standard deviations for cardiovascular variables before, during, and after exposure to the clip.

Table 4.2: Descriptive statistics for cardiovascular activity before, during, and after the clip

| | Before | | During | | After | |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD |
| HR | 75.76 | 12.81 | 73.87 | 13.93 | 76.69 | 12.41 |
| HRV | 48.69 | 30.47 | 57.82 | 46.63 | 47.10 | 33.27 |

*Note: M = mean; SD = standard deviation*

*Effect of clip manipulation on Heart Rate (HR)*

Mauchly's test indicated that the assumption of sphericity had not been violated ($\chi^2$ (2) = .99, $p$ = .87). The effect of video manipulation on mean HR was significant ($F$(2,62) = 6.70, $p$ < .01, $\eta^2_p$ = .18). Additional examination of planned contrasts revealed that the average HR obtained during the 5-minute motion clip was slower than in the preceding ($F$(1,31) = 5.39, $p$ < .05, $\eta^2_p$ = .15) and following ($F$(1,31) = 12.68, $p$ < .01, $\eta^2_p$ = .29) non-exposure 5-minute long conditions.

*Effect of clip manipulation on heart rate variability (rMSSD)*

Mauchly's test indicated that the assumption of sphericity had been violated ($\chi^2$ (2) = .67, $p$ = 0.002), therefore the Greenhouse-Geisser correction is reported. The effect of video manipulation on HRV was significant ($F$(2,62) = 3.79, $p$ < .05, $\eta^2_p$ =. 11). Further examination of planned contrasts revealed that HRV did not differ before compared to during exposure to the violent video clip ($F$(1,31) = 2.97, $p$ = .10 $\eta^2_p$ = .09), but immediately following the clip HRV significantly decreased ($F$(1,31) = 9.58, $p$ < .01, $\eta^2_p$ = .24).

*Zero-order correlations between personality characteristics and cardiovascular activity before exposure, and in phases of reactivity, and recovery*

Trait mindfulness had a positive correlation with resting HR and a negative correlation with HR recovery. The later outcome suggests a relationship between high mindfulness and diminished shift in average HR between during and after the video clip. As expected, trait anxiety had a negative correlation with heart rate reactivity, which suggests that for highly anxious individuals the HR deceleration effect is less conspicuous. The remaining correlations were not significant. Table 4.3 contains the outcomes discussed in this paragraph.

Table 4.3: Pearson's zero-order correlations between psychological characteristics and cardiovascular activity before exposure, and in phases of reactivity, and recovery

| | HR before | HR reactivity | HR recovery | HRV before | HRV reactivity | HRV recovery |
|---|---|---|---|---|---|---|
| MAAS | .390* (.027) | -.129 (.480) | -.372* (.036) | -.228 (.210) | -.248 (.172) | -.311 (.083) |
| Trait Anxiety | -.070 (.703) | -.387* (.029) | .001 (.997) | .120 (.514) | .132 (.472) | -.097 (.597) |

*Note: The "p" values are in brackets; *p < .05.*

*Partial correlations between psychological characteristics and the shifts in cardiovascular activity*

Table 4.4 contains partial correlations for psychological characteristics and the shifts in cardiovascular activity. The rationale for using trait anxiety as a covariate is described in the introduction section. When trait anxiety was used as a covariate, trait mindfulness had a negative correlation with both variables representing a shift in average heart rate, that is HR reactivity and recovery. This suggests that trait mindfulness is associated with an overall diminished slowing effect on HR in response to the clip. Additionally, trait mindfulness and HRV recovery were negatively correlated, meaning that HRV recovery is weaker in participants scoring high on mindfulness. Similarly, when trait mindfulness was entered as a covariate, anxiety had a negative correlation with HR reactivity. The remaining variables were not significantly correlated.

Table 4.4: Partial correlations between personality characteristics and shifts in cardiovascular activity

| | HR reactivity | HR recovery | HRV reactivity | HRV recovery |
|---|---|---|---|---|
| MAAS | -.364* (.044) | -.415* (.020) | -.213 (.250) | -.397* (.027) |
| Trait Anxiety | -.500** (.004) | -.197 (.287) | .025 (.892) | -.276 (.133) |

*Note: Anxiety was entered as a covariate out when mindfulness was correlated and vice versa; the "p" values are in brackets; * $p < .05$, ** $p < .01$; MAAS – Mindfulness Attention Awareness Scale.*

### 4.3 Discussion

Mindfulness can be defined as a process of regulating attention in a way that promotes acceptance of present moment personal experience (Bishop et al., 2004). This definition suggests the hypothesis that increased trait mindfulness relates to a less negative interpretation of aversive stimuli. The results of Study 2A showed that participants rated a violent video clip as mildly arousing and aversive, whereas ratings of specific emotions were highest for tension and disgust. Individuals scoring higher on trait mindfulness rated the clip as less aversive. Moreover, Study 2B showed that the average HR was lower during the clip and returned to pre-exposure values immediately after exposure. This is in accordance with the HR deceleration observed in response to aversive static (Lang, Greenwald, Bradley, & Hamm, 1993) and motion images (Palomba et al., 2000) that evoked feelings of disgust. The change in vagally mediated HRV did not reach a statistically significant level. This suggests that the HR deceleration was not specific to the vagal influences on HR, and might have been mediated by sympathetic activity, or resulted from an interplay of the two systems. The HR deceleration was weaker for participants scoring higher on trait mindfulness. In addition to the hypothesized results, a positive correlation of trait mindfulness with rHR was found. It was concluded that increased mindfulness is associated with a less negative interpretation of aversive stimuli.

Theories of mindfulness have emphasized the regulatory processes that guide attention. More specifically, these processes may entail sustained concentration, fluent shifting of focus, and inhibition of excessive elaboration of thoughts, emotions, and sensations (Bishop et al., 2004). Typically, when attention is directed towards a mildly aversive emotion evoking stimulus, the HR slows. The deceleration is greater in response to negative, compared with pleasant and neutral stimuli. In the current study, when trait anxiety scores were used as a statistical covariate, trait mindfulness had an action on attention induced changes in HR. This relationship between mindfulness and attention was expressed in a dampening of the commonly observed slowing of the heart in response to viewing of a negative stimulus. The current results suggest that mindful attention dampens the typically observed cardiac response. This pattern of results therefore suggests that the mindful participant is attending with focus but interprets the stimulus as less negative.

An alternative interpretation of these results is that mindfulness is associated with reduced sensory intake during viewing of aversive motion images. The concomitants of orientating associated cardiovascular changes remain poorly understood. Bradley (2009) critically analysed a series of studies on HR deceleration in response to static emotion eliciting stimuli. She described the phenomenon as cardiac orienting related to sensory intake, whereby a more pronounced deceleration indexes enhanced perceptual focus. The understanding that cardiac orienting is related to increased sensory intake is supported by studies exploring memorization of emotional stimuli. These studies show that greater cardiac deceleration is associated with improved recall for emotional pictures and words (Abercrombie, Chambers, Greischar, & Monticelli, 2008; Buchanan, Etzel, Adolphs, & Tranel, 2006). Conversely, mindfulness was previously found to attenuate recall for negative words (Alberts & Thewissen, 2011). In the current study, higher scores on trait mindfulness are related to weaker cardiac slowing when watching the violent video clip. This suggests that mindfulness is related to a decrease in sensory intake of stimuli evoking negative feelings. However, whether these propensities hold true for video clips requires further experimental assessment.

Although the interpretation that mindfulness is associated with reduced sensory intake may appear to be at odds with descriptions of mindfulness that emphasize attention and awareness in the present moment, it should be noted that the mindfulness measure used in this study, the MAAS, assesses mindfulness along a single dimension. As such, it is possible that while some components of mindfulness may be associated with reduced sensory intake, other components e.g., the putative *Acceptance* scale of the Freiburg Mindfulness Inventory (FMI)

(Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006; Sauer, Walach, Offenbächer, Lynch, & Kohls, 2011) may be associated with the converse pattern. Indeed, previous studies using the FMI measure that assesses various components of mindfulness found differing relations of the *Presence* subscale and the *Acceptance* subscale with anxiety, depression, valence of words, and Stroop reaction times, a test of higher-order brain function associated with activity of the ACC (Kohls, Sauer, & Walach, 2009; Sauer et al., 2011). The potentially contrasting relations of different components of mindfulness with cardiac deceleration and reduced sensory intake are worthy of future investigation.

Shifts in HR in response to environmental cues may serve an evolutionary advantage of freezing when challenged. This response can be characterized by heightened stimuli intake, reductions in body movements, and other physiological changes (Korte, Koolhaas, Wingfield, & McEven, 2005). These physiological changes purportedly increase the chance of survival when danger occurs. Together with the slowing of the heart, freezing was observed when individuals were exposed to distressing static and motion images (Azevedo et al., 2005, Facchinetti et al., 2006; Vila et al., 2007). These studies support the notion that mindfulness is related to a less negative interpretation of aversive stimuli.

Activity in brain areas, such as the mPFC, ACC, and insula, have been shown to be related to both mindfulness and attention (Petersen & Posner, 2012; Tang et al., 2015). The ACC has been shown to have a high level of resting state activity in both novice and expert meditators (Tang et al., 2015). It has been observed by Etkin et al., (2006) that during a task that involved resolution of emotional conflict, rostral ACC (rACC) activity was inversely related to activity in the right amygdala. Both the strength of this inverse relationship as well as dampened autonomic responsivity were related to increased performance on the emotional conflict resolution task. Furthermore, another study argued that grey matter volume of the right amygdala is decreased in individuals with high trait mindfulness (Taren, Creswell, & Ginaros, 2013). Hence, the underlying brain structure and function seen in mindful individuals may also lend support to the conclusion that mindfulness is associated with a less negative interpretation of emotional stimuli.

Surprisingly, the current study found that like more mindful individuals, the more anxious participants show similar patterns of HR reactivity when one would expect these constructs to diverge. The similarity in the direction of these relationships is likely driven by different underlying mechanisms. Anxiety might have a positive relationship with affective reactivity, while the converse link was previously observed between mindfulness and affective reactivity (Ostafin, Brooks, & Laitem, 2014). Furthermore, the different patterns might be masked by the correlational procedures applied in the current study. The distinct effects of mindfulness and trait anxiety on cardiac responses to aversive stimuli represents an area worthy of future investigation.

It was shown here that the positive effects of mindfulness are associated with higher levels of resting HR. This result has been previously found in other types of meditative practices (Peng et al., 2004; Peng et al., 1999). This is paradoxical in that high rHR is normally associated with increased all-cause mortality and various coronary illnesses (Fox et al., 2007; Ho et al., 2014). Conversely, although low rHR is associated with good physical health, it is also strongly linked to many types of offending, including violent and non-violent crimes but not sex offences, and psychopathy (Latvala et al., 2015; Ortiz & Raine, 2004; Portnoy & Farrington, 2015). Increased mindfulness has previously been associated with reduced aggressiveness (Borders et al., 2010; Heppner et al., 2008; Singh et al., 2003), and has been suggested as a potential therapeutic intervention for improving emotion regulation among sexual offenders (Gillespie et al., 2012). The current pattern of results might suggest that mindfulness may be linked to reductions in aggressive behaviour via intrinsic, physiological mechanisms. However, the mediating effects of cardiovascular parameters on the inverse relationship of mindfulness with aggression is beyond the scope of the current paper, and may represent a potentially interesting avenue for future research.

There may be contextual similarities between mindfulness and psychopathic traits in that both characteristics are associated with reduced physiological responding and both can be linked with self-detachment as explained in the General Introduction. However, high psychopathic traits were previously found to be related to low rHR (Portnoy & Farrington, 2015). Conversely, the current findings suggest that mindfulness is linked with high rHR. Henceforth, mindfulness and psychopathy may be associated with different underlying biological mechanisms. Furthermore, previously published studies linked mindfulness with positive and psychopathy with negative psychological adjustment. This accordingly suggest that diminished physiological responses associated with high mindfulness may serve an adaptive role. The converse association may be expected between psychopathy and reduced physiological responses.

The participants were not asked about their actual experience with mindfulness techniques. This leaves open the possibility that the trait measured with the MAAS does not resemble actual mindfulness experience but only a unique quality of consciousness possessed by the participants (Brown & Ryan, 2003). The findings are also based on a relatively small sample and this may have implications for statistical power and effect size estimates (Button et al., 2013; Kühberger, Fritz, & Scherndl, 2014). As such, while the current results represent an interesting advance on the understanding of the relationship between trait mindfulness and physiological mechanisms, they should be confirmed in a larger sample. Finally, the cardiovascular measures were obtained from a sample of physically active individuals.

Cardiac activity and patterns of responding and recovery may differ in individuals who do not engage in physical exercise.

The current studies evaluated the relationship between trait mindfulness and emotional, and cardiac responding to a non-imminent threat, that is, an aversive, violent video clip. Outcomes indicate that individuals scoring high on trait mindfulness felt less negative emotions while viewing the clip and exhibited diminished cardiovascular slowing in response to the clip. Higher trait mindfulness was also associated with increased resting HR. Altogether these results suggest that mindfulness is related to reductions in negative feelings while attending to a violent motion stimulus. Speculative mechanisms upon which mindfulness acts to reduce negative emotionality are the decreased intake of negative emotional stimuli, demonstrated here by diminished cardiac orienting.

In Study 1 mindfulness was positively related to reappraisal. The current finding that mindfulness is related to increased scores for emotional valence and reduced heart rate responding highlights that trait mindfulness supports processes of emotion regulation. Good emotion regulation has previously been related to high indices of cardiac vagal activity (Smith et al., 2017). Levels of vagal activity can be raised by utilising respiratory biofeedback techniques. This raises the issue of whether a biofeedback course could be used to increase trait mindfulness. If so, this may represent the basis for novel therapeutic approaches to the treatment of some offender groups.

# CHAPTER 5 (STUDY 3): HEART RATE VARIABILITY BIOFEEDBACK COURSE FOR INCARCERATED OFFENDERS WITH ADDICTION DIFFICULTUES – QUANTITATIVE AND QUALITATIVE OUTCOMES

## 5.1 Introduction

Study 1 and 2 recruited participants from the community and investigated the relationships of mindfulness to some psychological traits and cardiovascular function. The current study sought to extend this work by attempting to elevate trait mindfulness and emotion regulation in a sample of male offenders by utilising HRV biofeedback.

The results of Study 2 suggest that high scores for mindfulness are related to diminished cardiovascular responses and the ability to regulate emotions. The underlying mechanism of this arrangement may be accounted for by the propensity of the ACC to inhibit amygdalar responses. A similar mechanism has previously been associated with emotion regulation. Moreover, reduced amygdalar responses and unimpaired emotion regulation were previously related to primary psychopathic characteristics, including proactive aggression. The converse pattern of amygdalar responses and poor emotion regulation can be related to reactive aggression. Literature described in the general introduction argues that strong connectivity between the ACC and the amygdala, and an effective ability to regulate emotions are linked to high HRV. Therefore, emotionally dysregulated aggressive individuals may benefit from interventions aimed at increasing HRV. Furthermore, it may be that a chronic increase in participants HRV and emotion regulation may elevate trait mindfulness.

Consequently, individuals characterised by primary psychopathic characteristics may potentially experience adverse effects of HRV interventions.

Emotion regulation can be described as the ability to modify one’s personal experience of emotion or perception of an emotional event (Aldao et al., 2010; Gross, 1998). Psychopathologies such as depression, anxiety, stress (Gross & Muñoz, 1995; Martin & Dahlen, 2005; Sinha, 2008; Barlow et al., 2004; Gross & John, 2003), and substance abuse (Fox et al., 2007; Fox et al., 2008; Xin et al., 2014; Verdejo-García et al., 2007) can be perceived as originating from a poor ability to effectively regulate emotions. The vicious cycle of substance misuse can be both sustained and intensified by depression (Brady, 2005; Markou, Kosten, & Koob, 1998; Grant et al., 2004), anxiety (Grant et al., 2004; Drake & Ross, 1997), and stress (Sinha, 2008; Kreek, Nielsen, Butelman, & LaForge, 2005). Therefore, substance abusers may benefit from interventions that elevate emotion regulation.

The prevalence rate of substance misuse is substantial for male offenders based in the U.K. (Fazel, Bains, & Doll, 2006; Brooke, Taylor, Gunn, & Maden, 1996). Moreover, results of a U.K. based study (Breedvelt, Dean, Jones, Cole, & Moyes, 2014) demonstrated that depression is a significant risk factor for recidivism in male, but not female substance abusers. The previous paragraph suggests that offenders, who abuse substances may have underlying difficulties in emotion regulation. It had been proposed (Gillespie et al., 2012; Day, 2009) that prison-based psychological interventions for sex offenders would benefit from addressing poor emotion regulation, and that respiratory pattern biofeedback, which shares certain features with mindfulness techniques, may exert such benefits (Gillespie et al., 2012). This research aims to investigate the latter proposal in a sample of incarcerated offenders with addiction difficulties.

Mindfulness based therapies, as stated in the General Introduction, have been reported to be effective in reducing symptoms of depression and anxiety (Hofman et al., 2010; Grossman et al., 2004). It has been further argued that undertaking mindfulness based therapies can lead to improved emotion regulation (Chambers et al., 2009), and may be useful in the treatment of substance misuse disorders (Zgierska et al., 2010; Bowen et al., 2005; Bowen et al., 2014).

Previous studies (Arch & Craske, 2006; Goldin & Gross, 2010; Broderick, 2005; Praissman, 2008) have noted the similarities between mindfulness based therapies and breathing biofeedback techniques with both approaches centring undivided attention to the breath. Other researchers (Chambers et al., 2009; Feldman et al., 2007) have suggested that mindfulness may represent an emotion regulation strategy. However, the detailed relationship between mindfulness, breathing biofeedback and emotion regulation warrants further investigation.

Breathing biofeedback techniques utilize the covariation between respiration and subtle fluctuations of the interbeat intervals of the heart. The autonomic input to the heart is from both the sympathetic division of the autonomic nervous system (ANS) and the parasympathetic division, with the latter input being mediated by the vagus nerve. The heart beat intervals lengthen as a result of increased activation of the vagus nerve during expiration, a process called respiratory sinus arrhythmia (RSA) (Grossman & Taylor, 2007; Berntson et al., 1997). The resulting beat-to-beat variation of the heart is called heart rate variability (HRV) (Task Force of the European Society of Cardiology, 1996). Increases in HRV is associated with elevated blood flow in various areas of the brain, including frontal and limbic structures (Thayer et al., 2012; Smith et al., 2017). These areas of the brain are crucially involved in emotion regulation and executive function (Ochsner & Gross, 2005; Davidson et al., 2000; Kane & Engle, 2002). This strongly suggests that HRV biofeedback has the propensity to improve emotion regulation by acting on the activity of certain brain structures.

Previous research emphasized that low HRV is associated with negative psychological characteristics, including depression (Carney et al., 2001; Gorman & Sloan, 2000), phobic anxiety (Kawachi et al., 1995; Friedman & Thayer, 1997), stress (Vrijkotte et al., 2000; Hall et al, 2004), and anger (Francis, Penglis, & McDonald, 2016; Wilson et al., 2016). Conversely, elevated levels of HRV had been positively linked with good emotion regulation (Hovland et al., 2012; Mezzacappa et al. 1998; Ruiz-Padial et al., 2003; Thayer & Lane, 2009; Thayer & Lane, 2000; Thayer et al., 2012; Thayer et al., 2009), and with performance on executive functioning tasks (Hansen et al., 2009; Hansen et al., 2003; Thayer et al., 2012; Thayer et al., 2009). Conversely, these findings suggest that HRV is low in individuals characterised by emotion dysregulation, including substance disorder sufferers.

Short term effects of deep and regular breathing will temporarily increase vagal control over the heart which may create a deep state of relaxation. Studies investigating short term effects of HRV biofeedback have promising outcomes. For example, Prinsloo et al. (2011) found that breathing relaxation improves cognitive performance in healthy male subjects. Furthermore, HRV biofeedback courses have previously been found to reduce symptoms of depression (Zucker et al., 2009; Karavidas et al., 2007; Nolan et al., 2005), anxiety (Paul & Garg, 2012; Renier, 2008; Bradley et al., 2010), stress (Nolan et al., 2005), and anger (Renier, 2008).

Enduring use of HRV biofeedback exercises may lead to long-lasting improvements in baseline HRV values (Wheat & Larkin, 2010; Zucker et al., 2009; Nolan et al., 2005, Paul & Garg, 2012, Renier, 2008). For example, Zucker et al. (2009) tested the effectiveness of a

HRV biofeedback intervention on a sample of community based individuals receiving treatment for substance misuse disorders. Participants were asked to use a biofeedback device 20 minutes daily for four weeks. At the end of the course, compared to before, participants reported lower scores for depression and increased baseline HRV values. However, it remains underexplored whether similar effects can be observed in a sample of incarcerated offenders with addiction difficulties.

As described earlier, substance abuse, depression, anxiety, and stress can be viewed as originating from difficulties in emotion regulation. Prisoners based in the U.K. commonly have a history of substance abuse. Interventions focused on treating incarcerated substance abusers may benefit from addressing poor emotion regulation. Sharing similar features with mindfulness, the breathing biofeedback technique is a promising method previously related to reductions in depression, anxiety, stress, and anger. This method has also been linked to long-lasting improvements in HRV, a physiological marker of emotion regulation. However, the effectiveness of HRV biofeedback in the treatment of offenders with addiction difficulties remains poorly understood.

The current study utilised the propensity for slow-paced breathing to increase HRV and exert positive effects on emotion regulation. It was hypothesised that the acute effects of a single HRV biofeedback session will include changes in mood, in particular, elevated self-report positive and decreased negative affect. Furthermore, chronic effects of participation in the HRV biofeedback course would include reductions in self-report scores for depression, anxiety, stress, and anger. An additional hypothesis stated that the ability of participants to regulate emotions would increase. This would be apparent in elevated scores for certain emotion regulation strategies, manly *reappraisal* and facets of mindfulness *acting with awareness* (act aware) and *non-judgement*. In addition to the quantitative analysis, a series of informal interviews were conducted in order to explore participants' impressions of the effects of the curse. This included medical information, criminal history, general psychological presentation, course performance and satisfaction, reports of any significant change in behaviour, and comments obtained during a post course interview. It was anticipated that participants would provide descriptions of how the course affected their psychological well-being and ability to regulate emotions. The qualitative analysis is presented after the quantitative results.

## 5.2 Method

### *Participants*

This study recruited participants for a treatment and a control group. For the treatment group, a sample of 10 incarcerated white males with addiction difficulties, aged between 25 and 54 ($M$ = 35.7, $SD$ = 9.50) were recruited from a local prison. The criteria for recruitment were anxiety, emotion control issues, and substance abuse. Participants were either referred by their key workers or voluntarily approached the course facilitator. Prior to recruitment, the experimenter contacted the nursing staff to confirm the mental status of the volunteers. Majority of the men were medicated with methadone. However, other types of medication were also prescribed to them. These various types of medication are listed in Table 5.1. The participants were being sentenced for various offences with the majority of offences being economically motivated. The offence histories are detailed in the participants' individual descriptions. For the control group, participants were five white male prisoners with addiction difficulties. Individuals from the treatment and control groups were imprisoned in the same house block.

Table 5.1: Mental Health and Medication Glossary

| Pseudo | Clinical Mental Health | Medication |
|---|---|---|
| Participant 1 | Reactive anxiety, low mood | Methadone |
| Participant 2 | Anxiety, depression | Methadone, Sertraline |
| Participant 3 | Depression | Methadone, Omeprazole, Citalopram |
| Participant 4 | Personality disorder | Lofexidine |
| Participant 5 | None diagnosed | Vareniciline |
| Participant 6 | Anxiety | Methadone, Sertraline, Olanzapine |
| Participant 7 | Depression | Methadone |
| Participant 8 | Depression | Methadone, Mirtazipine, Omeprazole, Simvastatin, Rampril |
| Participant 9 | GAD, paranoia | Methadone, Pregabalin |
| Participant 10 | Depression, psychosis | Methadone, Zopiclone, Quetiapine |

*Note. GAD – General Anxiety Disorder.*

*Psychometric questionnaires*

The Positive and Negative Affect Schedule (PANAS) was administered to investigate the effects of a single session on acute changes in mood resulting from participation in the exercise. Psychometric questionnaires used to measure the chronic effects of biofeedback relaxation on psychological characteristics were the Emotion Regulation Questionnaire (ERQ), the Depression Anxiety Stress Scales (DASS-21), State Trait Anger Expression Inventory (STAXI-2), and the Five Facet Mindfulness Questionnaire - Short Form (FFMQ-SF). The abridged version of the FFMQ is useful when there are time constrictions and for the purpose of testing prisoners. Alpha reliabilities for the current outcomes were not calculated due to the small sample size. Details of these questionnaires can be found in section 2.1.

*Relaxing Rhythms*

The Relaxing Rhythms device (http://www.healingrhythms.co.uk/) generates a real time correlate of HRV which is shown as a graphic representation. The participant is instructed to adjust their pattern of breathing, typically by taking slow deep breaths in and out, so as to maximise the HRV correlate. The devise detects changes in pulse rate (a reliable index of heart rate) via sensors connected to three fingers of the left hand. Information from the device travels to a laptop computer with pre-installed Relaxing Rhythms software. This software computes a coherence score by comparing the participant's time based HRV values with pre-determined HRV values that reflect a respiratory pattern of six breaths per minute. Thus, if the participant's HRV deviates from the ideal values the coherence score decreases. The coherence score is presented to the participant in the form of coloured bars. This acts as a biofeedback prompt which the individual can use as an error signal in order to adjust the pattern of breathing. By this means the participant can potentially boost vagal output and thus increase HRV. When high coherence scores are achieved, the user typically finds himself in a state of relaxation. The system also presents skin conductance scores but the participants were encouraged to focus on the respiratory related feedback. The software also features relaxing music, which is played automatically during session.

*Procedure*

Participants for both the treatment and the control group were asked to read and sign a consent form, and provide responses to psychometric questionnaires in a set order: ERQ, DASS-21, STAXI-2, FFMQ-SF. The experimental group was asked to participate in biofeedback exercises, whereas the control group adhered to their usual activities. To explore the chronic effects of the treatment, participants in the experimental condition provided responses to identical questionnaires before and after the course. However, the post course questionnaires were administered to successful completers only. Participants in the control group completed the questionnaires before and after a five-week long interval. Moreover, to investigate the acute effects of the biofeedback exercise, the treatment group completed the PANAS immediately before and after the fifth session. These acute effects of HRV biofeedback were not explored earlier to allow the participants to become familiar with the slow-paced breathing pattern. Demographic, medical, and offence related information was obtained for the treatment group only.

The biofeedback sessions were facilitated in a U.K. based, male only prison. This prison was divided into house blocks, each holding over 100 inmates. An individual house block was further divided into sections called wings and a landing area. The former is where the prisoner cells were located. The biofeedback sessions were held in a room located on the landing area. This area was less noisy compared to the wings. This meant the participants could focus on their sessions. Sessions were administered for up to two participants at a time. Each participant was allocated with 15 sessions, a single session lasting 30 minutes. Session availability was three times in a week for up to six weeks. During a single session, each participant was asked to regulate the pattern of his breath for about 15 minutes.

*Quantitative analyses*

To investigate whether the assumption of normality was maintained, the differences between scores were computed for each set of variables obtained before and after the designated time periods. This resulted in the formation of new variables, one for each set, that were checked for normality with the Shapiro-Wilk test. This is a standard procedure applied for the paired samples t-test statistic (Field, 2013). Results indicated data obtained from the treatment group did not deviate from a normal distribution. However, for the control group variables *anger expression out* and *nonjudge* were not normally distributed.

Paired samples t-tests were performed to investigate the pre-post differences in scoring for all normally distributed variables both in the treatment and the control group. Because of the small sample sizes, bootstrapping was performed using 1000 bootstrap samples. The *bias corrected and accelerated* 95% confidence intervals are reported based on the bootstrap estimation as suggested by Field (2013). For each pair of variables (pre-post) Cohens *d* effect sizes were computed. According to de Winter (2013), the paired samples t-test is a feasible statistical analysis for small sample studies when the correlation between the investigated pair is high. Therefore, for the treatment group only, these correlations were also reported. Data that did not meet assumption of normality were analysed with the Wilcoxon repeated samples test.

*Qualitative analyses*

After completion of the biofeedback course, the majority of the participants were interviewed by the researcher on a one to one basis. The informal interviews were held in therapy rooms located in the prison house blocks. The aim of the interviews was to obtain participants' impressions of the effects of the course. The participants were encouraged to speak freely about their experience of participating in the course. Prison policies did not permit audio recording equipment on site. Instead, the researcher took written notes of the participants accounts. The notes were later screened for impressions expressed by more than one participant, and for any negative impressions. The final list of impressions was supplemented by information obtained from a list of informal observations of participants. This was collected by the researcher on a day to day basis. A summary of the findings of this analysis can be found in the results section.

Detailed conclusions from these interviews are incorporated in a series of informal profiles which are described in Appendix number two. The informal profiles provide a detailed description of the participants demographic, medical and offence related information, and behavioural and psychological presentation which was informally observed by the researcher during and shortly after the course. Furthermore, for each successful completer, that is a participant who completed 15 sessions, pre and post differences in personality characteristics were investigated. Noteworthy changes are mentioned in the participants' profiles. These profiles were created to provide the reader with a comprehensive account of the participants. Such an approach may act as a guide in processes of selection of participants for future prison based interventions. To ensure anonymity was maintained, the names of the participants were removed, and their age approximated.

## 5.3 Results

### *Acute effects of the fifth biofeedback session on positive and negative affect*

*Characterisation of the sample*

For the treatment sample (N = 10), mean values for *positive affect* (*M* = 13.60, *SD* = 1.65) were lower than normative values reported in a large community sample of males (*M* = 17.37, *SD* = 3.13). Furthermore, the current participants scored higher on *negative affect* (*M* = 10.10, *SD* = 3.28) before the session than the normative sample (*M* = 8.52, *SD* = 3.28) (Mackinnon et al., 1999).

*Acute effects of a single biofeedback session*

Participants scored higher on *positive affect* after the fifth session (*M* = 14.90, *SD* = 2.89) than before. This difference, -1.3, BCa 95% CI [-2.7, -0.1] was not significant $t(9) = -1.54$, $p = .158$. However, it did represent a medium-size effect, $d = -.55$. The within-pair correlation was not significant for positive affect ($r = .412$, $p = .24$).

The scores for *negative affect* were lower after the fifth session (*M* = 7.20, *SD* = 2.39), than before. This difference, 2.9, BCa 95% CI [1.8, 4.2] was significant $t(9) = 4.106$, $p = .003$, and indicated a large-size effect of $d = 2.74$. The within-pair correlation for negative affect was high ($r = .733$, $p = .02$).

***Chronic effects of the entire biofeedback course on various psychological characteristics***

*Characterisation of the treatment sample*

Data obtained from seven participants were included in this analysis. Mean values for each variable obtained before the course were compared to previously reported normative values found in healthy nonoffenders. The current participants scored lower than normative healthy controls on *observe*, *describe*, and *nonjudge*. Furthermore, the offenders scored higher on *suppression*, all DASS-21 subscales, both anger expression variables, and *nonreact*. Mean scores were roughly similar for *reappraisal*, both anger control scales, and *act aware* (Bohlmeijer et al., 2011; Melka et al., 2011; Lievaart et al., 2016; Henry & Crawford, 2005). Table 5.2 contains the means and standard deviations and normative values for all variables included in the current analysis.

Table 5.2: Descriptive statistics for the treatment group

| Variable | Before | | After | | Norm. | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ERQ Reappraisal | 28.00 | 6.856 | 28.86 | 5.843 | 28.48 | 6.29 |
| ERQ Suppression | 18.43 | 6.294 | 15.86 | 7.267 | 14.91 | 4.67 |
| DASS Depression | 15.29 | 4.112 | 9.71 | 5.112 | 2.83 | 3.87 |
| DASS Anxiety | 15.14 | 5.122 | 8.43 | 5.192 | 1.88 | 2.95 |
| DASS Stress | 15.43 | 3.690 | 9.43 | 6.268 | 4.73 | 4.20 |
| Anger Exp. Out | 18.71 | 3.729 | 16.71 | 3.546 | 14.76 | 3.90 |
| Anger Exp. In | 22.00 | 4.655 | 19.00 | 3.055 | 17.48 | 3.89 |
| Anger Cont. Out | 20.57 | 5.159 | 22.43 | 3.867 | 20.96 | 4.26 |
| Anger Cont. In | 19.43 | 6.241 | 22.14 | 3.671 | 21.23 | 5.03 |
| FFMQ Observe | 11.57 | 2.820 | 11.71 | 2.628 | 13.86 | 3.21 |
| FFMQ Describe | 13.57 | 3.101 | 13.86 | 2.968 | 16.28 | 3.91 |
| FFMQ Act Aware | 13.29 | 3.817 | 14.57 | 1.618 | 13.19 | 3.32 |
| FFMQ Non-judge | 11.71 | 2.690 | 14.86 | 3.579 | 14.09 | 3.63 |
| FFMQ Non-react | 14.86 | 2.478 | 13.57 | 3.599 | 13.47 | 3.07 |

*Note. Sample size = 7; Norm. = normative values; M = mean; SD = standard deviation; Exp. = expression; Cont. = control; ERQ = Emotion Regulation Questionnaire, DASS = Depression Anxiety Stress Scales (short version); FFMQ = Five Facet Mindfulness Questionnaire; Anger variables were assessed using the State Trait Anger Expression Inventory (STAXI-2).*

*Chronic effects of the biofeedback course*

Significant effects of the biofeedback course were observed for all subscales of the DASS-21 questionnaire, the *anger out*, and *anger in* subscales of the STAXI-2 and the *non-judge* facet of the FFMQ-SF. Cohen's *d* effect sizes were within the very large range for the DASS-21 subscales. A medium to large effect size was observed for *anger out*, *anger in*, and *non-judge*. However, significant and high within-pair correlations were only apparent for the three latter variables. Table 5.3 contains the results of the t-test and Cohen's *d* statistics for all variables relevant for the current analysis. Chart 1 presents these outcomes in easy to interpret bar charts.

Table 5.3: Chronic effects of the biofeedback course

| Variable | Mean diff. | Lower CI | Upper CI | df | t | p | d | r | p^ |
|---|---|---|---|---|---|---|---|---|---|
| ERQ Reappraisal | -.857 | -3.833 | 2.286 | 6 | -.456 | .658 | -.14 | .716 | .071 |
| ERQ Suppression | 2.571 | -1.881 | 7.235 | 6 | .840 | .433 | .38 | .293 | .524 |
| DASS Depression | 5.571 | 2.356 | 8.843 | 6 | 3.812 | .009** | 1.20 | .669 | .100 |
| DASS Anxiety | 6.714 | 3.875 | 9.667 | 6 | 4.502 | .004** | 1.45 | .659 | .108 |
| DASS Stress | 6.000 | 2.356 | 9.317 | 6 | 3.707 | .010** | 1.16 | .747 | .054 |
| Anger Exp. Out | 2.000 | .444 | 3.616 | 6 | 2.542 | .044* | .55 | .837 | .019* |
| Anger Exp. In | 3.000 | 1.459 | 4.500 | 6 | 2.598 | .041* | .76 | .726 | .047* |
| Anger Cont. Out | -1.857 | -4.721 | .857 | 6 | -1.355 | .224 | -.41 | .712 | .072 |
| Anger Cont. In | -2.714 | -6.220 | 1.370 | 6 | -1.321 | .235 | -.80 | .499 | .254 |
| FFMQ Observe | -.143 | -2.667 | 3.000 | 6 | -.091 | .930 | -.05 | -.154 | .741 |
| FFMQ Describe | -.286 | -2.667 | 2.143 | 6 | -.210 | .840 | -.10 | .300 | .513 |
| FFMQ Act Aware | -1.286 | -3.858 | 1.649 | 6 | -1.063 | .329 | -.44 | .563 | .188 |
| FFMQ Non-judge | -3.143 | -4.166 | -2.000 | 6 | -6.181 | .001** | -.99 | .947 | .001** |
| FFMQ Non-react | 1.286 | -1.000 | 3.833 | 6 | .836 | .435 | .42 | .141 | .762 |

*Note. Sample size = 7; CI = confidence interval; df = degrees of freedom; p = significance of the t-test; d = Cohen's d effect size; r = Pearson's correlation; p^ = significance of the Pearson's correlation between variables obtained before and after the course; * = p < .05; ** = p < .01; ERQ = Emotion Regulation Questionnaire, DASS = Depression Anxiety Stress Scales (short version); FFMQ = Five Facet Mindfulness Questionnaire; Anger variables were assessed using the State Trait Anger Expression Inventory (STAXI-2).*

***Summary of informal interviews and observations***

During the informal post-course interview completers frequently described reductions in anxiety and anger, which further supports the current quantitative findings. Less frequently described and noteworthy changes in psychological characteristics included reductions in intrusive thoughts and increased 'awareness' of bodily sensations and mental events. Each of the successful partakers reported using the slow-paced breathing technique outside the sessions. Moreover, a small number of participants reported improvements in sleep quality.

Importantly, certain negative impressions were reported and observed by the researcher. One participant, who suffered from general anxiety disorder, reported anxious feelings when taking deep breaths and this was interpreted as a case of asphyxophobia, that is the fear of being unable to breath. Furthermore, a participant who suffered from a personality disorder became more violent and antisocial thought the course. This participant appeared to be least satisfied with the effect of the biofeedback course. Moreover, the experimenter observed that for some participants ingestion of methadone or other medication prior to attending a session had an adverse effect on coherence scores during the session. Conversely, the participants suggested that medication interacted positively with the biofeedback exercise.

### ***Control group***

*Characterisation of the sample*

There were five participants in the control group. The mean scores obtained from the questionnaires completed at the first time point were compared to normative values found in healthy nonoffenders. Compared to the latter, the current sample scored lower on *reappraisal*, *anger control in*, *observe*, *describe*, and *nonreact.* Furthermore, the offenders scored higher on the three DASS-21 subscales, *anger out*, *anger in*, *act aware*, and *nonjudge.* Mean scores were roughly similar for *suppression,* and *anger control out*. (Bohlmeijer et al., 2011; Melka et al., 2011; Lievaart et al., 2016; Henry & Crawford, 2005). Similarly, to the treatment group, the current control sample showed marked elevations in baseline scores for all DASS-21 subscales and anger expression variables. Table 5.4 contains the means and standard deviations for all variables included in the current analysis, and the normative values for these variables.

Table 5.4: Descriptive statistics for the control group

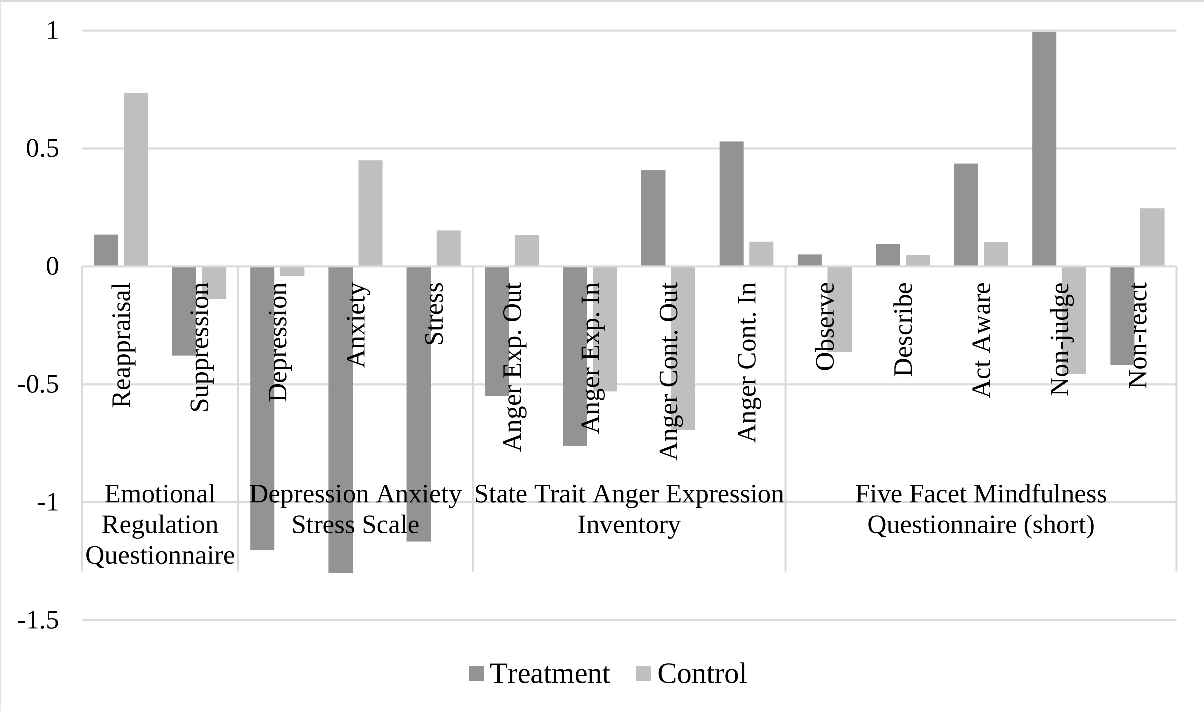
| | Before | | After | | Norm. | |
|---|---|---|---|---|---|---|
| Variable | M | SD | M | SD | M | SD |
| ERQ Reappraisal | 20.20 | 10.862 | 28.00 | 10.368 | 28.48 | 6.29 |
| ERQ Suppression | 15.80 | 5.718 | 15.00 | 5.916 | 14.91 | 4.67 |
| DASS Depression | 13.00 | 5.701 | 12.80 | 3.962 | 2.83 | 3.87 |
| DASS Anxiety | 10.20 | 7.463 | 13.00 | 4.690 | 1.88 | 2.95 |
| DASS Stress | 13.00 | 7.000 | 13.80 | 2.490 | 4.73 | 4.20 |
| Anger Exp. Out | 19.60 | 5.683 | 20.20 | 2.864 | 14.76 | 3.90 |
| Anger Exp. In | 22.40 | 3.362 | 20.60 | 3.435 | 17.48 | 3.89 |
| Anger Cont. Out | 22.20 | 6.017 | 18.80 | 3.421 | 20.96 | 4.26 |
| Anger Cont. In | 18.60 | 5.030 | 19.00 | 2.000 | 21.23 | 5.03 |
| FFMQ Observe | 12.60 | 3.847 | 11.20 | 3.899 | 13.86 | 3.21 |
| FFMQ Describe | 13.60 | 4.827 | 13.80 | 3.114 | 16.28 | 3.91 |
| FFMQ Act Aware | 14.20 | 1.643 | 14.40 | 2.191 | 13.19 | 3.32 |
| FFMQ Non-judge | 16.40 | 1.817 | 15.40 | 2.510 | 14.09 | 3.63 |
| FFMQ Non-react | 12.60 | 2.074 | 13.00 | 1.000 | 13.47 | 3.07 |

*Note. Sample size = 5; Norm. = normative values; M = mean; SD = standard deviation; ERQ = Emotion Regulation Questionnaire, DASS = Depression Anxiety Stress Scales (short version); FFMQ = Five Facet Mindfulness Questionnaire; Anger variables were assessed using the State Trait Anger Expression Inventory (STAXI-2).*

*Five weeks of imprisonment without biofeedback treatment*

For the control group, there were no significant differences in self-report psychological characteristics between responses obtained during the first and second assessments. Chart 1 graphically illustrates Cohen's *d* effect sizes for the differences in pre-post scores for the treatment and control group.

Chart 5.1: Cohen’s *d* effect size – chronic effects for both the treatment and the control group




*Note. Values were reversed to illustrate the actual direction of change i.e. decrease in depression.*

### 5.5 Discussion

The current study explored the potential for a breathing biofeedback course to improve emotion regulation in a sample of male prisoners who suffered with addiction difficulties and a variety of psychiatric conditions, including depression and anxiety. The data suggest that the therapeutic approach exerted positive effects, both acutely and chronically, on indexes of emotion regulation, that is, the ability to modify personal experience of emotion or perception of an emotional event (Aldao et al., 2010; Gross, 1998). These findings are especially pertinent in relation the treatment of offenders as difficulties with emotion regulation have been associated with offending and recidivism (Roberton et al., 2014; Long et al., 2014; Davidson et al., 2000; Breedvelt et al., 2014). Moreover, the results are all the more striking given the psychiatric complications and addiction problems that the participants were suffering from.

A single biofeedback session was associated with an immediate alleviation of negative affect while reduced symptoms of depression, anxiety, stress and anger expression were seen on completion of the treatment course. However, the most striking beneficial effect of chronic treatment was on the nonjudgement facet of mindfulness. This shift indicates that the participants developed a less critical approach to their personal experiences, including emotions. The absence of equivalent changes in the control sample of prisoners strongly suggests that therapeutic benefit results from the biofeedback programme and do not reflect the consequences of mere imprisonment.

The qualitative analysis of the response of the individual participants to the biofeedback programme enables some insight into the effectiveness of the therapy. On the whole, participants reported positive effects of participation. This included reductions in negative emotions and behaviours, increased attentiveness to personal sensations, and improvements in the quality of sleep. Furthermore, most participants reported using the controlled breathing technique in situations which they deemed it useful. This suggests actual attempts may have been made to regulate emotional experiences. Perhaps not surprisingly, there appears to be an interaction between the perceived effects of HRV biofeedback and medication ingested prior to a session. This interaction was expressed by reduced coherence scores during certain session and positive impressions of the affected individuals. Future research may investigate the link by controlling for the effects of medication. In summary, the findings of the informal interviews support the notion that offenders with addiction difficulties can benefit from prison based interventions aimed at improving emotion regulation.

The physiological mechanisms driving the observed beneficial effects of breathing biofeedback on emotion regulation cannot be discerned on the basis of the current data.

However, it seems likely on the basis of previous work that the effects reflect changes in HRV. The respiratory biofeedback technique encourages the participant to breathe at slow, regular intervals. This pattern of inhalation/exhalation is known to maximise the effects of the respiratory sinus arrhythmia. This physiological effect boosts activity in the vagus nerve, that is, the parasympathetic innervation of the heart, which accordingly slows the heartbeat (Grossman & Taylor, 2007). This augmented activity of the vagus simultaneously results in elevated blood flow in certain parts of the brain due to the actions of the ascending branches of this cranial nerve (Smith et al., 2017; Thayer et al., 2012; Ochsner & Gross, 2005; Davidson et al., 2000; Kane & Engle, 2002). Critically, the brain areas which are most influenced by the shift in blood flow are those which are integrally involved in the processes of emotion regulation and executive function. Thus, it seems plausible that the improvements seen in emotion regulation following breathing biofeedback result from increases in HRV and prefrontal function.

Repeated exposure to similar biofeedback exercises are known to have long-lasting effects (Wheat & Larkin, 2010; Zucker et al., 2009; Nolan et al., 2005, Paul & Garg, 2012, Renier, 2008) with individual practitioners developing a trait-like propensity to efficiently regulate emotions when they arise. In the current study the predisposition to regulate emotions is manifested in reductions of negative affect and a less judgemental approach to personal experiences, the latter being a facet of mindfulness that is closely related to the concept of emotion regulation. Increase in nonjudgement may account for the cumulative effects seen in the current study.

Heart rate variability biofeedback exercises have contextual similarities with mindfulness meditation whereby both techniques teach practitioners to focus on the breath. The results of the current study suggest that slow paced breathing may increase the practitioners' nonjudgement, that is the ability to approach personal experiences less critically. Moreover, the participants reported being more attentive to personal sensations which suggests that the continuous focus of attention on the pace of the breath may increase participants ability to act with awareness. Therefore, biofeedback sessions seem to elevate two critical factors of mindfulness (Shapiro et al., 2006). The current findings suggest that trait mindfulness can be taught with the use of biofeedback devices.

Teaching clients mindfulness techniques is frequently done by a skilled individual. Such interventions may last for several weeks or months. The cost of an eight week long course led by a skilled practitioner can sometimes be expensive. This cost may understandably increase if the course should be administered in a secure setting. Furthermore, certain clients may present with risky behaviours which can be frightening to the practitioner or simply lack the skills or abilities to acquire knowledge from verbal instructions. For example, foreign language speakers or deaf persons. In such circumstances, biofeedback equipment may provide a relatively inexpensive and risk-free alternative to person led intervention.

The current research may have considerable potential in aiding the treatment of offenders. Dowden and Andrews (2000), in a review of studies, found correctional treatments that target negative mood and anger reduce violent reoffending. Moreover, depression is a significant risk factor for recidivism in male substance abusers (Breedvelt et al., 2014). A systematic review of studies performed in the U.K., Canada, New Zealand, and the U.S.A. indicates that for male offenders, substance misuse rates varied between 10% and 48% (Fazel et al., 2006). In the current study, which recruited substance abusers, participation in the HRV biofeedback course led to reductions in depressive feelings and anger. Thus, HRV biofeedback may contribute to reduction in recidivism, which is a priority for the National

Offender Management Service (NOMS). It is proposed that the existing interventions should consider assimilating HRV biofeedback techniques. However, large-scale and longitudinal studies are essential to validate this proposal.

Despite the encouraging results presented here the use of breathing biofeedback approaches to the therapeutic treatment of offenders should be approached with caution. As stated above, the presumed mechanism underlying the beneficial effects of the programme are increases in HRV. High HRV, however, is very strongly related to low rHR (Berntson et al., 1997; Levy, 1990) and low rHR has been positively associated with incidences of several types of offending (Latvala, Kuja-Halkola, Almqvist, Larsson, & Lichtenstein, 2015) and with psychopathy (Portnoy & Farrington, 2015). The causes of the robust relationship between low rHR and offending are still the subject of debate. However, unpublished studies performed in our laboratory have demonstrated that rHR is related to proactive aggression but not to reactive aggression. Thus, it could be that increasing HRV may encourage proactive tendencies in individuals with high primary psychopathic traits.

The current study, as noted before, found that effects of participation in the HRV biofeedback course include elevated mindful nonjudging. Findings of Studies 1 and 2 suggest that primary psychopathic traits are positively associated with trait mindfulness. Thus, controversially, HRV biofeedback treatment may have an effect on clients' fearless and unemotional characteristics. Indeed, as mentioned in the results section, the participant diagnosed with personality disorder (Participant 4) showed increasingly disruptive behaviour which ultimately cumulated in him being moved to a different prison. This decline in behavioural presentation may be contributed to an increase in fearlessness and decrements in empathy which may have resulted from participation in the biofeedback course.

It should be noted that three participants failed to complete the breathing biofeedback course. Of these, two were diagnosed with psychoses or paranoia, and one developed a respiratory infection which caused him to cough when taking deep breaths. Interestingly, none of the successful completers were diagnosed with psychotic-like symptoms. This observation suggests a high dropout rate for individuals who reported a history of hallucinations and delusional beliefs. However, this putative explanation remains to be explored in larger samples.

Findings of this study are limited by the small sample size. Limited sample sizes may have implications for statistical power and effect size estimates (Button et al., 2013; Kühberger, Fritz, & Scherndl, 2014). However, the obtained within-pair correlations for both anger expression scales and nonjudgement were nonetheless high which suggests that the findings can be trusted (de Winter, 2013). Another limitation is that the values for HRV were not obtained. This brings to question the interpretation that the participants increased their emotion regulation due to elevated HRV. However, the intention of the current course was to elevate emotion regulation and this was achieved. The control group showed no improvements in emotion regulation. This suggests that the effects observed in the HRV biofeedback group were specific to the intervention.

The current research investigated the potential for respiratory biofeedback to improve emotion regulation in incarcerated offenders with addiction problems. A single session resulted in reductions in self-report negative affect. Compared to the initial assessment, after 15 biofeedback sessions the participants scored lower on depression, anxiety, stress, both anger expression scales, and notably higher on the nonjudgement facet of mindfulness. Outcomes of the post course interview widely support the quantitative findings and extend the effects of treatment by improvements in quality of sleep. However, the behaviour of one participant, who was diagnosed with a personality disorder, appeared to decline during the course with reports of increased aggressiveness. Furthermore, two of three drop-outs were previously diagnosed with psychotic-like symptoms indicative of a high dropout rate for individuals who have experienced symptoms of psychosis. It is concluded that HRV biofeedback can successfully increase emotion regulation in offenders with mood and addiction disorders whilst it may be of more limited use when dealing with individuals who are suffering from either personality or psychotic disorders.

This study has shown that slow, deep breathing exercises can elevate emotion regulation in a sample of male offenders. These exercises were previously shown to increase baseline HRV. Indices of HRV are commonly inversely related to rHR. Importantly, it is well supported that rHR is unusually low in many groups of offenders and aggressive individuals. This accordingly suggests that certain types of offenders may have high HRV and that some traits associated with offending may be positively related to HRV. Study 4 aimed to elucidate the concomitants of low rHR and aggressive traits.

# CHAPTER 6 (STUDY 4): CARDIAC AUTONOMIC FUNCTIONS AND PSYCHOLOGICAL CHARACTERISTICS OF HETEROSEXUAL FEMALE PERPETRATORS OF INTIMATE PARTNER PHYSICAL AGGRESSION

## Dissemination

As with Chapter 4, elements of this chapter are taken directly from a manuscript which was submitted for publication to Journal of Interpersonal Violence. This manuscript was co-authored by the candidate's supervisors (Dr Ian Mitchell and Dr Louise Dixon) and co-worker (Dr Steven Gillespie). The candidate was the principal researcher with respect to designing and executing the study, undertaking the data analyses, and writing the paper. Dr Ian Mitchell collaborated with the design and writing of the study. Dr Louise Dixon collaborated with editing of the final manuscript. Dr Steven Gillespie collaborated with the design and writing of the study, and assisted with the data analyses.

## 6.1 Introduction

The findings of Study 3 suggest that good emotion regulation may be linked to high HRV in male offender samples. However, offenders often show low resting heart rate (rHR) and this may reflect high parasympathetic activity and consequently would be associated with elevated HRV. This accordingly suggests that aggressive traits which can be associated with unimpaired emotion regulation may be related to high HRV. Previously published studies indicate that primary psychopathic traits and proactive aggression may not be characterised by emotion dysregulation. Interestingly, certain types of partner violent males react to marital interaction with heart rate deceleration and more speculatively with an increase in HRV.

These males were characterised by high rates of aggressive behaviour. This suggests that the vagal reactors may be characterised by certain psychopathic traits, proactive aggression, unimpaired emotion regulation, and high HRV.

One of the aims of the current study was to investigate whether female perpetrators of intimate partner violence have low rHR and high HRV, and whether certain traits associated with offending can be linked to high HRV. Existence of the proposed link between cardiovascular activity and aggressive traits in a sample of females would counter the idea that female perpetrated partner violence reflects mainly impulsive aggressive acts. This finding would also support the notion that IPV can originate from gender unbiased biological mechanisms and, therefore, observed in males and females in similar proportions.

Intimate partner violence (IPV) can be conceptualized as a form of physical, sexual and psychological aggression perpetrated against an intimate partner (Dixon & Graham-Kevan, 2011). Although IPV is predominantly viewed as a social problem of men’s violence against women, there is considerable evidence to suggest that women are also aggressive in relationships (Dixon & Graham-Kevan, 2011; Dutton & Corvo, 2006; Dutton, Nicholls, & Spidel, 2005; Graham-Kevan, 2007; Hamel, Desmarais, & Nicholls 2007). Indeed, a gendered perception of IPV stands in contrast to a growing evidence base which suggests that male and female acts of violence occur at approximately equal rates (e.g., Moffitt, 2001; O'Leary, Smith Slep, & O'Leary, 2007; Esquivel-Santoveña & Dixon, 2012). However, the psychological characteristics of female IPV perpetrators remain poorly understood.

The U.K. Office for National Statistics (2016) reports that twice as many females as males aged 16 – 59 were victims of any form of IPV during the 12 months preceding the survey. This accounted for 8.2% of women and 4.0% of men being victimized. However, there were no significant sex differences in prevalence of physical violence and injury amongst IPV sufferers. Similar results are reported in the meta-analysis of Archer (2000) which, based primarily on studies with young samples in the United State of America, found that females physically aggress against their intimate partners slightly more often than males, although injury was inflicted at a higher rate by men. Consistent with this, studies with university students typically find higher IPV rates perpetrated by women (Straus, 2008). It is therefore, important to progress the understanding of female intimate partner aggression.

Partner violent individuals have been differentiated from non-partner violent individuals in terms of their personality traits. This holds true for male and female perpetrators. For example, females arrested for IPV have elevated levels of histrionic, narcissistic and compulsive personality traits measured with the Millon Clinical Multiaxial Inventory – III [MCMI-III] (Simmons, Lehmann, Cobb, & Fowler, 2008) as well as increased impulsivity (Caetano, Vaeth, & Ramisetty-Mikler, 2008), antisocial and dependent personality (Goldenson, Geffner, Foster, & Clipson, 2007), and borderline features (Henning, Jones, & Holdford, 2003). Male perpetrated IPV has also been related to increased scores on unempathic traits and lower scores on impulsive tendencies (Swogger, Walsh, & Kosson 2007).

Psychopathic traits, such as empathy deficits and impulsivity, have been shown to exist on a continuum and are measurable in both forensic and non-forensic samples (Marcus et al., 2004). Certain psychopathic traits have previously been linked with both premeditated and impulsive aggression (Cornell et al., 1996; Patrick et al., 2009). For example, *meanness,* characterised by callousness and a lack of empathy, is more closely related to premeditated aggression, whereas *disinhibition,* characterized by risk taking and impulsivity, is more often linked with impulsive aggression (Patrick et al., 2009). Borderline personality features, however, are predominantly linked with increased anxiety and emotional dysregulation. Individuals with elevated levels of these traits are more likely to display acts of impulsive aggression (Lieb, Zanarini, Schmahl, Linehan, & Bohus, 2004).

Partner violent individuals were previously classed into three different subtypes, that is family only batterers (FO), borderline-dysphoric batterers (BD), and generally violent-antisocial (GVA) (Holtzworth-Munroe & Stuart, 1994). These subgroups differ on the level of violence and psychological dysfunctionality with least difficulties observed in the FO group, medium in the BD group, and most in the GVA group. A more recent study validated these three typologies and discovered an additional subtype, namely the low level antisocial (LLA) subtype (Holtzworth-Munroe, Meehan, Herron, Rehman, & Stuart, 2000). The LLA individuals were classed as more violent than the FO batterers but less violent than the BD group. The presence of these subtypes highlights the importance of examining theoretically important dimensions in partner violent individuals.

Previously published studies have investigated the relationship of cardiovascular activity to IPV perpetration. A study by Gottman and colleagues (1995) looked at male heart rate responses to marital interaction. Two distinct patterns of phasic cardiac responding were observed, namely deceleration (type 1) and acceleration (type 2). Type 1 males compared with type 2 males scored higher on proactive emotional aggression expressed during marital interaction. A follow up study also revealed that type 1 males were generally more aggressive towards others and scored higher on measures of antisocial and aggressive-sadistic personality disorder, and drug dependence. In another study, male to female physical aggression was linked with low rHR (Babcock, Green, Webb, and Graham, 2004). However, results of a follow up study (Babcock, Green, Webb, and Yerington, 2005) suggested a distinction between severe and low-level male perpetrated IPV, namely that only the former was linked to low rHR. Furthermore, compared to non-abusers, the severe perpetrators had weak heart rate responses, whereas the low-level perpetrators reacted with heart rate acceleration to marital conflict discussion.

The putative relationship between low rHR and offending has been postulated for some time (Ortiz & Raine, 2004; Portnoy & Farrington, 2015; Raine et al., 1997). The strength of this association has been emphatically supported by a recent Swedish study (Latvala et al., 2015). This vast longitudinal study, which followed over 700,000 men for 35 years, demonstrated that there is a quasi-linear relationship of rHR with many types of offending, including violent and non-violent crimes but not sex offences, as well as with non-intentional injuries. Although most of the work looking at rHR and offending has been conducted in male participants, Ortiz and Raine (2004) nonetheless suggested that low rHR predicts aggressive acts in male and female antisocial youths. Consequently, one of the current studies examined the relationship between low rHR, and female perpetrated IPV physical aggression.

The cause of the robust link between low rHR and offending remains unclear. The way that this relationship may be better understood is to consider the relationship between heart rate and the autonomic nervous system (ANS). The heart rate at rest is largely dictated by the balance of activity of the two branches of the ANS acting on the sinoatrial (SA) node. The sympathetic noradrenaline based division speeds up the beating of the heart while the acetylcholine based parasympathetic division slows it down. Raine (2002) has theorized that in aggressive individuals low rHR can reflect either withdrawal of sympathetic activity, or elevated vagally mediated parasympathetic activity. However, which of the two autonomic branches plays the crucial role remains open to interpretation.

One popular model to account for the relationship between low rHR and aggression has emphasized that the underaroused state may be aversive and consequently drives affected individuals to partake in risky activities to increase autonomic arousal (Raine, 2002; Raine et al. 1997; Raine, 1996; Raine & Venables, 1984). It is these activities that have a strong tendency to be related to criminal acts. Another model posits that low rHR may reflect lack of relative fear responses to minor laboratory stressors. However, a recent meta-analysis of studies disputed the latter explanation (Portnoy & Farrington, 2015).

The approach to understanding the relationship between low rHR and offending underlying the current studies entails focusing on the corollaries of low rHR on brain function. Low rHR typically stems from high activity in the vagus nerve of the parasympathetic nervous system and this in turn is reflected in high resting heart rate variability (HRV). HRV refers to the subtle changes in the interbeat intervals of the heart resulting from increased activation of the vagus nerve when breathing out, a phenomenon known as the respiratory sinus arrhythmia (RSA). This increased vagal activity also exerts an effect upon brain function.

High levels of HRV are associated with good executive functioning, including faster, more accurate responses on executive functioning tests (Hansen et al., 2009; Hansen et al., 2003; Thayer et al., 2012; Thayer et al., 2009), and strong emotion regulation processes, some of which include greater inhibition of prepotent responses and diminished startle responding (Hovland et al., 2012; Mezzacappa et al., 1998; Ruiz-Padial et al., 2003; Thayer & Lane, 2009; Thayer & Lane, 2000). For example, Hansen et al. (2003) showed that higher HRV was related to better working memory and better performance on a continuous performance test, and Johnsen et al. (2003) demonstrated that high HRV was inversely related to dental anxiety as assessed by an emotional Stroop task.

Low rHR is typically associated with high resting HRV (Berntson et al., 1997; Levy, 1990; Task Force of the European Society of Cardiology, 1996). This accordingly implies that low rHR is predictive of good prefrontal functioning and good control over emotional states. However, this conclusion is counterintuitive given the strong relationship between low rHR and aggressive and antisocial behaviour, including violent offenses. Perhaps one way that this relationship may be better understood is to consider the different types of aggressive behaviour.

Aggressive behaviours can be classified into two major subtypes, proactive and reactive (Cima et al., 2013; Polman et al., 2007). The former can emerge without any obvious antecedent. This form of aggression typically requires the presence of a plan and is not associated with executive function deficits (Ellis et al., 2009; Stanford et al., 2003). By contrast, reactive aggression results from interpretation of someone's intentions as being hostile and provocative (Dodge et al., 2015; Kempes et al., 2005). This form of aggression is associated with executive function deficits (Ellis et al., 2009). Low rHR and the associated high HRV would accordingly be expected to be associated with acts of proactive, rather than reactive, aggression. Conversely, poor emotion regulation would be predicted to be mainly associated with reactive, as opposed to proactive aggression.

Previous studies (Raine et al., 2014; Scarpa et al., 2010) emphasized the existence of a link between resting cardiovascular activity and the two subtypes of aggression. However, both of these studies investigated parent-reported aggression in children. Raine et al. (2014) argued that low rHR is related to proactive aggression, impulsive features of psychopathy, and total child psychopathy. Scarpa et al. (2010) found that high resting HRV is associated with proactive aggression, whereas low HRV is associated with reactive aggression. In contrast, the current study examined these relationships using self-report responses in a sample of adult females.

The relationship between low rHR and HRV would also be expected to be related to other antisocial traits. Hansen et al. (2007) found that in a group of incarcerated offenders a deceitful, manipulative lifestyle, and unempathic traits were significantly related to low rHR and high HRV. The manipulative lifestyle was also linked with increased performance on working memory tasks. A meta-analysis of studies by Portnoy and Farrington (2015) supports a link between low rHR and psychopathy. Furthermore, borderline personality disorder was associated with low levels of HRV compared to healthy volunteers (Meyer et al., 2016). Therefore, it is proposed that in the current model based on low rHR, high HRV, and good emotion regulation, IPV physical aggression (IPV-PA) perpetration will not be characterized by borderline and impulsive characteristics, rather with increased emotional resiliency and unempathic traits (assessed using the boldness and meanness subscales of the Triarchic Psychopathy Measure [TriPM] (Patrick et al., 2009).

As discussed earlier, the personality characteristics and cardiac autonomic function associated with female perpetrated IPV remain little understood. Thus, the aim of the present study was to investigate the prevalence of female IPV-PA in a heterosexual university sample, as well as the cardiovascular and psychological profile of female IPV perpetrators of physical violence, and the relationship of resting cardiovascular activity to reactive and proactive aggression. Personality traits studied included psychopathic tendencies, borderline features, anxiety, and tendencies toward proactive and reactive aggression. Indicators of cardiac autonomic function included rHR and parasympathetic activity expressed in terms of HRV.

It was predicted that the females who physically aggress against their partners would show psychopathic tendencies, including those that index emotion resilience and callous unempathic features of the disorder, and higher scores on proactive aggression. It was further hypothesized that lower rHR and higher HRV would be related to proactive, but not reactive aggression.

Two separate studies were conducted, both recruited only female university students as participants. An overwhelming majority of the participants reported being heterosexually orientated. As IPV-PA appears to be more prevalent in non-heterosexual samples (Whitton, Newcomb, Messinger, Byck, & Mustanski, 2016), non-heterosexual females were excluded from both studies. The first was an online study that examined the prevalence of female perpetrated IPV-PA, and the relationships between female perpetrated IPV-PA and a series of personality traits. The second study was a laboratory based exploration of the relationship between female perpetrated IPV-PA and resting cardiovascular activity. Ethical approval for both studies was granted by the University of Birmingham Committee for Ethical Review. Participants signed their fully informed consent and received either course credit or a monetary reward of ten pounds for their participation.

### 6.2.1 Study 4A

#### Method

*Participants*

A sample of 443 heterosexual female students, aged 18 to 45 (*M* = 19.37, *SD* = 1.94) were recruited from a U.K. based university via the local research participation scheme.

*Materials*

Intimate partner violence physical aggression was assessed with the Conflict Tactics Scale – 2 (CTS2) physical assault subscale. Alpha coefficient for the current study has not been reported because the CTS2 physical assault subscale was used as a dichotomous measure and implemented solely for the purposes of discrimination between IPV-PA perpetrators and non-perpetrators. Psychopathic traits were assessed with the Levenson Self Report Psychopathy scale (LSRP). Alpha reliabilities for this measure were $\alpha$=.85 and $\alpha$=.66 for the primary and secondary scales respectively. Trait anxiety was measured with the State Trait Anxiety Inventory (STAI). **F**or trait anxiety, alpha coefficient was $\alpha$=.82. Finally, the Millon Clinical Multiaxial Inventory – III (MCMI-III) was used to measure borderline traits. In the current study reliability values for the borderline measure reached the value of $\alpha$=.78. Detailed descriptions of these questionnaires can be found in the general methods section (Chapter 2.1).

*Procedure*

Questionnaires were uploaded and completed through an online survey hosted by the local research participation scheme. Participants received on-screen instructions which ensured that informed consent was given before demographic information relating to the participants' age, nationality, ethnicity, sexual orientation, cohabiting status, and the number of months of the previous year spent in intimate relationships was requested. The questionnaires were then completed in a set order: CTS2 physical assault items, LSRP, STAI, MCMI-III borderline features. After completion, a debrief section was displayed and the participant was granted credit.

*Statistical analyses*

IPV-PA prevalence rates in the entire sample (N=443) were calculated as the percentage of participants who responded positively to at least one item on the physical assault scale of the CTS2. The CTS2 generates a lot of data about the distinct types of IPV. However, this article has focused on IPV physical aggression. Accordingly, it was abstracted whether the individuals had perpetrated a violent act or not. Thus, the entire sample was split in two groups. Participants who reported physical assault against partners that occurred within 12 months of participation in the study formed one group, and participants who did not report violence formed another group. The Shapiro-Wilk tests indicated that the distribution of all continuous variables significantly deviated from normality. Therefore, a series of nonparametric Mann-Whitney U tests for independent samples were used to compare scores on the LSRP-I and LSRP-II, STAI-T, and MCMI-III borderline features between IPV-PA perpetrators and non-perpetrators. To control for multiple testing the obtained asymptotic alpha values were corrected using the false discovery rate (FDR) procedure proposed by Benjamini and Hochberg (1995). Both the asymptotic and the corrected alpha values are reported. Approximate effect sizes (*r*) were calculated using a procedure described by Field (2013), with the following recommended norms for interpretation: small=.0; medium=.3; large=.5.

## Results

*Characterization of the sample*

Study 4A aimed to examine differences in selected personality traits between IPV and non-IPV perpetrators of physical violence in a female university sample. Table 6.1 contains the means, standard deviations, medians and the corresponding ranges for scores on the LSRP-I and LSRP-II, STAI-T, and the MCMI-III borderline scale in Study 4A. The percentage of participants who reported IPV-PA perpetration, and scores on the primary and secondary subscales of the LSRP, were similar to those previously reported in a female sample. Thus, out of 443 heterosexual female university students, 137 (30.9%) reported acts of physical aggression against their intimate partners in the previous 12 months. The proportion is similar to that reported in an equivalent USA study where the prevalence score for female IPV-PA perpetration was 35% (Straus et al., 1996). Many of the aggressive acts were classed as minor although a small number of severe acts were also reported, including the use of a knife or a gun by one of the participants. For the whole sample, (that is, IPV and non-IPV) primary and secondary psychopathy scores were similar to normative values observed in undergraduate females (Lilienfeld & Hess, 2001). However, the current sample showed elevated levels of trait anxiety and less noticeable borderline features compared to female norms for anxiety (*M* = 40.54, *SD* = 12.86) (Spielberger et al., 1983), and borderline features (*M* = 13) (Rossi et al., 2007).

Table 6.1: Descriptive statistics of variables used in Study 4A

| | Whole sample | | | |
|---|---|---|---|---|
| | M | SD | Median | Range |
| Primary Psychopathy | 28.84 | 7.02 | 28 | 37 |
| Secondary Psychopathy | 20.85 | 4.23 | 21 | 22 |
| Trait Anxiety | 45.04 | 8.97 | 45 | 57 |
| Borderline Score | 7.14 | 5.26 | 6 | 24 |

*Note. M=mean; SD=standard deviation; Med=median; R.=range; IPV=intimate partner violence; Psych.= psychopathy;* $^{*}$*= significant difference IPV vs non-IPV (pFDR = .02).*

Table 6.1 (continued): Descriptive statistics of variables used in Study 4A

| | IPV | | | | non-IPV | | | |
|---|---|---|---|---|---|---|---|---|
| | M | SD | Median | Range | M | SD | Median | Range |
| Primary Psychopathy | 29.78 | 7.38 | 29 | 36 | 28.42 | 6.82 | 28 | 32 |
| Secondary Psychopathy* | 21.68 | 4.07 | 22 | 22 | 20.48 | 4.25 | 20 | 22 |
| Trait Anxiety | 45.58 | 7.87 | 46 | 44 | 44.80 | 9.43 | 45 | 57 |
| Borderline Score | 7.48 | 5.04 | 7 | 24 | 6.98 | 5.36 | 6 | 22 |

*Note. M=mean; SD=standard deviation; IPV=intimate partner violence; *= significant difference IPV vs non-IPV (pFDR = .02).*

*Differences in personality traits between IPV and non-IPV perpetrators*

Participants who aggressed against their intimate partners within the last 12 months had significantly higher secondary psychopathy scores compared to those who did not aggress ($U$ = 17433.5, $z$ = -2.839, $p$ = .005, *pFDR* = .020, $r$ = -.14). The two groups did not differ in primary psychopathic traits ($U$ = 18924.5, $z$ = -1.637, $p$ = .102, *pFDR* = .204, $r$ = -.08), trait anxiety ($U$ = 19691.5, $z$ = -1.020, $p$ = .308, *pFDR* = .308, $r$ = -.05) or borderline features ($U$ = 19302, $z$ = -1.335, $p$ = .182, *pFDR* = .242, $r$ = -.06).

### 6.2.2 Study 4B

*Participants*

A sample of 92 heterosexual female university students aged 18 to 28 ($M$ = 19.09, $SD$ = 1.25) were recruited via the local participation scheme. Individual time slots were assigned for the participants to arrive at a laboratory where testing procedure took place. Consent to participate was taken upon arrival at the testing facility.

*Materials*

In the current study, the STAI and the MCMI-III were redundant because in Study 4A there were no significant links between these two scales and female IPV. The Conflict Tactics Scale 2 (CTS2) physical assault subscale was used as a dichotomous variable to investigate the differences between IPV perpetrators and non-perpetrators, and as a continuous variable to investigate the relationship of intimate partner physical aggression to reactive and proactive aggression. Alpha coefficient for the CTS2 physical assault continuous variable was α=.61. The LSRP was replaced with a three-factor scale, namely the Triarchic Psychopathy Measure (TriPM), to investigate how emotional resiliency (boldness) and unempathic traits (meanness) are associated with IPV. In the current study, reliability coefficients for the TriPM ranged from α=.77 to α=.84. An additional inventory was also used, namely the Reactive – Proactive Aggression Questionnaire (RPQ). The currently obtained reliability values for the RPQ were α=.86 and α=.67 for reactive and proactive aggression respectively. For more information on these tests please refer to section 2.1.

*Procedure*

Participants were tested individually in a quiet research testing cubicle. After informed consent was obtained and demographic information collected the personality inventories and the CTS2 were completed. Shortly after completion of the self-report scales a silver/silver-chloride electrode was placed on each wrist (Russoniello et al., 2010; Porto & Junqueira, 2009) of the participants. Prior to the positioning of the electrodes the skin was prepared by gentle rubbing with an abrasive skin cream and then wiped with alcohol. A 5-minute ECG trace was recorded using a Biocom 4000 USB device (Biocom Technologies, Poulsbo WA) with at a sampling rate of up to 1024Hz. Participants were asked to sit still, rest hands on their thighs and keep their eyes open. On some occasions problems with conductivity across the electrodes meant that a reliable trace was not obtained. Of the 92 participants, six did not generate a successful trace.

A Heart Rhythm Scanner Professional Edition (Biocom Technologies, Poulsbo WA) automatically computed all measures of cardiovascular activity. Resting heart rate and vagally mediated parasympathetic activity was calculated from the 5-minute long epoch. The activity of the parasympathetic system is expressed using a measure of HRV. This is based on the standard deviation of successive interbeat intervals (SDNN), a reliable and widely accepted measure of HRV (Task Force of the European Society of Cardiology, 1996).

*Statistical analyses*

Examination of the data revealed that the distribution of most variables significantly deviated from normality. Therefore, nonparametric tests were selected to investigate the relationships between IPV-PA, psychological characteristics, and resting cardiovascular activity. Most of the analysis, excluding partial correlations, was performed with the use of IBM SPSS version 24. Nonparametric partial correlations were performed using Statistical Analysis Software (SAS 9.4) (SAS Institute Inc., Cary, NC, USA).

The entire sample was split into two groups. Participants who reported at least one assault against their partner within 12 months of participation in the study formed one group, and those who did not report an assault formed the second group. Differences in cardiovascular activity (rHR, HRV (SDNN)), self-report aggression (reactive, proactive) and psychopathic traits (boldness, meanness, disinhibition) were analysed with separate Mann – Whitney U tests. An FDR correction (Benjamini & Hochberg, 1995) was applied to all U tests and effect sizes (Field, 2013) were estimated with procedures briefly described in Study 4A.

In a subsequent analysis, partial correlations of proactive and reactive aggression with IPV-PA, HR, and HRV (SDNN) were performed. Reactive and proactive aggression scores were interchangeably entered as a correlated or control variable to control for the typically medium sized correlations between these two constructs. Thus, the results reported here refer to the unique relationships with reactive and proactive aggression independent of the other.

## Results

*Characterization of the sample*

Table 6.2 contains the means, standard deviations, medians and the corresponding ranges for cardiovascular parameters and personality inventory scores used in Study 4B. Mean rHR for the whole sample was comparable to normative values (*M* = 80bpm). SDNN values were higher than the young female norms (SDNN: *M* = 48.7, *SD* = 19) (reported by Voss, Schroeder, Heitmann, Peters, & Perz, 2015).

Table 6.2: Descriptive statistics of variables used in Study 4B

| | Whole sample | | | |
|---|---|---|---|---|
| | M | SD | Median | Range |
| rHR | 79.36 | 11.44 | 77.7 | 57.6 |
| HRV (SDNN) | 62.86 | 29.59 | 55 | 149 |
| Proactive Aggression | .79 | 1.52 | 0 | 10 |
| Reactive Aggression | 6.04 | 3.97 | 6 | 22 |
| Boldness | 26.33 | 7.47 | 27 | 37 |
| Meanness | 8.61 | 6.29 | 7 | 37 |
| Disinhibition | 14.09 | 6.94 | 13 | 44 |

*Note. Psychometric data is presented for N=92, 86 of whom generated cardiovascular data. rHR = resting heart rate; HRV (SDNN) = resting heart rate variability expressed in standard deviation of successive interbeat intervals.*

Table 6.2 (continued): Descriptive statistics of variables used in Study 4B

| | IPV | | | | non-IPV | | | |
|---|---|---|---|---|---|---|---|---|
| | M | SD | Med | Ran | M | SD | Med | Ran |
| rHR* | 75.43 | 9.50 | 75.1 | 39.3 | 82.06 | 11.95 | 82.1 | 57.1 |
| HRV (SDNN)** | 77.39 | 34.86 | 62.9 | 143.7 | 52.88 | 20.31 | 48.5 | 79 |
| Proactive Agg.** | 1.32 | 1.94 | 1 | 10 | 0.44 | 1.01 | 0 | 5 |
| Reactive Agg.* | 7.41 | 3.75 | 7 | 19 | 5.13 | 3.89 | 5 | 22 |
| Boldness* | 28.30 | 8.36 | 28 | 35 | 25.00 | 6.55 | 26 | 34 |
| Meanness* | 10.89 | 8.00 | 9 | 37 | 7.07 | 4.24 | 7 | 17 |
| Disinhibition | 15.68 | 7.73 | 15 | 44 | 13.02 | 6.20 | 12 | 32 |

*Note. Psychometric data is presented for N=92, (IPV perpetrators: N=37, non-perpetrators: N=55) 86 of whom generated cardiovascular data (IPV perpetrators: N=35, non-perpetrators: N=51). rHR = resting heart rate; HRV (SDNN) = resting heart rate variability expressed in standard deviation of successive interbeat intervals; Agg. = aggression *= significant difference IPV vs non-IPV (pFDR < .05); **= significant difference IPV vs non-IPV (pFDR < .01)*

Out of the whole sample (N=92), 37 participants (40.2%) reported IPV-PA. The aggressive acts were typically described as being mild assaults where there were no obvious lasting effects. However, five of the participants caused bruising, a sprain or small cut to their partners. A further two participants reported causing pain that lasted for 24 hours. Reactive and proactive aggression values were slightly lower than those previously reported for a community sample of adolescent females (Fossati, Borroni, Eisenberg, & Maffei, 2010). The mean scores for meanness, boldness, and disinhibition were relatively similar to normative values (Poy, Segarra, Esteller, López, & Moltó, 2014).

*Differences between IPV and non-IPV groups*

The Mann – Whitney U tests examining differences in rHR and HRV (SDNN) revealed that perpetrators showed a lower rHR ($U$ = 1210, $z$ = -2.747, $p$ = .006, $pFDR$ = .011,

$r$ = -.30) and higher SDNN values ($U$ = 1811, $z$ = -3.582, $p$ < .001, $pFDR$ = .002, $r$ = -.39) compared with non-perpetrators.[1]

Two more Mann – Whitney U tests were conducted to test whether IPV-PA perpetrators scored higher on self-report aggression than non-perpetrators. The outcomes revealed significantly higher levels of both proactive ($U$ = 2199.5, $z$ = -3.334, $p$ = .001, $pFDR$ = .002, $r$ = -.35) and reactive ($U$ = 2154.5, $z$ = -3.223, $p$ = .001, $pFDR$ = .046, $r$ = -.34) aggression among IPV-PA perpetrators.

It was hypothesized that IPV perpetrators would have increased levels of psychopathic traits, mainly those that index emotion resilience and callous unempathic features of the disorder. Results of the Mann – Whitney U tests indicated that the IPV-PA group showed significantly higher scores for boldness ($U$ = 2300.5, $z$ = -2.049, $p$ = .040, $pFDR$ = .047, $r$ = -.21), and meanness ($U$ = 2249.5, $z$ = -2.459, $p$ = .014, $pFDR$ = .019, $r$ = -.25), but not disinhibition ($U$ = 2325.5, $z$ = -1.851, $p$ = .064, $pFDR$ = .064, $r$ = -.19).

*Partial correlations for IPV, cardiovascular variables, reactive, and proactive aggression*

The nonparametric partial correlation between IPV-PA and proactive aggression was significant ($r_s$ = .213, $p$ = .037) when the effects of reactive aggression were controlled. The partial correlation between IPV-PA and reactive aggression was also significant ($r_s$ = 203, $p$ = .047) when effects of proactive aggression were held constant. Thus, after controlling for the effects of one on the other, there were unique positive correlations of IPV-PA with both reactive and proactive aggression.

There was no significant correlation for rHR and proactive aggression ($r_s$ = -.205, $p$ =.061) when reactive aggression was used as a covariate. Similarly, no significant effects

[1] The IPV perpetrators obtained higher values than the non-perpetrators on another measure of parasympathetic activity, namely the rMSSD ($U$ = 542, $z$ = -3.081, $p$ = .002).

were found when rHR was correlated with reactive aggression ($r_s$ = .039, $p$ = .723) controlling for proactive aggression.

However, there was a significant partial correlation between HRV (SDNN) and proactive aggression ($r_s$ = .294, $p$ = .006) when reactive aggression was used as a covariate. There was no significant relationship between HRV (SDNN) and reactive aggression ($r_s$ = .057, $p$ = .602) when controlling for proactive aggression.[2] Thus, proactive, but not reactive, aggression was associated with higher levels of HRV (SDNN).

**6.3 Discussion**

This study aimed to establish the prevalence of IPV-PA in a university sample, and to investigate the relationship of female perpetrated IPV-PA with relevant personality traits, and with cardiac autonomic function. The results of Study 4A showed that about a third of heterosexual female participants 30.9% physically aggressed against their intimate partners in the previous 12 months. These finding were further supported by results from Study 4B, which showed that 40.2% of females had aggressed against their partner. Though contrary to some models of IPV that emphasize patriarchy as a motivating factor for this type of aggression, the findings are in keeping with several recent studies, including a meta-analysis by Williams, Ghandour, and Kub (2008).

Consistent with the current hypothesis, female IPV-PA perpetrators were found to have a lower rHR than non-perpetrators. This finding is consistent with the results of one study of male IPV perpetrators which showed that males with low rHR commit more severe acts of IPV perpetration than those with high rHR (Babcock et al., 2005). This observation is

[2] The partial correlation between rMSSD and proactive aggression was significant ($r_s$ = .330, $p$ = .002) when reactive aggression was used as a covariate. The partial correlation between rMSSD and reactive aggression was not significant ($r_s$ = -.009, $p$ = .935) when proactive aggression was used as a covariate.

also supported by the well-established finding that low rHR in males is related to aggressive behaviour and several forms of offending, as well as unintentional injuries (Latvala et al., 2015; Raine, 1996; Raine, 2002; Raine, 2015). These physiological similarities suggest the expression of aggressive tendencies may originate by the same mechanisms for males and females. This interpretation is in keeping with a previous study which reported low rHR in male and female samples of antisocial adolescents (Ortiz & Raine, 2004).

In a separate correlational analysis, although IPV-PA was not found to be negatively correlated with rHR, a significant positive correlation of IPV-PA with HRV (SDNN) was observed. The mechanisms underlying the relationship of aggression with low rHR have been extensively debated (Raine, 2002; Wilson & Scarpa, 2014). It has been emphasized that low rHR reflects either poor sympathetic arousal, or elevated parasympathetic activity. Low autonomic arousal has been assumed to result in impulsive sensation seeking, and aggressive behaviours (Portnoy & Farrington, 2015; Portnoy et al., 2014; Raine, 1996; Raine et al., 1997; Raine & Venables, 1984). The findings presented here, showing a positive correlation of IPV-PA with HRV (SDNN), help to shed some new light on these underlying mechanisms, and suggest that this relationship better reflects a high level of parasympathetic activity.

Extensive lines of experimental evidence have indicated that HRV is associated with good prefrontal activity and good emotion regulation (Hansen et al., 2009; Thayer et al., 2012). Circuits involving specific parts of the prefrontal cortex are critically involved in executive functioning (Miller & Cohen, 2001) and proactive thinking (Tekin & Cummings, 2002). Taken together, these two lines of reasoning imply that female perpetrated aggression is associated with high HRV (SDNN), good executive functioning and emotion control, and proactive thinking. This conclusion suggests that a considerable amount of female IPV aggressive acts originate from proactive and instrumental tendencies.

Instrumental motives for female IPV-PA are inconsistent with the commonly held assumption that intimate partner physical aggression is perpetrated predominantly by males, and that females primarily respond aggressively only in response to aggression from a male partner (Capaldi, Kim & Shortt, 2004; O'Leary et al., 2007; Whitaker, Haileyesus, Swahn, and Saltzman, 2007). However, the proposed instrumental nature of IPV is also supported by the findings that heterosexual female intimate partner physical aggression is related to elevated secondary psychopathic traits, as well as higher scores on the boldness and meanness subscales of the TriPM. These traits are strongly associated with reactive and with proactive aggression (Cima et al., 2013; Patrick et al., 2009; Skeem et al., 2007) and further support the argument that the motivations for female IPV-PA may be instrumental, as well as reactive.

Although mindfulness was not assessed in the current study it may be that those who perpetrated IPV have high mindfulness as this is associated with high HRV and primary psychopathic traits. These relationships were discussed in Studies 1 and 3 respectively. The current reasoning highlights the need for caution when mindfulness is offered as an adjunct to therapy for female IPV perpetrators.

A limitation of the current study is the reliance on HRV to act as an index of parasympathetic function. The measurement of HRV is influenced by mechanisms other than vagal activity, including respiration rate (Grossman & Taylor, 2007), and residual inspiratory vagal activity (Grossman & Kollai, 1993). Nonetheless, HRV (SDNN) remains a widely recognized and recommended measure of vagal influences on the rate of the heart (Task Force of the European Society of Cardiology, 1996). Contrary to the prediction, rHR was not directly linked with proactive aggression. This finding is similar to a study that investigated cardiovascular activity and aggression in a sample of children (Scarpa et al., 2010). It should be noted that the findings presented here are based on heterosexual university samples. The extent to which a similar pattern of results would be found among other, non-student, adult samples is worthy of further investigation.

In conclusion, results presented here suggest that female IPV-PA is perpetrated at similar rates to those reported among males, and is related to both reactive and proactive aggression, and psychopathic tendencies indexing emotional resilience, and a callous lack of empathy. Furthermore, the cardiac autonomic function of female IPV-PA perpetrators appears to be characterized by a low rHR and elevated levels of parasympathetic activity, as reflected in elevated levels of HRV (SDNN). These results highlight the need to reappraise the previously hypothesized mechanisms driving the relationship between low rHR and aggressive and antisocial behaviour. Previous work has emphasized the possibility that low rHR might reflect an aversive state of sympathetic under arousal, rather than elevated parasympathetic activity. The current data provide support for an alternative mechanism whereby low rHR is driven by increased vagal activity. This is associated with good executive functioning and good emotional control. Thus, increased vagal activity, as found in the current study, would be expected to be associated with the expression of planned and instrumental/proactive aggression, rather than impulsive and/or reactive aggression.

Study 4 supported the proposition that aggressive individuals have high HRV and that HRV is positively associated with proactive aggressive traits. However, these conclusions are derived from the study of female undergraduates only. It would be interesting to explore these relationships in male offender samples.

# CHAPTER 7 (STUDY 5): PRELIMINARY INVESTIGATION OF THE RELATIONSHIP BETWEEN CARDIOVASCULAR ACTIVITY AND EXECUTIVE FUNCTION IN MALE OFFENDERS

## 7.1 Introduction

Findings of the previous experimental chapter indicate that violent individuals who have low rHR also have high HRV. Moreover, high HRV was found to be related to proactive aggression. Previously published studies argue that high HRV is associated with good emotion regulation. This is in part supported by the findings that the HRV biofeedback course increased emotion regulation and mindfulness. Interestingly, high HRV can also be related to good executive functioning. This suggests that offenders characterised with low rHR may have unimpaired executive functions. Study 5 extended the previous exploration of the concomitants of cardiovascular activity and aggressive traits to a sample of male serious offenders. This study also investigated whether cardiovascular activity relates to executive performance.

Underperformance on executive function tasks is often assumed to be positively related to offending. This relationship, although intuitively pleasing, lacks strong empirical evidence (Krämer, Kopyciok, Richter, Rodriguez-Fornells, & Münte, 2011). Violent offending and impulsivity have been shown to be associated in several studies (Davidson et al., 2000; Cornell et al., 1996; Woodworth & Porter; 2002), and there are clear links between impulsivity and the lack of inhibitory control, a facet of executive functions. However, the links are less clear between aggression and other forms of executive functioning, such as working memory or attention. The issue becomes even less clear when cardiovascular functioning is taken into consideration. Low rHR is positively associated with offending, including aggressive acts, and negatively related to HRV. The latter has previously been linked with good executive function. This accordingly implies that some aggressive offenders may not have executive function deficits. Indeed, primary psychopathic traits have been previously associated with unimpaired executive functions in offenders (Ross et al., 2007; Hansen et al., 2007) and healthy adults (Lantrip et al., 2016). The study reported in this chapter represents and initial attempt to explore the effect of cardiovascular function on executive function in relation to personality traits in a group of incarcerated male offenders.

As stated in section 1.7.4, there is a well-evidenced view that low rHR is a major predictor of offending (Ortiz & Raine 2004; Lorber, 2004; Raine et al., 1997; Portnoy & Farrington, 2015; Raine et al., 1997). A recent Swedish study (Latvala et al., 2015), which followed approximately 700,000 men for 35 years has emphatically supported this robust relationship by demonstrating that there is a quasi-linear relationship of rHR with violent and non-violent crimes, as well as with non-intentional injuries. The cause of this association, however, remains unclear.

A frequently cited model of aggression posits that that in aggressive individuals low rHR can reflect either withdrawal of sympathetic activity, or elevated vagally mediated parasympathetic activity (Raine, 2002). Raine and colleagues (Raine, 1996; Raine et al. 1997; Raine & Venables, 1984) have postulated that low sympathetic activity would result in autonomic underarousal, which in turn would be aversive and consequently drive affected individuals to partake in risky, impulsive activities in order to increase autonomic arousal. It is these activities that have a strong tendency to be related to criminal acts. However, there appears to be limited evidence to support this conjecture. From this model, it could be predicted that offenders will show executive deficits relating to impulsivity which will correlate negatively with rHR and positively with personality traits relating to impulsive sensation seeking and risk taking.

The above model, however, does not sit comfortably with the literature relating cardiac function with executive function. Low rHR typically stems from high activity in the vagus nerve of the parasympathetic nervous system and this in turn is reflected in high resting heart rate variability (HRV) (Berntson et al., 1997; Levy, 1990; Task Force of the European Society of Cardiology, 1996). HRV refers to the subtle changes in the interbeat intervals of the heart resulting from increased activation of the vagus nerve when breathing out, a phenomenon known as the respiratory sinus arrhythmia (RSA). This increased vagal activity also exerts an effect upon several aspects of higher brain function.

Several studies have indicated that higher HRV may be related to better performance on executive function tasks that assess updating and attentional shifting (Hansen et al., 2009; Hansen et al., 2003; Hovland et al., 2012; Stenfors et al., 2016). Moreover, studies have shown that executive working memory and Stroop task-related inhibition are influenced by HRV (Albinet et al., 2016; Jennings et al., 2015; Hansen et al., 2009; Hansen et al., 2003).

This relationship between HRV and executive function results in the counterintuitive prediction that offenders, who are characterised by low rHR, will have good prefrontal functioning. This unusual position may be better understood by consideration of the different types of aggressive behaviour.

As noted in section 1.7, aggressive behaviours can be subdivided into two major types, proactive and reactive (Cima et al., 2013; Polman et al., 2007). Proactive aggression is typically planned and can be expressed in the absence of an obvious triggering factor (Ellis et al, 2009; Stanford et al., 2003). Proactive aggression can also be referred to as instrumental as it is often motivated by a desire to obtain a specific outcome. Reactive aggression, by contrast, results from construing the intentions of another individual as being hostile and provocative (Dodge et al., 2015; Kempes et al., 2005). Reactive aggression is sometimes referred to as impulsive as the individual perpetrating the act shows little or no foresight into the behaviour. Proactive and reactive aggression are potentially differentially related to executive performance and conduct problems with proactive being more strongly related to good executive functioning than reactive (Ellis et al., 2009; Vitaro et al., 1998; Brendgen et al., 2001; Raine et al., 2006).

The possible differential relationship between rHR and the two subtypes of aggression has been previously explored in children (Raine et al., 2014; Scarpa et al., 2010). While the literature tends to place emphasis on low rHR and impulsive sensation seeking there are some reports which have focussed upon instrumental aggression. For example, Raine et al. (2014) concluded that low rHR is related to proactive aggression as well as the impulsive features of psychopathy, and total child psychopathic trait scores. Similarly, Scarpa et al. (2010) found that high resting HRV is associated with proactive aggression, whereas low HRV is associated with reactive aggression.

The relationship between low rHR and HRV might also be expected to be related to other antisocial traits. Hansen et al. (2007) found that in a group of incarcerated offenders a deceitful, manipulative lifestyle, and unempathic traits were significantly related to low rHR and high HRV. The manipulative lifestyle was also linked with increased performance on working memory tasks. A meta-analysis by Portnoy and Farrington (2015) supports a link between low rHR and psychopathy.

Psychopathy refers to a severe personality disorder characterised by high levels of criminality and aggression. However, psychopathic traits are continuous and occur in the general population. It is now widely accepted that, although psychopathy refers to a clinical condition, psychopathic traits can nonetheless be observed in the general population. Moreover, research with non-clinical samples has shown that scores for psychopathic tendencies form negative relationships with scores for socially desirable characteristics (Marcus et al., 2004).

The relationship of psychopathic traits and aggression is complex as revealed by studies using the Triarchic Psychopathy Measure (TriPM) of Patrick (2010). This inventory assesses psychopathy on three dimensions, meanness, disinhibition and boldness. Meanness, characterised by malignant fearlessness and a lack of empathy, was shown to be related to premeditated aggression (Cornell et al., 1996; Patrick et al., 2009). By contrast, disinhibition, characterized by lack of foresight and impulsivity, was linked with impulsive aggression. Boldness, however, which is characterised by emotional resilience, fearless dominance, and venturesomeness, a carefully planned form of stimulation seeking behaviour, was linked to proactive aggression (Patrick et al., 2009). Boldness has also been shown to be associated with low rHR (Kyranides et al., 2017).

Further insights into the relationship between low rHR and offending can be gained by considering the nature of impulsivity and sensation seeking. As mentioned above, the frequently cited model of aggression suggests that underarousal is aversive and likely leads to impulsive sensation seeking.

Impulsive behaviours can be divided into two major components, the first being the tendency to act without planning ahead, whereas the second can be described as compulsive repetitiveness, that is, the tendency to constantly repeat a behaviour despite its inappropriateness (Bari & Robbins, 2013). The former component appears to be closely related to reactive forms of aggression and the disinhibition factor of psychopathic traits. However, premeditated/instrumental acts of aggression, unlike reactive aggression, can be pre-planned.

Similarly, sensation seeking can be subdivided into two types of behaviour, impulsive and a relatively well-planned form referred to as venturesome (Eysenck & Eysenck, 1978). Venturesome individuals are thought to be well aware of the risk intrinsic to their activities. Examples of such risky activities are rock climbing and skydiving. Researchers interested in the concept of psychopathy associated venturesomeness with boldness, a psychopathic trait characterised by high social dominance and emotional stability (Patrick et al., 2009). Venturesomeness, but not impulsivity, has been positively associated with cerebrospinal fluid testosterone levels, a putative biological marker of aggression (Coccaro et al., 2007). Unpublished studies performed in our laboratory using samples of male and female undergraduate students supported the link between venturesomeness, but not impulsivity, and low rHR. The current research investigated the relationship in a sample of adult male offenders.

Sensation seeking behaviours may be closely intertwined with increased propensity to take risky actions (Lejuez et al., 2002). In his study Vigil-Colet (2007) found a positive relationship between venturesomeness and a measure of behavioural risk taking called the Balloon Analogue Risk Taking (BART). In a sample of offenders and community members, increased scores on the BART were recently found to correlate with the boldness subscale of the TriPM (Snowden, Smith, & Gray, 2017). Another study found that the BART scores were negatively correlated with a measure of anxiety (Swogger, Walsh, Lejuez, & Kosson, 2010).

Therefore, it can be deduced that the BART is not a measure of impulsive but rather premeditated risk-taking behaviours. This accordingly suggests that scores the BART may be positively related to the currently proposed model of aggression.

Low rHR has also been associated with the frequency of injuries sustained in accidents (Latvala et al., 2015). Such injuries may include exposure to animate and inanimate forces, including collision with a vehicle or an assault. Latvala et al. (2015) proposed that such injuries may be a consequence of low fear or tendencies to seek stimulating sensations. As mentioned above, fearlessness can be phenotypically expressed by mean and bold psychopathic traits (Patrick et al., 2009). The explanation that accidental injuries are related to sensation seeking links with the previously mentioned proposition by Raine (2002), whereby aggressive individuals impulsively seek stimulation. However, with respect to the currently proposed model it is predicted that unintentional injuries will be closely linked with psychopathic traits associated with tendencies to behave fearlessly.

Executive functioning refers to the mechanisms that control and organise a set of complex high level cognitive processes. These mechanisms include working memory, selective attention, impulse inhibition and set shifting. Working memory can be thought of as being synonymous with holding information on-line while impulse inhibition refers to the capacity to stop, break, or pause a more dominant response. Shifting refers to the ability to switch attention between tasks, operations, or sets (Miyake et al., 2000).

An extensive series of cognitive psychology instruments is available to test executive function. The N-back tests working memory associated with storage and management of information (Owen et al., 2005). The Stroop task measures selective allocation of attention and inhibition of inaccurate responses (Kane & Engle, 2003; Lamers et al., 2010). The

Porteus mazes measure impulsive errors associated with lack of planning (Tuvbald et al., 2017).

Evidence concerning the link between underperformance on certain executive function tasks and offending remains inconclusive. There is a definitive link between offending, unintentional injuries and low rHR. Heart rate slowing is predominantly driven by activity of the vagus nerve which is reflected by higher HRV values. Furthermore, the latter is associated with good executive functioning. This arrangement suggests the controversial proposal that certain traits associated with offending may be positively linked executive functioning. The current literature review suggests that traits associated with offending such as proactive aggression or boldness and meanness can be characterised by more social success and better psychological functioning than reactive aggressive tendencies and disinhibition. Furthermore, these traits may be differently related to subcomponents of sensation seeking, risk taking, and the frequency of accidental injuries. Exploring these relationships may enable a better understanding of the relationship of low rHR and offending. More explicitly, the findings may reveal that offenders characterised by low rHR commit crimes because they are fearless and act with foresight and not because they impulsively seek stimulation as it was previously suggested.

The main hypotheses tested by the current study are concerned with the relationships between aggression, psychopathic traits, cardiovascular function and executive performance in incarcerated male offenders. Proactive aggression, bold and mean psychopathic traits, lack of empathy and venturesomeness were hypothesised to be related to higher HRV and increased performance on the N-back, Stroop tests, and the BART. Conversely, reactive aggression, the disinhibition facet of triarchic psychopathy measure, and impulsive sensation seeking, will be related to low HRV and an overall decreased executive performance.

Importantly, HRV will be positively related to performance on the N-back, Stroop tests, the BART, and negatively related to the Porteus maze "Q-score". It was also hypothesized that unintentional injuries will relate to the psychopathic traits associated with fearlessness, that is, boldness and meanness.

## 7.2 Method

### *Participants*

Participants, (N=13) were predominantly white male offenders, aged between 25 and 62 (*M* = 38.15, *SD* = 11.47), recruited from a UK prison. Initially, the purpose of the research was communicated to the wing representatives, who then informed the other inmates. Volunteers were screened by the prison staff for suitability to participate. The exclusion criteria comprised of an early release date and other time restricting obligations. In brief, the modal sentence length was life (N=10). Six of the participants were convicted for sex offences, four for murder, and three for robbery. Most reported abusing drugs, and some were physically and/or sexually abused at some point in their lives. Three participants reported using medication that may have influenced their cardiovascular function.

### *Materials*

Participants completed psychometric questionnaires and executive function tests, detailed descriptions of which can be found in the general methods section (Chapter 2). Aggression was assessed with the RPQ, psychopathic traits were measured with the TriPM, the $I_7$ was used as a measure of sensation seeking, the STAI was used to assess state and trait anxiety. Alpha values for these measures were not calculated because the sample size was small.

The participants also provided responses to a measure of accidental injuries developed for the purposes of the current study. This questionnaire has been designed to reflect some of the questions asked in the tenth version of the International Statistical Classification of Diseases and Related Health Problems (ICD-10, Chapter X) which assess unintentional injuries sustained in various circumstances. In addition, the measure asked whether participants sustained a brain injury which required a medical attention. The measure has 15 questions, each are scored on a three-point scale from zero to two. Therefore, the total score on this scale falls within a range from zero to 30.

The Stroop task was used as a measure of selective allocation of attention and inhibition of inaccurate responses, the N-back assessed working memory performance, whereas the Porteus mazes were used to assess impulsive errors associated with lack of planning. The N-back task and the Porteus maze tasks were modified to reduce the time spent on completing the tasks. The number of trials for these tests was reduced. The N-back consisted of two practice trials and two main trials. Participants were allowed to repeat the practice trial but only one attempt at the actual task was permitted. For the Porteus task two mazes were selected, one was a simple maze used as a practice trial, whereas a more complicated maze was used to obtain the “Q-score”. These executive functioning tasks were introduced in section 2.1.

*Balloon Analogue Risk Task [BART]*

In this task, the participant was asked to inflate a balloon displayed on a computer screen. Each successful inflation was rewarded with a small, fictional amount of money which accumulated in a temporary reserve. However, the sometimes the balloon popped when inflated in which case all money stored in the temporary reserve was lost. In this version of the BART (Lejuez et al., 2002) the balloons exploded in a random order. The participant can stop inflating the balloon, collect the money to a permanent storage from which the money cannot be lost. Each time the balloon popped or money was collected a new balloon was displayed up to a total of 30 balloons. Thus, the participant risked losing the temporarily accumulated balance each time the balloon is inflated. Information about the amount of money earned per each successful inflation, the money stored in the temporary and permanent reserve, and the number of balloons left was displayed on the screen at all times.

*Procedure*

The entire testing procedure lasted approximately one hour and was held normally on Fridays between 11am and 3pm. Participants were sat in a relatively quiet therapy room located on the prison wing. Prior to the commencement of testing, each individual read a study information sheet and signed a consent form. Afterwards psychometric questionnaires were completed in the following order: RPQ, TriPM, $I_7$, STAI, and the ICD-10 based accidental injury scale (AIS). This was followed by a 5-minute-long assessment of the cardiovascular function with the Biocom 4000 ECG device. A detailed description of this device and the assessment procedure can be found in the general methods section (Chapter 2). Thereafter, participants completed the computerised risk task and the executive function tests in the following order: BART, Stroop, N-back, and then the Porteus mazes. Upon completion, a debrief form was handed out and the participant had time to ask questions. Ethical approval for the current study was granted by the University of Birmingham Science, Technology, Engineering, and Mathematics (STEM) Ethical Review Committee.

*Statistical analyses*

Responses to all measures and the data obtained with the ECG were analysed with the SPSS version 24. Most of the data was not normally distributed and the sample size was small. Therefore, the nonparametric, rank-ordered Spearman's correlations were performed to investigate the relationships between the various psychological characteristics, including executive function performance, and resting cardiovascular activity. Intercorrelations for the various tests were not included in the analysis due to the large amount of data. The standard deviation of successive interbeat intervals (SDNN) was used as a measure of vagal activity. This measure is first introduced in the general methods section (Chapter 2).

The participant responses were investigated for missing or inaccurate data. For one participant (serving a life sentence for murder) the scores on the aggression questionnaire seemed to be inappropriately low. These scores were accordingly excluded from the analysis. Two participants had difficulties understanding the N-back procedure. One of them did not attempt to complete the test, thus, his responses were not included in the analysis. For the other participant, responses on the 2-back version were available and included in the analysis. The remaining data appeared to be sound.

## 7.3 Results

### *Characterisation of the sample*

The participants' scores were relatively similar to those from a comparative sample of offenders on the $I_7$ and to non-offenders on the STAI (Eysenck & McGurk, 1980; Spielberger et al., 1983). Scores for the RPQ were slightly higher than those of non-offenders, whereas the TriPM scores were generally lower than in a published sample of offenders (Fite, Raine, Stouthamer-Loeber, Loeber, & Pardini, 2009; Stanley et al., 2013). Heart rate averaged over the 5-minute sampling period ($M$ = 63.015, $SD$ = 9.038) was in the lower norms reported by the NHS ($M$ = 80, $SD$ = 20). Accordingly, HRV (SDNN) was slightly higher ($M$ = 57.946, $SD$ = 31.017) than norms ($M$ = 41.05, $SD$ = 16.75) for an age matched male sample (Voss et al., 2015).

*The relationship of psychological characteristics to cardiovascular activity*

There was a significant negative correlation between HRV (SDNN) and the empathy scale ($r_s$ = -.657, $p$ = .015)[3] of the $I_7$ questionnaire. This outcome suggests that higher HRV (SDNN) values are associated with lower empathy scores.

***The relationship of psychological characteristics to executive function***

*The Stroop tests*

Proactive aggression was negatively correlated with the proportion of correct responses on the Stroop task ($r_s$ = -.593, $p$ = .042) and positively correlated with mean latency of responses overall ($r_s$ = .621, $p$ = .031), and mean latency of correct congruent ($r_s$ = .600, $p$ - = .039) and incongruent ($r_s$ = .582, $p$ = .047) trials. The disinhibition scale of the TriPM was negatively correlated with the proportion of correct responses ($r_s$ = -.583, $p$ = .037), and positively correlated with mean latency of all responses ($r_s$ = .591, $p$ = .033) and mean latency of correct incongruent ($r_s$ = .641, $p$ = .018) trials. The frequency of accidental injuries was negatively correlated with the proportion of correct responses overall ($r_s$ = -.753, $p$ = .003) and with proportion of correct responses on incongruent trials ($r_s$ = -.683, $p$ = .010). In summary, poor performance on the various measures of the Stroop task were significantly correlated with high levels of proactive aggression, disinhibition and accidental injuries.

*Other executive function tests*

The state anxiety scale (STAI-S) was negatively correlated with the amount of accurate responses on the 2-back test ($r_s$ = -.661, $p$ = .019). The accidental injury scale was positively correlated with the Porteus “Q-score” ($r_s$ = .587, $p$ = .035). The latter result suggests a positive link between the frequency of accidental injuries and impulsive errors associated with poor planning.

[3] RMSSD and empathy ($r_s$ = -.713, $p$ = .006).

*The relationship of cardiovascular activity to executive function*

There was a significant negative correlation between HRV (SDNN) and the mean latency of correct responses on the incongruent trials ($r_s$ = -.626, $p$ = .022)[4]. This outcome suggests that HRV (SDNN) is associated with fast, accurate responses on the Stroop incongruent trials.

*The relationship between accidental injuries, sensation seeking, and psychopathic traits*

Scores on the accidental injury scale were positively correlated with the meanness factor of psychopathic traits ($r_s$ = -.618, $p$ = .024). This finding suggests that accidental injuries are more frequent in individuals who are characterised by malignant fearlessness and lack of empathy. Scores on the BART were negatively correlated with proactive aggression ($r_s$ = -.646, $p$ = .023). This suggests proactive aggressive offenders have a decreased tendency to take planned risks.

## 7.4 Discussion

This study set out to investigate the relationships between various psychological characteristics, resting cardiovascular activity, and executive functioning in a sample of male offenders convicted for a variety of serious crimes. The major findings of the current study are that higher HRV (SDNN) was associated with lower scores on the empathy scale, and with fast and accurate responses on incongruent trials of the Stroop test. These findings are in keeping with the modified model relating low rHR and offending that has stressed that the concomitant high HRV will be associated with good executive functioning and high primary psychopathic traits. Similarly, the findings show that performance on the Stroop test was

[4] RMSSD and the mean latency of correct responses on the incongruent trials ($r_s$ = -.571, $p$ = .041).

negatively associated with the disinhibition factor of the psychopathy scale, and the accidental injury scores were positively linked with meanness (see figure 7.1).

However, the modified model was not supported by the observations of good performance on the Stroop being related to low levels of proactive aggression and to accidental injuries scores. Similarly, high levels of accidental injury were associated with high Porteus maze "Q-scores" of impulsivity whereas scores on the BART were inversely related to proactive aggression (see figure 7.2).

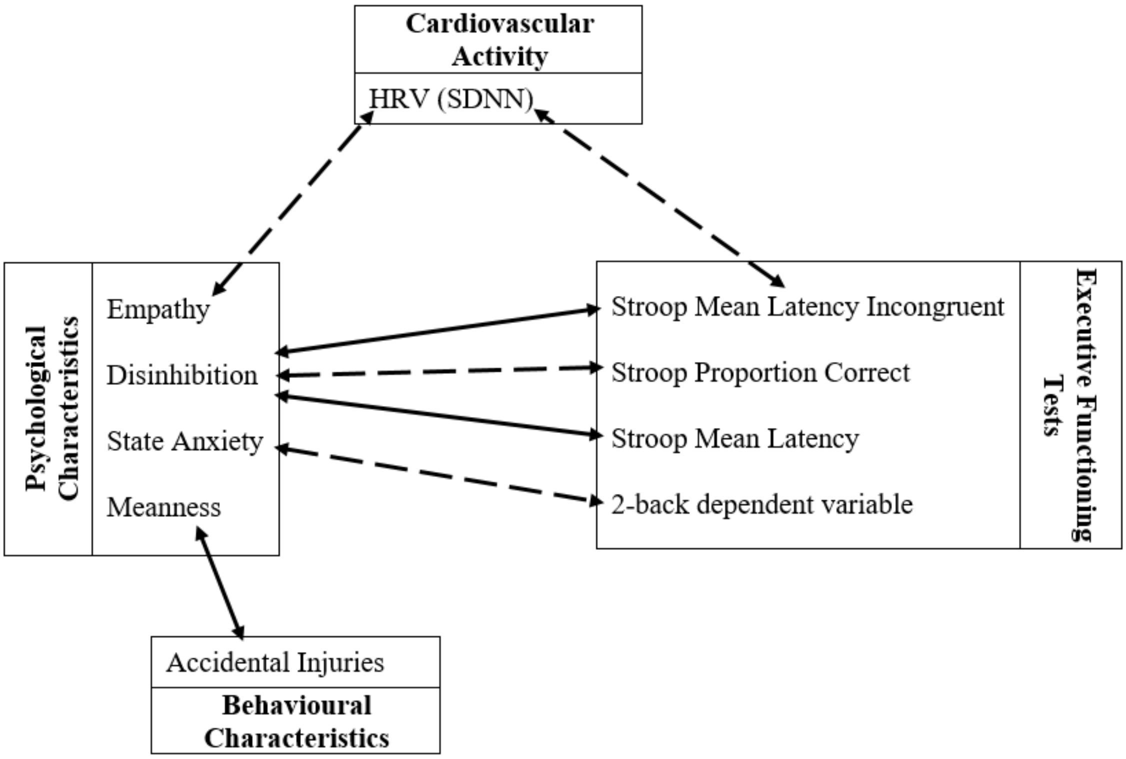



Figure 7.1: Correlations Supporting the Modified Model of Aggression

*Note. Solid and dashed arrows represent positive and negative Spearman's correlations respectively.*

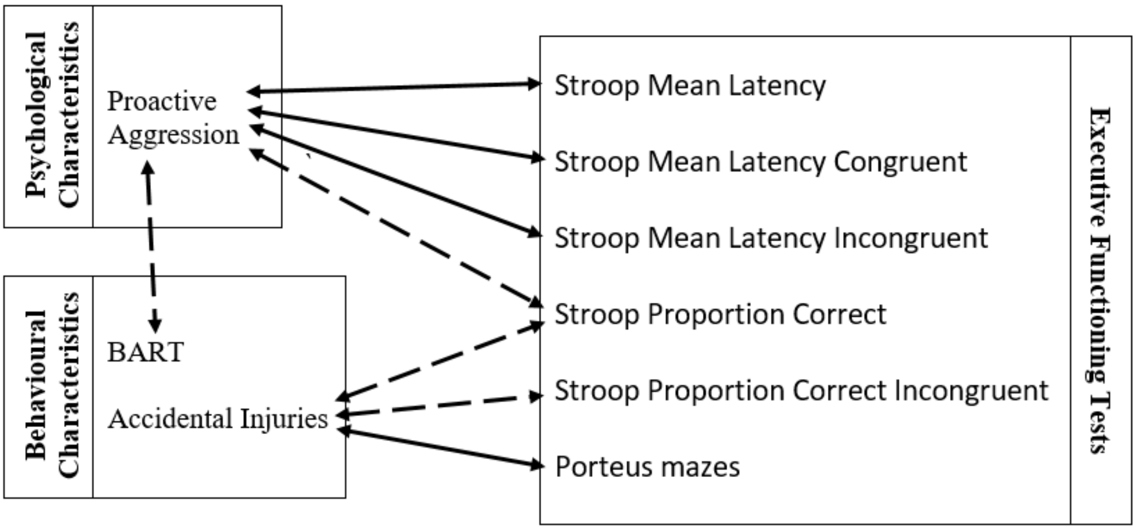



Figure 7.2: Correlations Failing to Support the Modified Model of Aggression

*Note: Solid and dashed arrows represent positive and negative Spearman's correlations respectively.*

Several of these findings are in keeping with those from the preceding experiment involving female undergraduates. Thus, individuals in both the male offender and female community sample who were aggressive showed low rHR, high HRV and low empathic traits but did not show signs of excessive disinhibition. These similar findings imply that a common biological mechanism maybe driving aggression in the two disparate groups of participants.

The major finding that high HRV is associated with both good executive functioning on the Stroop tests and with low empathy scores is of direct relevance to the understanding of the mechanisms underlying offending behaviour. One approach to understanding results on the Stroop tasks takes the view that better performance is associated with good decision making skills (Botvinick, 2007). The current data suggest that serious offending is associated with rational decision making which is accompanied by a callous disregard for others rather than acts related to impulsive sensation seeking. This view is in marked contrast to that advanced by Raine (2002) and colleagues (Raine et al. 1997; Raine & Venables, 1984) which is formulated on the premises that the link between low rHR and offending is mediated by impulsive acts which are intended to increase arousal.

The current findings also have implications for our understanding of psychopathy. Recent conceptualisations of psychopathy have emphasised the different contributions to the condition of factor 1 and factor 2 traits. Individuals diagnosed with psychopathy who show high factor 2 have been termed secondary psychopaths. These are characterised by high impulsivity and emotional instability. However, individuals with high factor 1 can be termed as primary psychopaths and are typically unemotional, fearless and low in anxiety (Cornell et al., 1996). Factor 2 can be associated with disinhibition, whereas factor 1 with the boldness and meanness subscales of the Triarchic Psychopathy Measure (Patrick et al., 2009).

Performance on the tests of executive function were related to traits associated with psychopathy. Thus, good performance on the 2-back variant of the N-back working memory task was associated with the absence of feelings of anxiety during the testing procedure, that is, states associated with factor 1. Furthermore, weaker performance on the Stroop task was associated with increased scores for disinhibition, that is, traits associated with factor 2. These findings imply that primary psychopaths can make quick and accurate decisions and have good working memory whereas the converse relationship would be expected in secondary psychopaths. This interpretation is in keeping with findings of Hansen et al. (2007), whereby interpersonal characteristics of the Psychopathy Checklist Revised (PCL-R) were associated with better working memory and higher HRV. Higher HRV scores would also be expected to be related to better emotion regulation (Smith et al., 2017).

Proactive and reactive aggression were previously reported to be differentially related to good and poor executive functioning respectively (Ellis et al., 2009). It was hypothesised that this relationship would also be seen in the current study. However, evidence of the opposite relationship was found. Higher scores on proactive aggressive traits were associated with taking longer to respond on the Stroop and less accurate responding. This poor Stroop performance would be expected to be indicative of poor decision making in general (Botvinick, 2007). By implication, although proactive aggressors act in a goal-oriented manner, their decisions could be poorly guided. As such the current results suggest that in offender samples the consequences of high proactive aggressive traits are not comfortably accommodated by the modified model of aggression.

The view that sensation seeking is related to aggressive behaviours is frequently expressed in the literature. This view originates from the putative claim that low rHR may be aversive and creates a desire engage in risky, criminogenic activities to upregulate arousal (Raine, 2002). Hence, sensation seeking can be seen as a concomitant of risk taking. The latter has been measured here with the BART (Lejuez et al., 2002). The BART is related to several aspects of decision making. Is generally assumed to measure the propensity to take bold and well-informed risks (Vigil-Colet, 2007; Snowden et al., 2017) but was also positively related to impulsivity (Cross et al., 2011). The current finding of a negative correlation between proactive aggression and the BART scores suggests that offenders who utilise instrumental aggression are not risk takers. The tendency to not take risks in these individuals may reflect a poor ability to make accurate judgements, as discussed in the previous paragraph. Although this account does not support the currently proposed model of aggression, it also questions the validity of the frequently cited claim that aggressive individuals take risks to upregulate arousal (Raine, 2002).

Accidental injuries were previously found to be related to low rHR (Latvala et al., 2015). The current study investigated this association in the anticipation that it may provide further insight into the mechanisms of the link between low rHR and aggression. It was hypothesized that frequent injuries will reflect the offenders' fearless character rather than their impulsivity. This proposition was supported by the positive correlation between meanness and unintentional injuries. However, higher scores on the latter also linked with increased impulsive errors of the Porteus mazes task and weaker Stroop performance. These results indicate that accidental injuries may be related to both malignant fearlessness and impulsive, irrational decision making. These characteristics are not mutually exclusive and, most likely, frequently coexist. Contrary to expectations, this account provided conflicting support for the currently proposed model of aggression.

The current study investigated various aspects of executive function with the Stroop, N-back, and Porteus mazes tasks. Performance on these tasks is believed reflect activity in certain areas of the brain. The Stroop is mostly associated with the anterior cingulate cortex (ACC) (Bush et al., 2000; Yuan & Raz, 2014). The N-back has been known to activate the dorsal part of the prefrontal cortex (PFC) (Royall et al. 2002; Goldman-Rakic, 1995; Jaeggi et al., 2003), whereas the Porteus mazes may be expected to map onto the ventral PFC (Kirsch et al., 2006). As discussed in the general introduction it is expected that high HRV reflects the activity of the dorsal PFC and the dorsal ACC but not in the ventral PFC. It has been found here that high HRV was linked with good performance on the Stroop task which maps onto the dorsal ACC. This tentatively implies that offenders characterised by low rHR and low empathy, as was found here, have strong ACC activity.

The ACC has previously been associated with processes of cognitive control related to emotion regulation, self regulation and many other functions (Ochsner & Gross, 2005; Allman, Hakeem, Erwin, Nimchinsky, & Hof, 2001; Shenhav, Botvinick, & Cohen, 2013). This assumed function supports findings discussed in previous experimental chapters which emphasized that individuals with high vagal control over the heart have good emotion regulation. This arrangement is in keeping with models of offending that highlight foresight as part of criminal behaviour and is in contrast to models relating aggressive behaviour to uncontrollable and illogical acts.

Even though mindfulness was not evaluated in the current study it can be expected that the offenders who scored low on empathy and high on HRV are mindful. This observation can be drawn based on the findings of Studies 1 to 3 which indicated that mindfulness is positively related to primary psychopathic traits, dampened emotional and physiological responding, and high HRV. This line of reasoning further supports the notion highlighted in previous chapters, namely that caution should be practiced when mindfulness is offered as an adjunct to therapy for aggressive individuals, including male offenders.

Clearly, a limitation of the study is the small number of participants. The current findings should be viewed as preliminary information and a guide to further research. Furthermore, the sample consisted of offenders with a variety of convictions. Several participants were sentenced for sex offences which were previously found unrelated to low rHR (Latvala et al., 2015; Latvala et al., 2016). The sex offenders, however, were also convicted for other crimes, including violent offences, and these have been previously related to low rHR. This observation highlights the difficulty of investigating the relationships of low rHR in criminal samples.

Future research investigating the underlining mechanisms of offending would benefit from the direct manipulation of cardiovascular function and the study of the changes in the associated psychological variables. The study using HRV biofeedback reported in Chapter 5 can be seen as tentatively addressing this issue. The findings suggest that raising HRV results decreases in anxiety. This may impact upon offending behaviour. The precise relationship, however, will be dictated by the interactions of anxiety, psychopathic traits and the subtypes of aggression.

The current findings do not lend support to the model described by Raine (2002) which emphasises the assumption that low rHR leads to offending behaviours via a drive to increase arousal. The currently proposed alternative model is supported by currently found evidence of relationships between cardiovascular activity and executive performance and unempathic traits. It is concluded that the criminogenic behaviour of offenders, particularly those characterised by high primary psychopathic traits, is reflected in rational decision making. Therefore, their behaviour is unlikely driven by impulsive stimulation seeking behaviour.

# CHAPTER 8: GENERAL CONCLUSION

## 8.1 Restatement of aims

The ability to adequately regulate emotions is perceived as a strongly desirable characteristic which is frequently promoted by modern societies. Effective emotion regulation is sometimes associated with elevated levels of trait mindfulness and effective task resolution (Arch & Craske, 2006; Hofmann et al., 2012; Johnsen et al., 2001). However, poor emotion regulation is frequently associated with aggression and can be linked to offending (Davidson et al., 2000; Roberton et al., 2014). Consequently, there is considerable interest within forensic psychology as to how therapeutic approaches to the treatment of offenders could target emotion regulation. This thesis set out to examine how emotion regulation and mindfulness are related to cardiovascular activity and the implications of these relationships for our understanding of aggressive behaviour.

Specifically, two controversial concepts which relate to the interactions between emotion regulation, mindfulness and aggression were explored. First is the commonly held view that trait mindfulness is associated with good well-being and that practices aimed at increasing trait mindfulness can be used to alleviate a variety of psychological difficulties (Didonna, 2009; Velotti et al., 2016; Baer, 2015). The second concept focussed on challenging a frequently cited model which attempts to explain the cause of aggressive behaviour by looking at its relationship to cardiovascular activity. This has led to the development of an alternative model of aggressive behaviour which is presented here. These two concepts have contextual similarities in that both were found to be associated with indices of emotion regulation and cardiovascular activity (Chambers et al., 2009; Feldman et al., 2007; Long et al., 2014; Portnoy & Farrington, 2015).

Mindfulness is frequently incorporated into therapies including Cognitive Behavioural Therapy (Singh et al., 2008), Dialectical Behaviour Therapy (Robins & Chapman, 2004), and Mindfulness Based Stress Reduction (Kabat-Zinn, 2003). Mindfulness based techniques have previously been used in prison settings (Auty, Cope, & Liebling, 2017; Samuelson, Carmody, Kabat-Zinn, & Bratt, 2007) and in substance misuse treatment centres (Black, 2014) to reduce stress and substance cravings. The frequently reported effects of mindfulness training are overwhelmingly positive (Brown & Ryan, 2003; Khoury et al., 2013; Giluk, 2009).

Trait mindfulness can be understood from a multimodal perspective (Bishop et al., 2004). Some of the critical factors of mindfulness have been linked to superior attentional skills, and being non-judgemental and nonresponsive to subjective experiences (Baer et al., 2008). Similar, primary psychopathic traits have previously been associated with abnormalities in certain processes of attention (Hiatt & Newman, 2006; Blair & Mitchell, 2009), reduced ability to utilise inner stimuli, and reductions in emotional and physiological responding (Skeem et al., 2007; Nentjes et al., 2013; van Honk et al., 2002). These similarities between mindfulness and primary psychopathic traits may represent a cause for concern and potentially undermine the view that mindfulness can be regarded as a universal treatment for psychological conditions.

A separate but related line of enquiry has focused on the well supported association between violent offending and low rHR (Latvala et al., 2015). This relationship has driven some researchers to postulate that aggressive individuals have a low level of sympathetic activity (Raine & Venables, 1984; Raine, 2002; Portnoy et al., 2014). This proposition has further led to speculations that the underarousal is aversive and drives individuals to impulsively seek stimulation. Some of the resultant activities are assumed to reflect criminal acts. This model of aggression is frequently cited and well known to researchers in the field.

However, it is lacking in empirical support and does not sit comfortably with the idea that some offenders act with premeditation.

The alternative view proposed in this thesis entails focussing on the corollaries of low rHR and brain function. Resting heart rate is predominantly mediated by the activity of the vagus (Levy, 1990; Uijtdehaage & Thayer, 2000). Increased activity of the vagus slows the heart rate and increases HRV (Reyes del Paso et al., 2013). Indexes of HRV were previously associated with certain processes of attention (Park & Thayer, 2014), and both good emotion regulation and executive functioning (Smith et al., 2017). This arrangement controversially suggests that offenders with low rHR are emotionally stable and well capable of planning their criminal acts. Such a view is in direct disagreement with the frequently cited model of aggression (Raine, 2002; Raine & Venables, 1984).

In summary, the literature on the positive effects of practicing mindfulness seems to be in contradiction with the conclusion that some of the factors of mindfulness are associated with the potentially damaging effects of psychopathy, while the assumption that low rHR is linked to offending via aversive underarousal and impulsive sensation seeking lacks empirical support.

The initial experimental chapters investigated the relationship between emotion regulation, mindfulness, aggressive traits and cardiovascular activity. Contrary to the frequently held view, it was found that high scores for trait mindfulness are associated with elevated primary psychopathic traits and dampened physiological responding to emotion-evoking stimuli.

Furthermore, Study 3 found that offenders, who undertook a programme of HRV biofeedback, increased their emotion regulation and trait mindfulness. By extrapolation, this finding suggested that offenders with high HRV, and associated low rHR, have good emotion regulation and are mindful. This analysis contradicts the commonly held views of the universal utility of mindfulness based interventions and the cause of offending. This line of reasoning led to the investigation of the concomitants of the relationship between rHR and aggressive traits. It was found that high vagal activity is linked to proactive aggression in female perpetrators of partner violence and lack of empathy, and in good executive performance in male offenders.

## 8.2 Summary of findings

The scrutiny of trait mindfulness and its seemingly universal benefits began with the investigation of its links to psychopathic traits. The literature review highlighted contextual similarities between certain facets of mindfulness and primary psychopathic characteristics. For example, both mindfulness and primary psychopathic traits were related to nonresponding to inner sensations (Baer et al., 2008; Bernstein et al., 2013; van Honk et al., 2002). A separate line of enquiry explored the relationships between psychopathic traits and two emotion regulation strategies, namely suppression and reappraisal. Findings from previous research suggested that primary but not secondary psychopathic traits were characterised by good emotion regulation (Long et al., 2014). The current study explored these two controversial views and found some evidence in support of them.

*Study 1*

Study 1 aimed to detail the relationships between emotion regulation strategies, psychopathic traits, and facets of mindfulness. The findings from Study 1 can be summarised in two interesting observations. The most interesting finding was that primary psychopathic traits were positively correlated with a total score of mindfulness. This suggests that mindfulness based therapies may not be the best choice for offenders characterised by high levels of callous and fearless traits. The second finding was that individuals' high in both primary and secondary psychopathic traits suppress their emotional responses. Controversially, this finding suggests that psychopaths can have strong intentional inhibitory control over expression of emotions. Therefore, treatments offered to affected individuals may be better focused on teaching reappraisal strategies.

The first study emphasised how total mindfulness scores were related to primary psychopathic traits. A deeper understanding of this relationship can be achieved by examining the different facets of mindfulness where two nearly significant correlations were observed, that is, between primary psychopathy and act with awareness and with non-reacting. The mindfulness facet of act with awareness means to focus undivided attention to subjective experiences (Bishop et al., 2004). Psychopathy has previously been associated with abnormalities in certain processes of attention, including failure to attend to secondary cues (Hiatt & Newman, 2006; Blair & Mitchell, 2009). This can be interpreted as a tendency to be more attentive to primary information or to become less distracted, which has also been linked to mindfulness (Jain et al., 2007). Nonreacting to subjective experience presents itself as a common denominator for both mindfulness and psychopathy. In psychopaths, this has been observed in the form of reduced ability to utilise inner stimuli (Bernstein et al., 2013; van Honk et al., 2002).

The findings described in the previous paragraph raise the possibility that mindfulness, when expressed in a single factor, may be related to reduced emotional and physiological responses to emotion evoking stimuli. Study 2 of this thesis set out to investigate the proposition by exploring self-report emotions and heart rate responding to a video clip containing graphic scenes of violence. In a previously published study, mindfulness was associated with increased ratings for emotional valence and attenuated physiological arousal (Lang, 1995). This implies that mindful individuals feel more positive and less intense emotions (Cameron & Fredrickson, 2015; Brown et al., 2012). Interestingly, convicted psychopaths, as defined by the PCL-R, were previously found to score higher on ratings of valence and failed to show physiological responses to aversive stimuli (Birbaumer et al., 2005).

*Study 2*

Study 2 aimed to investigate whether mindfulness elevates self-report emotions and dampens heart rate responding to a video clip containing graphic scenes of violence. In Study 2, heart rate was used as a measure of physiological responding. The heart typically decelerates in response to mildly aversive stimuli (Bradley et al., 2012; Codispoti et al., 2008). This deceleration is weaker if stimuli is perceived as less aversive (Bradley, 2009; Pittig et al., 2013). The major findings of Study 2 are that mindfulness was related to reduced self-report valence during the clip. This indicates that increased non-judgemental attention is associated with more positive feelings, even during viewing of the violent, tension and disgust evoking clip. Furthermore, when trait anxiety scores were partialed out, trait mindfulness was associated with a dampened heart rate response. This result reflects the observation made in Study 1 that mindfulness could be related to reduced physiological responding to emotional stimuli. The current findings further highlight the conclusion that mindfulness based therapies should not be offered without prior assessment of the clients' levels of callous and fearless traits, that is traits associated with primary psychopathy (Cornell et al., 1996).

Study 2 has implications for understanding the underlining mechanisms of trait mindfulness. In his review of studies, Bradley (2009) argued that cardiac deceleration in response to static images is related to sensory intake, whereby a more pronounced deceleration indexes enhanced perceptual focus. This view has been supported by the recognition that greater cardiac deceleration is associated with improved recall for emotional pictures and words (Abercrombie et al., 2008; Buchanan et al., 2006). In the light of these studies, the current findings suggest that mindfulness is related to a decrease in aversive stimuli intake. In support of this interpretation, mindfulness was previously found to attenuate recall for negative words (Alberts & Thewissen, 2011).

*Study 3*

Study 3 aimed to investigate the propensity for HRV biofeedback to elevate emotion regulation (Grossman & Taylor, 2007; Smith et al., 2017). It has been previously proposed that HRV biofeedback, which shares commonalities with mindfulness techniques, may be used to alleviate psychological characteristics associated with deficiencies in emotion regulation (Gillespie et al., 2012; Zucker et al., 2009; Renier, 2008; Gross & Muñoz, 1995). Study 3 explored this possibility by administering a 5-week-long HRV biofeedback course to a sample of incarcerated male offenders with substance misuse difficulties. Previous studies exploring the subject reported reductions in depression, anxiety, stress, anger, and increase in baseline HRV values (Zucker et al., 2009; Nolan et al., 2005; Renier, 2008). Importantly, higher HRV has previously been associated with better emotion regulation (Smith et al., 2017). The study adopted a mixed-method approach whereby a quantitative and qualitative analysis was performed.

Results of the quantitative analysis showed that emotion regulation and trait mindfulness had increased after the biofeedback course. Thus, lower scores for psychological difficulties, including depression, anxiety, stress and anger were seen. For trait mindfulness, only the non-judgemental factor of the FFMQ (Baer et al., 2008) was found to be significantly increased. Furthermore, findings of the post course interview indicated that the treatment improved participants' quality of sleep. However, analysis of participants' behaviour suggested that a participant diagnosed with personality disorder became more disruptive and violent over the duration of the course. These findings tentatively suggest that HRV biofeedback can be offered to depressed and anxious offenders but not to personality disordered individuals.

In summary, Studies 1 to 3 investigated the relationship of trait mindfulness to certain psychological characteristics and cardiovascular activity. These studies have shown that trait mindfulness is positively related to characteristics of primary psychopathy. Primary psychopaths were previously found to score higher on self report scores for valence and have reduced physiological responding to aversive stimuli (Birbaumer et al., 2005). Similarly, it was found here that mindfulness is related to reduced emotional responding, including physiological responses to mildly aversive stimuli. Furthermore, emotion regulation and trait mindfulness has been increased in consequence of participation in a HRV biofeedback course. High HRV has previously been related to good both emotion regulation and executive function (Smith et al., 2017; Hovland et al., 2012; Stenfors et al., 2016). However, high HRV is also associated with low rHR which is linked to increased offending (Latvala et al., 2015). Controversially, this suggests that offenders with low rHR are mindful and have good emotion regulation skills. Hence, further studies aimed at exploring the relationship of cardiovascular activity and offending.

Previous research exploring the relationship of low rHR and offending was focused on the perspective that the underarousal is driven by low sympathetic activity and tendencies to impulsively seek stimulation to increase arousal (Raine, 2002; Raine et al. 1997; Raine, 1996;

Raine & Venables, 1984). However, the low heart rate at rest, as was previously explained, is predominantly driven by increased activity of the vagus which is associated with feelings of relaxation and good emotion regulation (Smith et al., 2017). This promotes the idea that individuals with low rHR are characterised by aggressive traits which were previously associated with foresight in thinking, such as proactive aggression and factor 1 psychopathic traits (Ross et al., 2007; Hansen et al., 2007; Lantrip et al., 2016; Ellis et al., 2009; Maes & Brazil, 2013). Such interpretation stands in contrast to the frequently cited view championed by Raine and colleagues.

*Study 4*

Study 4 aimed to explore how cardiovascular activity and psychopathic traits relate to female perpetrated intimate partner physical aggression in a sample of female undergraduates. Previous literature has reported that male perpetrated partner violence can be related to low rHR (Babcock et al., 2004; Babcock et al., 2004). Therefore, it was hypothesized that a similar relationship can be found in aggressive compare to non-aggressive females.

Results of Study 4 showed that the scale of female perpetrated violence amongst UK university students is extensive with about a third of the participants having recently committed an act of violence against their male partners. Perpetrators significantly differed from non-perpetrators in their psychological characteristics and cardiovascular activity. The major findings were that perpetrators scored higher on aggressive traits, and psychopathic traits characterised by emotional resiliency and lack of empathy. Furthermore, the perpetrators had lower rHR and higher vagally mediated parasympathetic activity, as reflected in elevated levels of HRV (SDNN). Importantly, the latter was significantly associated with planned or proactive aggressive traits whereas no relationship was found for impulsive/reactive aggression. These results highlight the need to modify the existing model of aggression to account for the parasympathetically driven slowing of the heart and incorporate traits associated with premeditated offending.

The findings of Study 4 were specific to aggressive females. Hence, Study 5 aimed to extend this work to a sample of male serious offenders. Furthermore, Study 5 investigated whether cardiovascular activity relates to executive performance. High HRV has previously been associated with good performance on tests that assess working memory and Stroop task-related inhibition (Albinet et al., 2016; Jennings et al., 2015; Hansen et al., 2009; Hansen et al., 2003). It is generally believed that these tests or executive functions map onto the dlPFC and dACC regions of the brain respectively (Royall et al. 2002; Jaeggi et al., 2003; Yuan & Raz, 2014). Moreover, changes in the activity of these brain areas are believed to be mirrored by shifts in HRV (Chang et al., 2013; Critchley & Harrison, 2013; Smith et al., 2017). This evidence based reasoning implies that at least individuals with high HRV have good executive function and, contrary to what has been previously proposed, do not act on impulse.

*Study 5*

Results of Study 5 which supported the revised model linking low rHR and aggression were that HRV (SDNN) was negatively related to empathy and positively to performance on the Stroop task. Similarly, the latter was negatively associated with the disinhibition factor of the psychopathy scale. The results also led to the questioning of the view that offending is related to sensation seeking as no associations were found. However, contrary to the revised model, proactive aggression was found to be related to poor executive performance.

The results described here undermine the validity of the previously made claims that low rHR is aversive and inspires impulsive sensation seeking (Raine, 2002). The current results are in broad agreement with the literature which shows that low rHR is linked to high HRV. This necessarily weakens the unsupported claim that low rHR results from low sympathetic arousal and thus, makes the conclusion that low rHR is associated with an aversive psychological state less tenable.

Increased parasympathetic nervous system activity is related to high HRV and is also typically associated with feelings of relaxation and good emotion regulation (Smith et al., 2017). This is hard to reconcile with the idea that low rHR associated offending reflects the expression of impulsive sensation seeking to alleviate an aversive under aroused state.

The findings of Studies 3 to 5 encouraged the formulation of a modified model of aggressive behaviour which emphasises how low rHR is associated with high HRV and emotional stability, low empathic concern and the capacity to make rational decisions. Consequently, this new model implies that offending is related to a callous disregard for the wellbeing of others, and is more likely to be driven by instrumental than impulsive factors.

### 8.3 General interpretation of findings

In summary, the findings from the above studies allow for the formulation of two distinct psychological profiles. The “well functioning” profile (type 1) is characterised by good emotion regulation, high mindfulness, increased scores for primary psychopathic traits, high HRV and good executive performance. Conversely, the “dysfunctional” profile (type 2) is characterised by emotion dysregulation, low mindfulness, high secondary psychopathic traits, low HRV and poor executive performance. It is feasible that these two profiles can be observed in offending and non-offending individuals. Thus, in community samples type 1 characteristics may be apparent in individuals who utilise charm, dishonesty and callousness to enjoy profitable careers whereas in prison establishments these individuals may hold a high social status. Individuals with strong type 2 features may be expected to hold a lower social status and suffer from affective disorders.

The two profiles distinctively differ on their ability to regulate emotions. The current work suggests that at least three emotion regulatory strategies described in Chapter 1.3, that is attention deployment, cognitive change, and response modulation are unimpaired in type 1 individuals. Strong attention deployment can be associated with such characteristics as high mindfulness and primary psychopathic traits. Effective cognitive change can be linked with heightened performance on the Stroop task and high HRV. Finally, response modulation can be related to use suppression as a primary strategy and to the effects that mindfulness has on heart rate responses to graphic violence. Conversely, type 2 individuals appear to have a poor ability to regulate emotions. Importantly, both profiles can be characterised by heightened tendencies to aggress. This suggests that both hyper and hypoactivity of emotion regulatory mechanisms can potentially lead to acts of violence.

The currently proposed profiles are expected to differ on other psychological characteristics. For example, the two profiles can differ in the level of anxiety. Chapter 1.7.2 describes studies that demonstrate both high and low anxiety can be related to aggression. Individuals with type 2 features can be considered anxious because of their poor ability to regulate emotions, low mindfulness, and high secondary psychopathic traits. Conversely, individuals with type 1 features may be characterised by low levels of anxiety. The two different types may also link with partner batterers typologies advocated by Holtzworth-Munroe. Type 1 characteristics seem to resemble the features of a generally violent-antisocial batterer whereas type 2 features share similarities with characteristics of the borderline-dysphoric type of batterer. However, future studies should scientifically investigate these hypothetical connections.

The currently proposed typology can be theoretically linked to frequently cited psychological models of aggression which were briefly discussed in Chapter 1.7. For example, Lorenz’s etiological model posits that aggression is innate and this implies a biological basis of violent acts. The currently proposed psychological profiles have biological foundations expressed in the various levels of vagal activity. The frustration – aggression theory emphasizes that the likelihood of a persons’ aggression is a function of the persons’ cognitive abilities. The currently proposed typology distinguishes between individuals characterised with poor and good executive functions. The social learning model of aggression posits that acquisition of skills can both lower and increase aggressiveness. The current findings suggest that teaching skills such as mindfulness to type 1 individuals may make them more aggressive. Conversely, type 2 individuals would largely benefit from acquisition of mindfulness skills. These theoretical links support the reliability of the newly constructed typology.

Several psychological factors including; the ability to regulate emotions, utilise mindfulness skills, the strength of HRV, and executive performance, can all be expected to relate to the activity of certain brain areas. The area of the brain which appears to be associated with all of these factors is the ACC. From a neurobiological perspective, the ACC can regulate emotions by inhibiting the activity of the amygdala nuclei as was discussed in section 1.4. There is, however, little consensus about the precise role that the ACC plays in influencing these psychological functions.

The putative roles that the ACC is most frequently associated with include inhibitory control (Garavan, Ross, Murphy, Roche, & Stein, 2002), conflict monitoring (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Kerns et al., 2004), decision making (Botvinick, 2007; Bush et al., 2002), and emotional processing (Etkin et al., 2006; Etkin et al., 2011). Shenhav et al. (2013) have proposed a unified account of how the ACC can contribute to this diverse range of psychological functions. Their model posits that the dACC monitors task-related information and integrates it to compute an expected value of control (EVC). This value represents the anticipated overt and covert costs and payoffs of control-demanding behaviour. Information about the EVC can be relayed to other regulatory structures, such as the higher cortical centres. Considering this explanation, poor dACC functioning can be associated with inadequate monitoring and integration of control-related information, and a weaken aptitude to relay signals to other structures of the brain. Overtly, this arrangement may be expressed by an increase in type 2 traits and behaviours.

**8.4 Conclusion**

To conclude, the studies presented here fail to support the two frequently held views, namely that high trait mindfulness has "universal" benefits to psychological well-being, and that low rHR is aversive and motivates impulsive sensation seeking. In contrast to these views mindfulness was shown to be positively associated with primary psychopathic traits and shallow affective responding. Furthermore, the current studies show that HRV biofeedback can elevate mindfulness while paradoxically high HRV is associated with proactive aggression, lack of empathy and good executive functioning. This suggests that the relationship of low rHR and offending may be better explained by the influence of factor 1 psychopathic traits and premeditated aggressive behaviour. These findings highlight the need to review the stance on therapies offered to certain types of aggressive individuals.

The current findings have implications for the use of mindfulness based treatments. These treatments could be therapeutically effective in individuals with elevated levels of anxiety, empathy and secondary psychopathic traits. The current studies, however, also raise the real possibility that such therapies could cause callous and fearless individuals to become more aggressive. This highlights the dangers of assuming that high trait mindfulness is always associated with positive effects and psychological well-being.

The findings further emphasise how offending by individuals with low rHR may reflect the interactions of low empathic abilities and rational decision making. This final conclusion, however, must be tempered by the acknowledgment that the current studies on rHR and aggression were limited by the paucity of large numbers of convicted male offenders.

Future studies should focus on the effects of regulating respiratory patterns on; executive function, different types of risk taking and responding to stimuli evoking fear and anxiety. It is anticipated that such work would show improved prefrontal performance with slowing of the rate of breathing which would be accompanied by more accurate perception of risk and consequently more appropriate responding to fear and anxiety related cues. Parallel brain imaging studies should investigate how increasing mindfulness, or raising HRV, is reflected both in increased dACC baseline activity and evoked changes in response to fear and anxiety inducing cues, which would be accompanied by corresponding decreased activity in the central amygdala nuclei.

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# APPENDIX 1

The appendix contains some of the less informative correlational analyses for studies described in chapters three (Study 1), four (Study 2A and 2B), six (Study 4A and 4B), and seven (Study 5). The all variables used in the current analysis were first introduced in the General Methods section (Chapter 2).

**Study 1**

Spearman's rank-ordered correlations between the total mindfulness score and remaining variables used in Study 1

**Correlations**

| | | Total Mindfulness | Reappraisal | Suppression | Primary Psychopathy | Secondary Psychopathy |
|---|---|---|---|---|---|---|
| Total Mindfulness | Pearson Correlation | 1 | .238** | -.271** | -.095 | -.416** |
| | Sig. (2-tailed) | | .000 | .000 | .149 | .000 |
| | N | 234 | 234 | 234 | 234 | 234 |
| Reappraisal | Pearson Correlation | .238** | 1 | .076 | -.094 | -.135* |
| | Sig. (2-tailed) | .000 | | .246 | .151 | .040 |
| | N | 234 | 234 | 234 | 234 | 234 |
| Suppression | Pearson Correlation | -.271** | .076 | 1 | .287** | .321** |
| | Sig. (2-tailed) | .000 | .246 | | .000 | .000 |
| | N | 234 | 234 | 234 | 234 | 234 |
| Primary Psychopathy | Pearson Correlation | -.095 | -.094 | .287** | 1 | .489** |
| | Sig. (2-tailed) | .149 | .151 | .000 | | .000 |
| | N | 234 | 234 | 234 | 234 | 234 |
| Secondary Psychopathy | Pearson Correlation | -.416** | -.135* | .321** | .489** | 1 |
| | Sig. (2-tailed) | .000 | .040 | .000 | .000 | |
| | N | 234 | 234 | 234 | 234 | 234 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: The total mindfulness score was obtained by summating facets of the Five Facet Mindfulness Questionnaire. Reappraisal and suppression are scales of the Emotion Regulation Questionnaire. Primary and Secondary psychopathy are facets of the Levenson psychopathy measure.*

## Study 2A

Pearson's zero-order correlations between trait mindfulness and emotions evoked during the clip

**Correlations**

| | | MAAS | Amusement | Anger | Arousal | Confusion | Contempt | Contentment | Disgust | Embarrassment |
|---|---|---|---|---|---|---|---|---|---|---|
| MAAS | Pearson Correlation | 1 | .397** | -.132 | .025 | -.256 | -.301* | -.101 | -.282* | -.328* |
| | Sig. (2-tailed) | | .005 | .366 | .864 | .076 | .035 | .490 | .050 | .021 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Amusement | Pearson Correlation | .397** | 1 | -.119 | .046 | -.232 | -.010 | .243 | -.356* | -.269 |
| | Sig. (2-tailed) | .005 | | .416 | .752 | .109 | .944 | .093 | .012 | .062 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Anger | Pearson Correlation | -.132 | -.119 | 1 | .167 | .330* | .327* | .203 | .739** | .329* |
| | Sig. (2-tailed) | .366 | .416 | | .251 | .021 | .022 | .162 | .000 | .021 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Arousal | Pearson Correlation | .025 | .046 | .167 | 1 | .039 | -.057 | .153 | .165 | .290* |
| | Sig. (2-tailed) | .864 | .752 | .251 | | .790 | .697 | .293 | .256 | .043 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Confusion | Pearson Correlation | -.256 | -.232 | .330* | .039 | 1 | -.159 | .013 | .462** | .257 |
| | Sig. (2-tailed) | .076 | .109 | .021 | .790 | | .274 | .928 | .001 | .075 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Contempt | Pearson Correlation | -.301* | -.010 | .327* | -.057 | -.159 | 1 | .424** | .156 | -.082 |
| | Sig. (2-tailed) | .035 | .944 | .022 | .697 | .274 | | .002 | .284 | .577 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Contentment | Pearson Correlation | -.101 | .243 | .203 | .153 | .013 | .424** | 1 | -.080 | .130 |
| | Sig. (2-tailed) | .490 | .093 | .162 | .293 | .928 | .002 | | .587 | .374 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Disgust | Pearson Correlation | -.282* | -.356* | .739** | .165 | .462** | .156 | -.080 | 1 | .400** |
| | Sig. (2-tailed) | .050 | .012 | .000 | .256 | .001 | .284 | .587 | | .004 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Embarrassment | Pearson Correlation | -.328* | -.269 | .329* | .290* | .257 | -.082 | .130 | .400** | 1 |
| | Sig. (2-tailed) | .021 | .062 | .021 | .043 | .075 | .577 | .374 | .004 | |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: The MAAS (Mindfulness Attention Awareness Scale) is a single construct measure of trait mindfulness. The emotions were measured with the Self-Report Emotion Questionnaire.*

Pearson’s zero-order correlations between trait mindfulness and emotions evoked during the clip (cont.)

**Correlations**

| | | MAAS | Fear | Happiness | Interest | Pain | Relief | Sadness | Surprise | Tension |
|---|---|---|---|---|---|---|---|---|---|---|
| MAAS | Pearson Correlation | 1 | -.290* | .184 | .072 | -.213 | -.013 | -.258 | -.261 | -.241 |
| | Sig. (2-tailed) | | .043 | .206 | .625 | .142 | .932 | .073 | .070 | .096 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Fear | Pearson Correlation | -.290* | 1 | -.108 | .111 | .502** | -.008 | .460** | .274 | .626** |
| | Sig. (2-tailed) | .043 | | .460 | .447 | .000 | .956 | .001 | .057 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Happiness | Pearson Correlation | .184 | -.108 | 1 | .193 | -.182 | .343* | -.161 | -.079 | -.027 |
| | Sig. (2-tailed) | .206 | .460 | | .184 | .211 | .016 | .269 | .588 | .852 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Interest | Pearson Correlation | .072 | .111 | .193 | 1 | .035 | .308* | .356* | .468** | .301* |
| | Sig. (2-tailed) | .625 | .447 | .184 | | .813 | .032 | .012 | .001 | .035 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Pain | Pearson Correlation | -.213 | .502** | -.182 | .035 | 1 | -.067 | .695** | .148 | .624** |
| | Sig. (2-tailed) | .142 | .000 | .211 | .813 | | .648 | .000 | .312 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Relief | Pearson Correlation | -.013 | -.008 | .343* | .308* | -.067 | 1 | -.038 | .114 | .075 |
| | Sig. (2-tailed) | .932 | .956 | .016 | .032 | .648 | | .795 | .437 | .610 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Sadness | Pearson Correlation | -.258 | .460** | -.161 | .356* | .695** | -.038 | 1 | .366** | .585** |
| | Sig. (2-tailed) | .073 | .001 | .269 | .012 | .000 | .795 | | .010 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Surprise | Pearson Correlation | -.261 | .274 | -.079 | .468** | .148 | .114 | .366** | 1 | .412** |
| | Sig. (2-tailed) | .070 | .057 | .588 | .001 | .312 | .437 | .010 | | .003 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Tension | Pearson Correlation | -.241 | .626** | -.027 | .301* | .624** | .075 | .585** | .412** | 1 |
| | Sig. (2-tailed) | .096 | .000 | .852 | .035 | .000 | .610 | .000 | .003 | |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The MAAS (Mindfulness Attention Awareness Scale) is a single construct measure of trait mindfulness. The emotions were measured with the Self-Report Emotion Questionnaire.*

Pearson's zero-order correlations between valence and emotions evoked during the clip

**Correlations**

| | | Valence | Amusement | Anger | Arousal | Confusion | Contempt | Contentment | Disgust | Embarrassment |
|---|---|---|---|---|---|---|---|---|---|---|
| Valence | Pearson Correlation | 1 | .607** | -.282* | -.160 | -.335* | .015 | .230 | -.598** | -.381** |
| | Sig. (2-tailed) | | .000 | .050 | .271 | .019 | .919 | .111 | .000 | .007 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Amusement | Pearson Correlation | .607** | 1 | -.119 | .046 | -.232 | -.010 | .243 | -.356* | -.269 |
| | Sig. (2-tailed) | .000 | | .416 | .752 | .109 | .944 | .093 | .012 | .062 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Anger | Pearson Correlation | -.282* | -.119 | 1 | .167 | .330* | .327* | .203 | .739** | .329* |
| | Sig. (2-tailed) | .050 | .416 | | .251 | .021 | .022 | .162 | .000 | .021 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Arousal | Pearson Correlation | -.160 | .046 | .167 | 1 | .039 | -.057 | .153 | .165 | .290* |
| | Sig. (2-tailed) | .271 | .752 | .251 | | .790 | .697 | .293 | .256 | .043 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Confusion | Pearson Correlation | -.335* | -.232 | .330* | .039 | 1 | -.159 | .013 | .462** | .257 |
| | Sig. (2-tailed) | .019 | .109 | .021 | .790 | | .274 | .928 | .001 | .075 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Contempt | Pearson Correlation | .015 | -.010 | .327* | -.057 | -.159 | 1 | .424** | .156 | -.082 |
| | Sig. (2-tailed) | .919 | .944 | .022 | .697 | .274 | | .002 | .284 | .577 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Contentment | Pearson Correlation | .230 | .243 | .203 | .153 | .013 | .424** | 1 | -.080 | .130 |
| | Sig. (2-tailed) | .111 | .093 | .162 | .293 | .928 | .002 | | .587 | .374 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Disgust | Pearson Correlation | -.598** | -.356* | .739** | .165 | .462** | .156 | -.080 | 1 | .400** |
| | Sig. (2-tailed) | .000 | .012 | .000 | .256 | .001 | .284 | .587 | | .004 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Embarrassment | Pearson Correlation | -.381** | -.269 | .329* | .290* | .257 | -.082 | .130 | .400** | 1 |
| | Sig. (2-tailed) | .007 | .062 | .021 | .043 | .075 | .577 | .374 | .004 | |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: Valence was obtained with a measure proposed by Lang (1995). The emotions were measured with the Self-Report Emotion Questionnaire.*

Pearson's zero-order correlations between valence and emotions evoked during the clip (cont.)

**Correlations**

| | | Valence | Fear | Happiness | Interest | Pain | Relief | Sadness | Surprise | Tension |
|---|---|---|---|---|---|---|---|---|---|---|
| Valence | Pearson Correlation | 1 | -.329* | .267 | .235 | -.493** | .230 | -.387** | -.191 | -.412** |
| | Sig. (2-tailed) | | .021 | .063 | .104 | .000 | .111 | .006 | .190 | .003 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Fear | Pearson Correlation | -.329* | 1 | -.108 | .111 | .502** | -.008 | .460** | .274 | .626** |
| | Sig. (2-tailed) | .021 | | .460 | .447 | .000 | .956 | .001 | .057 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Happiness | Pearson Correlation | .267 | -.108 | 1 | .193 | -.182 | .343* | -.161 | -.079 | -.027 |
| | Sig. (2-tailed) | .063 | .460 | | .184 | .211 | .016 | .269 | .588 | .852 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Interest | Pearson Correlation | .235 | .111 | .193 | 1 | .035 | .308* | .356* | .468** | .301* |
| | Sig. (2-tailed) | .104 | .447 | .184 | | .813 | .032 | .012 | .001 | .035 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Pain | Pearson Correlation | -.493** | .502** | -.182 | .035 | 1 | -.067 | .695** | .148 | .624** |
| | Sig. (2-tailed) | .000 | .000 | .211 | .813 | | .648 | .000 | .312 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Relief | Pearson Correlation | .230 | -.008 | .343* | .308* | -.067 | 1 | -.038 | .114 | .075 |
| | Sig. (2-tailed) | .111 | .956 | .016 | .032 | .648 | | .795 | .437 | .610 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Sadness | Pearson Correlation | -.387** | .460** | -.161 | .356* | .695** | -.038 | 1 | .366** | .585** |
| | Sig. (2-tailed) | .006 | .001 | .269 | .012 | .000 | .795 | | .010 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Surprise | Pearson Correlation | -.191 | .274 | -.079 | .468** | .148 | .114 | .366** | 1 | .412** |
| | Sig. (2-tailed) | .190 | .057 | .588 | .001 | .312 | .437 | .010 | | .003 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Tension | Pearson Correlation | -.412** | .626** | -.027 | .301* | .624** | .075 | .585** | .412** | 1 |
| | Sig. (2-tailed) | .003 | .000 | .852 | .035 | .000 | .610 | .000 | .003 | |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Valence was obtained with a measure proposed by Lang (1995). The emotions were measured with the Self-Report Emotion Questionnaire.*

Pearson's zero-order correlations between arousal and emotions evoked during the clip

**Correlations**

| | | Arousal_Lang | Amusement | Anger | Arousal | Confusion | Contempt | Contentment | Disgust | Embarrassment |
|---|---|---|---|---|---|---|---|---|---|---|
| Arousal_Lang | Pearson Correlation | 1 | -.061 | .277 | .688** | .148 | -.107 | .092 | .350* | .430** |
| | Sig. (2-tailed) | | .676 | .054 | .000 | .311 | .463 | .530 | .014 | .002 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Amusement | Pearson Correlation | -.061 | 1 | -.119 | .046 | -.232 | -.010 | .243 | -.356* | -.269 |
| | Sig. (2-tailed) | .676 | | .416 | .752 | .109 | .944 | .093 | .012 | .062 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Anger | Pearson Correlation | .277 | -.119 | 1 | .167 | .330* | .327* | .203 | .739** | .329* |
| | Sig. (2-tailed) | .054 | .416 | | .251 | .021 | .022 | .162 | .000 | .021 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Arousal | Pearson Correlation | .688** | .046 | .167 | 1 | .039 | -.057 | .153 | .165 | .290* |
| | Sig. (2-tailed) | .000 | .752 | .251 | | .790 | .697 | .293 | .256 | .043 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Confusion | Pearson Correlation | .148 | -.232 | .330* | .039 | 1 | -.159 | .013 | .462** | .257 |
| | Sig. (2-tailed) | .311 | .109 | .021 | .790 | | .274 | .928 | .001 | .075 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Contempt | Pearson Correlation | -.107 | -.010 | .327* | -.057 | -.159 | 1 | .424** | .156 | -.082 |
| | Sig. (2-tailed) | .463 | .944 | .022 | .697 | .274 | | .002 | .284 | .577 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Contentment | Pearson Correlation | .092 | .243 | .203 | .153 | .013 | .424** | 1 | -.080 | .130 |
| | Sig. (2-tailed) | .530 | .093 | .162 | .293 | .928 | .002 | | .587 | .374 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Disgust | Pearson Correlation | .350* | -.356* | .739** | .165 | .462** | .156 | -.080 | 1 | .400** |
| | Sig. (2-tailed) | .014 | .012 | .000 | .256 | .001 | .284 | .587 | | .004 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Embarrassment | Pearson Correlation | .430** | -.269 | .329* | .290* | .257 | -.082 | .130 | .400** | 1 |
| | Sig. (2-tailed) | .002 | .062 | .021 | .043 | .075 | .577 | .374 | .004 | |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: Arousal was obtained with a measure proposed by Lang (1995). The emotions were measured with the Self-Report Emotion Questionnaire.*

Pearson’s zero-order correlations between arousal and emotions evoked during the clip (cont.)

**Correlations**

| | | Arousal_Lang | Fear | Happiness | Interest | Pain | Relief | Sadness | Surprise | Tension |
|---|---|---|---|---|---|---|---|---|---|---|
| Arousal_Lang | Pearson Correlation | 1 | .275 | -.111 | -.045 | .562** | .059 | .393** | .158 | .304* |
| | Sig. (2-tailed) | | .056 | .446 | .757 | .000 | .689 | .005 | .277 | .034 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Fear | Pearson Correlation | .275 | 1 | -.108 | .111 | .502** | -.008 | .460** | .274 | .626** |
| | Sig. (2-tailed) | .056 | | .460 | .447 | .000 | .956 | .001 | .057 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Happiness | Pearson Correlation | -.111 | -.108 | 1 | .193 | -.182 | .343* | -.161 | -.079 | -.027 |
| | Sig. (2-tailed) | .446 | .460 | | .184 | .211 | .016 | .269 | .588 | .852 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Interest | Pearson Correlation | -.045 | .111 | .193 | 1 | .035 | .308* | .356* | .468** | .301* |
| | Sig. (2-tailed) | .757 | .447 | .184 | | .813 | .032 | .012 | .001 | .035 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Pain | Pearson Correlation | .562** | .502** | -.182 | .035 | 1 | -.067 | .695** | .148 | .624** |
| | Sig. (2-tailed) | .000 | .000 | .211 | .813 | | .648 | .000 | .312 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Relief | Pearson Correlation | .059 | -.008 | .343* | .308* | -.067 | 1 | -.038 | .114 | .075 |
| | Sig. (2-tailed) | .689 | .956 | .016 | .032 | .648 | | .795 | .437 | .610 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Sadness | Pearson Correlation | .393** | .460** | -.161 | .356* | .695** | -.038 | 1 | .366** | .585** |
| | Sig. (2-tailed) | .005 | .001 | .269 | .012 | .000 | .795 | | .010 | .000 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Surprise | Pearson Correlation | .158 | .274 | -.079 | .468** | .148 | .114 | .366** | 1 | .412** |
| | Sig. (2-tailed) | .277 | .057 | .588 | .001 | .312 | .437 | .010 | | .003 |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| Tension | Pearson Correlation | .304* | .626** | -.027 | .301* | .624** | .075 | .585** | .412** | 1 |
| | Sig. (2-tailed) | .034 | .000 | .852 | .035 | .000 | .610 | .000 | .003 | |
| | N | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: Arousal was obtained with a measure proposed by Lang (1995). The emotions were measured with the Self-Report Emotion Questionnaire.*

**Study 2B**

Pearson's zero-order correlations between trait mindfulness and trait anxiety

**Correlations**

| | | Mindfulness | Trait Anxiety |
|---|---|---|---|
| Mindfulness | Pearson Correlation | 1 | -.443* |
| | Sig. (2-tailed) | | .011 |
| | N | 32 | 32 |
| Trait Anxiety | Pearson Correlation | -.443* | 1 |
| | Sig. (2-tailed) | .011 | |
| | N | 32 | 32 |

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: Mindfulness was measured with the Mindfulness Attention Awareness Scale. Trait Anxiety was measured with the State Trait Anxiety Inventory.*

## Study 4A

Spearman's rank-ordered correlations for variables used in Study 4A

**Correlations**

| | | | Physical Assautl Scale | Primary Psychopathy | Secondary Psychopathy | Trait Anxiety | Borderline |
|---|---|---|---|---|---|---|---|
| Spearman's rho | Physical Assautl Scale | Correlation Coefficient | 1.000 | .068 | .131** | .041 | .051 |
| | | Sig. (2-tailed) | . | .161 | .006 | .391 | .291 |
| | | N | 432 | 432 | 432 | 432 | 432 |
| | Primary Psychopathy | Correlation Coefficient | .068 | 1.000 | .454** | .175** | .213** |
| | | Sig. (2-tailed) | .161 | . | .000 | .000 | .000 |
| | | N | 432 | 443 | 443 | 443 | 443 |
| | Secondary Psychopathy | Correlation Coefficient | .131** | .454** | 1.000 | .287** | .573** |
| | | Sig. (2-tailed) | .006 | .000 | . | .000 | .000 |
| | | N | 432 | 443 | 443 | 443 | 443 |
| | Trait Anxiety | Correlation Coefficient | .041 | .175** | .287** | 1.000 | .374** |
| | | Sig. (2-tailed) | .391 | .000 | .000 | . | .000 |
| | | N | 432 | 443 | 443 | 443 | 443 |
| | Borderline | Correlation Coefficient | .051 | .213** | .573** | .374** | 1.000 |
| | | Sig. (2-tailed) | .291 | .000 | .000 | .000 | . |
| | | N | 432 | 443 | 443 | 443 | 443 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The Physical Assault variable used in the current analysis was recoded back to its original, nominal values. Physical Assault was measured with the Conflict Tactics Scale – 2. Primary and Secondary psychopathy are facets of the Levenson psychopathy measure. Trait Anxiety was measured with the State Trait Anxiety Inventory. Borderline was measured with the Millon Clinical Multiaxial Inventory – III.*

**Study 4B**

Spearman's rank-ordered correlations between indices of intimate partner violence and measures of resting cardiovascular activity

**Correlations**

| | | | CTS2 Negotiation | CTS2 Psychological Aggression | CTS2 Physical Aggression | CTS2 Sexual Coercion | CTS2 Injury | mean Heart Rate Sitting | SDNN Sitting |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | CTS2 Negotiation | Correlation Coefficient | 1.000 | .391** | .213* | .066 | -.061 | -.003 | -.024 |
| | | Sig. (2-tailed) | . | .000 | .042 | .534 | .562 | .979 | .837 |
| | | N | 92 | 91 | 92 | 92 | 92 | 73 | 73 |
| | CTS2 Psychological Aggression | Correlation Coefficient | .391** | 1.000 | .589** | .066 | .219* | .067 | .031 |
| | | Sig. (2-tailed) | .000 | . | .000 | .532 | .037 | .575 | .797 |
| | | N | 91 | 91 | 91 | 91 | 91 | 73 | 73 |
| | CTS2 Physical Aggression | Correlation Coefficient | .213* | .589** | 1.000 | .149 | .322** | -.297* | .300** |
| | | Sig. (2-tailed) | .042 | .000 | . | .157 | .002 | .011 | .010 |
| | | N | 92 | 91 | 92 | 92 | 92 | 73 | 73 |
| | CTS2 Sexual Coercion | Correlation Coefficient | .066 | .066 | .149 | 1.000 | .039 | .001 | .045 |
| | | Sig. (2-tailed) | .534 | .532 | .157 | . | .714 | .995 | .704 |
| | | N | 92 | 91 | 92 | 92 | 92 | 73 | 73 |
| | CTS2 Injury | Correlation Coefficient | -.061 | .219* | .322** | .039 | 1.000 | -.137 | .087 |
| | | Sig. (2-tailed) | .562 | .037 | .002 | .714 | . | .249 | .466 |
| | | N | 92 | 91 | 92 | 92 | 92 | 73 | 73 |
| | mean Heart Rate Sitting | Correlation Coefficient | -.003 | .067 | -.297* | .001 | -.137 | 1.000 | -.709** |
| | | Sig. (2-tailed) | .979 | .575 | .011 | .995 | .249 | . | .000 |
| | | N | 73 | 73 | 73 | 73 | 73 | 73 | 73 |
| | SDNN Sitting | Correlation Coefficient | -.024 | .031 | .300** | .045 | .087 | -.709** | 1.000 |
| | | Sig. (2-tailed) | .837 | .797 | .010 | .704 | .466 | .000 | . |
| | | N | 73 | 73 | 73 | 73 | 73 | 73 | 73 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: All variables used in the current analysis were nominal. The CTS2 items were obtained with the use of the Conflict Tactics Scale – 2. Cardiovascular activity was measured with a wrist-worn Biocom 4000 USB device.*

Spearman’s rank-ordered correlations between indices of intimate partner violence and psychological characteristics

**Correlations**

| | | | CTS2 Negotiation | CTS2 Psychological Aggression | CTS2 Physical Aggression | CTS2 Sexual Coercion | CTS2 Injury | Proactive Aggression | Reactive Aggression | Boldness | Meanness | Disinhibition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | CTS2 Negotiation | Correlation Coefficient | 1.000 | .391** | .213* | .066 | -.061 | -.024 | .202 | -.059 | .056 | .079 |
| | | Sig. (2-tailed) | . | .000 | .042 | .534 | .562 | .822 | .053 | .576 | .597 | .452 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | CTS2 Psychological Aggression | Correlation Coefficient | .391** | 1.000 | .589** | .066 | .219* | .275** | .323** | .101 | .183 | .185 |
| | | Sig. (2-tailed) | .000 | . | .000 | .532 | .037 | .008 | .002 | .339 | .083 | .079 |
| | | N | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| | CTS2 Physical Aggression | Correlation Coefficient | .213* | .589** | 1.000 | .149 | .322** | .343** | .324** | .244* | .222* | .183 |
| | | Sig. (2-tailed) | .042 | .000 | . | .157 | .002 | .001 | .002 | .019 | .033 | .081 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | CTS2 Sexual Coercion | Correlation Coefficient | .066 | .066 | .149 | 1.000 | .039 | .178 | .172 | -.011 | .203 | .230* |
| | | Sig. (2-tailed) | .534 | .532 | .157 | . | .714 | .089 | .101 | .917 | .053 | .027 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | CTS2 Injury | Correlation Coefficient | -.061 | .219* | .322** | .039 | 1.000 | .129 | -.041 | .114 | -.044 | -.068 |
| | | Sig. (2-tailed) | .562 | .037 | .002 | .714 | . | .220 | .698 | .278 | .679 | .519 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | Proactive Aggression | Correlation Coefficient | -.024 | .275** | .343** | .178 | .129 | 1.000 | .467** | .101 | .456** | .382** |
| | | Sig. (2-tailed) | .822 | .008 | .001 | .089 | .220 | . | .000 | .340 | .000 | .000 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | Reactive Aggression | Correlation Coefficient | .202 | .323** | .324** | .172 | -.041 | .467** | 1.000 | .027 | .326** | .422** |
| | | Sig. (2-tailed) | .053 | .002 | .002 | .101 | .698 | .000 | . | .799 | .002 | .000 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | Boldness | Correlation Coefficient | -.059 | .101 | .244* | -.011 | .114 | .101 | .027 | 1.000 | .265* | -.078 |
| | | Sig. (2-tailed) | .576 | .339 | .019 | .917 | .278 | .340 | .799 | . | .011 | .459 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | Meanness | Correlation Coefficient | .056 | .183 | .222* | .203 | -.044 | .456** | .326** | .265* | 1.000 | .535** |
| | | Sig. (2-tailed) | .597 | .083 | .033 | .053 | .679 | .000 | .002 | .011 | . | .000 |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | Disinhibition | Correlation Coefficient | .079 | .185 | .183 | .230* | -.068 | .382** | .422** | -.078 | .535** | 1.000 |
| | | Sig. (2-tailed) | .452 | .079 | .081 | .027 | .519 | .000 | .000 | .459 | .000 | . |
| | | N | 92 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: All variables used in the current analysis were nominal. The CTS2 items were obtained with the use of the Conflict Tactics Scale – 2. Proactive and Reactive aggression were measured with the Reactive Proactive Questionnaire. Boldness, Meanness, and Disinhibition were measured with the Triarchic Psychopathy Measure.*

## Study 5

Spearman's rank-ordered correlations between psychological characteristics and cardiovascular activity

**Correlations**

| | | | Reactive Aggression | Proactive Aggression | Boldness | Meanness | Disinhibition | mean Hear Rate | HRV (SDNN) |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Reactive Aggression | Correlation Coefficient | 1.000 | .691* | .316 | .733** | .328 | -.039 | .446 |
| | | Sig. (2-tailed) | . | .013 | .318 | .007 | .298 | .904 | .146 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| | Proactive Aggression | Correlation Coefficient | .691* | 1.000 | .435 | .201 | .735** | -.113 | -.060 |
| | | Sig. (2-tailed) | .013 | . | .158 | .531 | .006 | .727 | .853 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| | Boldness | Correlation Coefficient | .316 | .435 | 1.000 | .059 | .426 | -.446 | .289 |
| | | Sig. (2-tailed) | .318 | .158 | . | .848 | .147 | .127 | .338 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 | 13 |
| | Meanness | Correlation Coefficient | .733** | .201 | .059 | 1.000 | -.008 | .308 | .270 |
| | | Sig. (2-tailed) | .007 | .531 | .848 | . | .979 | .306 | .373 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 | 13 |
| | Disinhibition | Correlation Coefficient | .328 | .735** | .426 | -.008 | 1.000 | .171 | -.354 |
| | | Sig. (2-tailed) | .298 | .006 | .147 | .979 | . | .576 | .236 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 | 13 |
| | mean Hear Rate | Correlation Coefficient | -.039 | -.113 | -.446 | .308 | .171 | 1.000 | -.500 |
| | | Sig. (2-tailed) | .904 | .727 | .127 | .306 | .576 | . | .082 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 | 13 |
| | HRV (SDNN) | Correlation Coefficient | .446 | -.060 | .289 | .270 | -.354 | -.500 | 1.000 |
| | | Sig. (2-tailed) | .146 | .853 | .338 | .373 | .236 | .082 | . |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Proactive and Reactive aggression were measured with the Reactive Proactive Questionnaire. Boldness, Meanness, and Disinhibition were measured with the Triarchic Psychopathy Measure. Cardiovascular activity was measured with a wrist-worn Biocom 4000 USB device.*

Spearman's rank-ordered correlations between psychological characteristics and cardiovascular activity (cont.)

**Correlations**

| | | | Impulsivity i7 | Venturesomeness i7 | Empathy i7 | State Anxiety | Trait Anxiety | mean Hear Rate | HRV (SDNN) |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Impulsivity i7 | Correlation Coefficient | 1.000 | .402 | -.069 | .235 | .264 | .320 | -.229 |
| | | Sig. (2-tailed) | . | .173 | .823 | .439 | .384 | .286 | .452 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Venturesomeness i7 | Correlation Coefficient | .402 | 1.000 | -.296 | .031 | -.108 | -.393 | .190 |
| | | Sig. (2-tailed) | .173 | . | .326 | .919 | .726 | .184 | .535 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Empathy i7 | Correlation Coefficient | -.069 | -.296 | 1.000 | .148 | .459 | .426 | -.657* |
| | | Sig. (2-tailed) | .823 | .326 | . | .630 | .114 | .146 | .015 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | State Anxiety | Correlation Coefficient | .235 | .031 | .148 | 1.000 | .760** | .130 | -.160 |
| | | Sig. (2-tailed) | .439 | .919 | .630 | . | .003 | .673 | .602 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Trait Anxiety | Correlation Coefficient | .264 | -.108 | .459 | .760** | 1.000 | .333 | -.223 |
| | | Sig. (2-tailed) | .384 | .726 | .114 | .003 | . | .266 | .464 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | mean Hear Rate | Correlation Coefficient | .320 | -.393 | .426 | .130 | .333 | 1.000 | -.500 |
| | | Sig. (2-tailed) | .286 | .184 | .146 | .673 | .266 | . | .082 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | HRV (SDNN) | Correlation Coefficient | -.229 | .190 | -.657* | -.160 | -.223 | -.500 | 1.000 |
| | | Sig. (2-tailed) | .452 | .535 | .015 | .602 | .464 | .082 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The $I_7$ items were obtained with the use of the Sensation Seeking scale. Trait Anxiety was measured with the State Trait Anxiety Inventory. Cardiovascular activity was measured with a wrist-worn Biocom 4000 USB device.*

Spearman's rank-ordered correlations between reactive and proactive aggression and proportion of correct responses on the Stroop task

**Correlations**

| | | | Reactive Aggression | Proactive Aggression | Stroop Proportion Correct | Stroop Proportion Correct Congruent | Stroop Proportion Correct Incongruent | Stroop Proportion Correct Control |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Reactive Aggression | Correlation Coefficient | 1.000 | .691* | -.512 | . | -.469 | -.088 |
| | | Sig. (2-tailed) | . | .013 | .089 | . | .124 | .785 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 |
| | Proactive Aggression | Correlation Coefficient | .691* | 1.000 | -.593* | . | -.484 | -.176 |
| | | Sig. (2-tailed) | .013 | . | .042 | . | .111 | .584 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 |
| | Stroop Proportion Correct | Correlation Coefficient | -.512 | -.593* | 1.000 | . | .929** | .238 |
| | | Sig. (2-tailed) | .089 | .042 | . | . | .000 | .433 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Congruent | Correlation Coefficient | . | . | . | . | . | . |
| | | Sig. (2-tailed) | . | . | . | . | . | . |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Incongruent | Correlation Coefficient | -.469 | -.484 | .929** | . | 1.000 | -.119 |
| | | Sig. (2-tailed) | .124 | .111 | .000 | . | . | .698 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Control | Correlation Coefficient | -.088 | -.176 | .238 | . | -.119 | 1.000 |
| | | Sig. (2-tailed) | .785 | .584 | .433 | . | .698 | . |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Proactive and Reactive aggression were measured with the Reactive Proactive Questionnaire. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between reactive and proactive aggression and latency of correct responses on the Stroop task

**Correlations**

| | | | Reactive Aggression | Proactive Aggression | Stroop Mean Latency | Stroop Mean Latency Congruent | Stroop Mean Latency Incongruent | Stroop Mean Latency Control |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Reactive Aggression | Correlation Coefficient | 1.000 | .691* | .074 | .198 | -.032 | .035 |
| | | Sig. (2-tailed) | . | .013 | .818 | .537 | .922 | .913 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 |
| | Proactive Aggression | Correlation Coefficient | .691* | 1.000 | .621* | .600* | .582* | .550 |
| | | Sig. (2-tailed) | .013 | . | .031 | .039 | .047 | .064 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 |
| | Stroop Mean Latency | Correlation Coefficient | .074 | .621* | 1.000 | .901** | .951** | .989** |
| | | Sig. (2-tailed) | .818 | .031 | . | .000 | .000 | .000 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Congruent | Correlation Coefficient | .198 | .600* | .901** | 1.000 | .791** | .896** |
| | | Sig. (2-tailed) | .537 | .039 | .000 | . | .001 | .000 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Incongruent | Correlation Coefficient | -.032 | .582* | .951** | .791** | 1.000 | .929** |
| | | Sig. (2-tailed) | .922 | .047 | .000 | .001 | . | .000 |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Control | Correlation Coefficient | .035 | .550 | .989** | .896** | .929** | 1.000 |
| | | Sig. (2-tailed) | .913 | .064 | .000 | .000 | .000 | . |
| | | N | 12 | 12 | 13 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Proactive and Reactive aggression were measured with the Reactive Proactive Questionnaire. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between psychopathic traits and proportion of correct responses on the Stroop task

**Correlations**

| | | | Boldness | Meanness | Disinhibition | Stroop Proportion Correct | Stroop Proportion Correct Congruent | Stroop Proportion Correct Incongruent | Stroop Proportion Correct Control |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Boldness | Correlation Coefficient | 1.000 | .059 | .426 | -.321 | . | -.305 | -.155 |
| | | Sig. (2-tailed) | . | .848 | .147 | .285 | . | .311 | .614 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Meanness | Correlation Coefficient | .059 | 1.000 | -.008 | -.478 | . | -.357 | -.309 |
| | | Sig. (2-tailed) | .848 | . | .979 | .098 | . | .231 | .304 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Disinhibition | Correlation Coefficient | .426 | -.008 | 1.000 | -.583* | . | -.458 | -.388 |
| | | Sig. (2-tailed) | .147 | .979 | . | .037 | . | .115 | .190 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct | Correlation Coefficient | -.321 | -.478 | -.583* | 1.000 | . | .929** | .238 |
| | | Sig. (2-tailed) | .285 | .098 | .037 | . | . | .000 | .433 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Congruent | Correlation Coefficient | . | . | . | . | . | . | . |
| | | Sig. (2-tailed) | . | . | . | . | . | . | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Incongruent | Correlation Coefficient | -.305 | -.357 | -.458 | .929** | . | 1.000 | -.119 |
| | | Sig. (2-tailed) | .311 | .231 | .115 | .000 | . | . | .698 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Control | Correlation Coefficient | -.155 | -.309 | -.388 | .238 | . | -.119 | 1.000 |
| | | Sig. (2-tailed) | .614 | .304 | .190 | .433 | . | .698 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Boldness, Meanness, and Disinhibition were measured with the Triarchic Psychopathy Measure. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between psychopathic traits and latency of correct responses on the Stroop task

**Correlations**

| | | | Boldness | Meanness | Disinhibition | Stroop Mean Latency | Stroop Mean Latency Congruent | Stroop Mean Latency Incongruent | Stroop Mean Latency Control |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Boldness | Correlation Coefficient | 1.000 | .059 | .426 | .143 | .091 | .077 | .069 |
| | | Sig. (2-tailed) | . | .848 | .147 | .641 | .768 | .802 | .823 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Meanness | Correlation Coefficient | .059 | 1.000 | -.008 | -.261 | -.190 | -.330 | -.242 |
| | | Sig. (2-tailed) | .848 | . | .979 | .388 | .535 | .271 | .426 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Disinhibition | Correlation Coefficient | .426 | -.008 | 1.000 | .591* | .470 | .641* | .514 |
| | | Sig. (2-tailed) | .147 | .979 | . | .033 | .105 | .018 | .072 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency | Correlation Coefficient | .143 | -.261 | .591* | 1.000 | .901** | .951** | .989** |
| | | Sig. (2-tailed) | .641 | .388 | .033 | . | .000 | .000 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Congruent | Correlation Coefficient | .091 | -.190 | .470 | .901** | 1.000 | .791** | .896** |
| | | Sig. (2-tailed) | .768 | .535 | .105 | .000 | . | .001 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Incongruent | Correlation Coefficient | .077 | -.330 | .641* | .951** | .791** | 1.000 | .929** |
| | | Sig. (2-tailed) | .802 | .271 | .018 | .000 | .001 | . | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Control | Correlation Coefficient | .069 | -.242 | .514 | .989** | .896** | .929** | 1.000 |
| | | Sig. (2-tailed) | .823 | .426 | .072 | .000 | .000 | .000 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Boldness, Meanness, and Disinhibition were measured with the Triarchic Psychopathy Measure. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between the subscales of the $I_7$ questionnaire and proportion of correct responses on the Stroop task

**Correlations**

| | | | Impulsivity i7 | Venturesome ness i7 | Empathy i7 | Stroop Proportion Correct | Stroop Proportion Correct Congruent | Stroop Proportion Correct Incongruent | Stroop Proportion Correct Control |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Impulsivity i7 | Correlation Coefficient | 1.000 | .402 | -.069 | -.380 | . | -.477 | .077 |
| | | Sig. (2-tailed) | . | .173 | .823 | .200 | . | .099 | .801 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Venturesomeness i7 | Correlation Coefficient | .402 | 1.000 | -.296 | -.316 | . | -.369 | .079 |
| | | Sig. (2-tailed) | .173 | . | .326 | .293 | . | .215 | .796 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Empathy i7 | Correlation Coefficient | -.069 | -.296 | 1.000 | -.156 | . | -.022 | -.394 |
| | | Sig. (2-tailed) | .823 | .326 | . | .611 | . | .944 | .183 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct | Correlation Coefficient | -.380 | -.316 | -.156 | 1.000 | . | .929** | .238 |
| | | Sig. (2-tailed) | .200 | .293 | .611 | . | . | .000 | .433 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Congruent | Correlation Coefficient | . | . | . | . | . | . | . |
| | | Sig. (2-tailed) | . | . | . | . | . | . | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Incongruent | Correlation Coefficient | -.477 | -.369 | -.022 | .929** | . | 1.000 | -.119 |
| | | Sig. (2-tailed) | .099 | .215 | .944 | .000 | . | . | .698 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Control | Correlation Coefficient | .077 | .079 | -.394 | .238 | . | -.119 | 1.000 |
| | | Sig. (2-tailed) | .801 | .796 | .183 | .433 | . | .698 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The $I_7$ items were obtained with the use of the Sensation Seeking scale. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between the subscales of the $I_7$ questionnaire and latency of correct responses on the Stroop task

**Correlations**

| | | | Impulsivity i7 | Venturesomeness i7 | Empathy i7 | Stroop Mean Latency | Stroop Mean Latency Congruent | Stroop Mean Latency Incongruent | Stroop Mean Latency Control |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Impulsivity i7 | Correlation Coefficient | 1.000 | .402 | -.069 | .102 | .019 | .215 | .017 |
| | | Sig. (2-tailed) | . | .173 | .823 | .740 | .950 | .480 | .957 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Venturesomeness i7 | Correlation Coefficient | .402 | 1.000 | -.296 | .204 | .082 | .269 | .161 |
| | | Sig. (2-tailed) | .173 | . | .326 | .504 | .790 | .374 | .599 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Empathy i7 | Correlation Coefficient | -.069 | -.296 | 1.000 | -.020 | -.140 | .084 | .036 |
| | | Sig. (2-tailed) | .823 | .326 | . | .949 | .648 | .785 | .906 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency | Correlation Coefficient | .102 | .204 | -.020 | 1.000 | .901** | .951** | .989** |
| | | Sig. (2-tailed) | .740 | .504 | .949 | . | .000 | .000 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Congruent | Correlation Coefficient | .019 | .082 | -.140 | .901** | 1.000 | .791** | .896** |
| | | Sig. (2-tailed) | .950 | .790 | .648 | .000 | . | .001 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Incongruent | Correlation Coefficient | .215 | .269 | .084 | .951** | .791** | 1.000 | .929** |
| | | Sig. (2-tailed) | .480 | .374 | .785 | .000 | .001 | . | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Control | Correlation Coefficient | .017 | .161 | .036 | .989** | .896** | .929** | 1.000 |
| | | Sig. (2-tailed) | .957 | .599 | .906 | .000 | .000 | .000 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The $I_7$ items were obtained with the use of the Sensation Seeking scale. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman’s rank-ordered correlations between the state and trait anxiety and proportion of correct responses on the Stroop task

**Correlations**

| | | | State Anxiety | Trait Anxiety | Stroop Proportion Correct | Stroop Proportion Correct Congruent | Stroop Proportion Correct Incongruent | Stroop Proportion Correct Control |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | State Anxiety | Correlation Coefficient | 1.000 | .760** | -.280 | . | -.404 | .426 |
| | | Sig. (2-tailed) | . | .003 | .355 | . | .172 | .147 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Trait Anxiety | Correlation Coefficient | .760** | 1.000 | -.175 | . | -.349 | .464 |
| | | Sig. (2-tailed) | .003 | . | .566 | . | .243 | .111 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct | Correlation Coefficient | -.280 | -.175 | 1.000 | . | .929** | .238 |
| | | Sig. (2-tailed) | .355 | .566 | . | . | .000 | .433 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Congruent | Correlation Coefficient | . | . | . | . | . | . |
| | | Sig. (2-tailed) | . | . | . | . | . | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Incongruent | Correlation Coefficient | -.404 | -.349 | .929** | . | 1.000 | -.119 |
| | | Sig. (2-tailed) | .172 | .243 | .000 | . | . | .698 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Control | Correlation Coefficient | .426 | .464 | .238 | . | -.119 | 1.000 |
| | | Sig. (2-tailed) | .147 | .111 | .433 | . | .698 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: State and Trait Anxiety were measured with the State Trait Anxiety Inventory. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between the state and trait anxiety and latency of correct responses on the Stroop task

**Correlations**

| | | | State Anxiety | Trait Anxiety | Stroop Mean Latency | Stroop Mean Latency Congruent | Stroop Mean Latency Incongruent | Stroop Mean Latency Control |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | State Anxiety | Correlation Coefficient | 1.000 | .760** | .121 | .044 | .243 | .138 |
| | | Sig. (2-tailed) | . | .003 | .693 | .886 | .424 | .653 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Trait Anxiety | Correlation Coefficient | .760** | 1.000 | -.179 | -.275 | -.014 | -.140 |
| | | Sig. (2-tailed) | .003 | . | .559 | .363 | .964 | .648 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency | Correlation Coefficient | .121 | -.179 | 1.000 | .901** | .951** | .989** |
| | | Sig. (2-tailed) | .693 | .559 | . | .000 | .000 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Congruent | Correlation Coefficient | .044 | -.275 | .901** | 1.000 | .791** | .896** |
| | | Sig. (2-tailed) | .886 | .363 | .000 | . | .001 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Incongruent | Correlation Coefficient | .243 | -.014 | .951** | .791** | 1.000 | .929** |
| | | Sig. (2-tailed) | .424 | .964 | .000 | .001 | . | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Control | Correlation Coefficient | .138 | -.140 | .989** | .896** | .929** | 1.000 |
| | | Sig. (2-tailed) | .653 | .648 | .000 | .000 | .000 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: State and Trait Anxiety were measured with the State Trait Anxiety Inventory. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between accidental injuries and performance on the Stroop task

**Correlations**

| | | | Accidental Injury | Stroop Proportion Correct | Stroop Mean Latency | Stroop Mean Latency Congruent | Stroop Mean Latency Incongruent | Stroop Mean Latency Control | Stroop Proportion Correct Congruent | Stroop Proportion Correct Incongruent | Stroop Proportion Correct Control |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Accidental Injury | Correlation Coefficient | 1.000 | -.753** | -.193 | -.204 | -.177 | -.193 | . | -.683* | -.272 |
| | | Sig. (2-tailed) | . | .003 | .527 | .503 | .563 | .527 | . | .010 | .370 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct | Correlation Coefficient | -.753** | 1.000 | -.138 | -.011 | -.246 | -.082 | . | .929** | .238 |
| | | Sig. (2-tailed) | .003 | . | .652 | .971 | .418 | .790 | . | .000 | .433 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency | Correlation Coefficient | -.193 | -.138 | 1.000 | .901** | .951** | .989** | . | .017 | -.309 |
| | | Sig. (2-tailed) | .527 | .652 | . | .000 | .000 | .000 | . | .956 | .305 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Congruent | Correlation Coefficient | -.204 | -.011 | .901** | 1.000 | .791** | .896** | . | .147 | -.309 |
| | | Sig. (2-tailed) | .503 | .971 | .000 | . | .001 | .000 | . | .631 | .305 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Incongruent | Correlation Coefficient | -.177 | -.246 | .951** | .791** | 1.000 | .929** | . | -.125 | -.231 |
| | | Sig. (2-tailed) | .563 | .418 | .000 | .001 | . | .000 | . | .685 | .447 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Control | Correlation Coefficient | -.193 | -.082 | .989** | .896** | .929** | 1.000 | . | .085 | -.309 |
| | | Sig. (2-tailed) | .527 | .790 | .000 | .000 | .000 | . | . | .783 | .305 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Congruent | Correlation Coefficient | . | . | . | . | . | . | . | . | . |
| | | Sig. (2-tailed) | . | . | . | . | . | . | . | . | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Incongruent | Correlation Coefficient | -.683* | .929** | .017 | .147 | -.125 | .085 | . | 1.000 | -.119 |
| | | Sig. (2-tailed) | .010 | .000 | .956 | .631 | .685 | .783 | . | . | .698 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Control | Correlation Coefficient | -.272 | .238 | -.309 | -.309 | -.231 | -.309 | . | -.119 | 1.000 |
| | | Sig. (2-tailed) | .370 | .433 | .305 | .305 | .447 | .305 | . | .698 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: The measure of accidental injuries was designed to reflect some of the questions asked in the tenth version of the International Statistical Classification of Diseases and Related Health Problems. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman's rank-ordered correlations between accidental injuries, executive performance, and risk taking

**Correlations**

| | | | Accidental Injury | 2-back dependent variable | 3-back dependent variable | Porteus test | Balloon Analogue Risk Task |
|---|---|---|---|---|---|---|---|
| Spearman's rho | Accidental Injury | Correlation Coefficient | 1.000 | -.293 | -.016 | .587* | .088 |
| | | Sig. (2-tailed) | . | .355 | .962 | .035 | .774 |
| | | N | 13 | 12 | 11 | 13 | 13 |
| | 2-back dependent variable | Correlation Coefficient | -.293 | 1.000 | .736** | -.255 | .188 |
| | | Sig. (2-tailed) | .355 | . | .010 | .423 | .558 |
| | | N | 12 | 12 | 11 | 12 | 12 |
| | 3-back dependent variable | Correlation Coefficient | -.016 | .736** | 1.000 | .063 | -.410 |
| | | Sig. (2-tailed) | .962 | .010 | . | .853 | .210 |
| | | N | 11 | 11 | 11 | 11 | 11 |
| | Porteus test | Correlation Coefficient | .587* | -.255 | .063 | 1.000 | -.206 |
| | | Sig. (2-tailed) | .035 | .423 | .853 | . | .498 |
| | | N | 13 | 12 | 11 | 13 | 13 |
| | Balloon Analogue Risk Task | Correlation Coefficient | .088 | .188 | -.410 | -.206 | 1.000 |
| | | Sig. (2-tailed) | .774 | .558 | .210 | .498 | . |
| | | N | 13 | 12 | 11 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The measure of accidental injuries was designed to reflect some of the questions asked in the tenth version of the International Statistical Classification of Diseases and Related Health Problems. The 2-back and 3-back variables are variants of the n-back working memory task. The Porteus test is a measure of impulsivity. The Balloon Analogue Risk Task is a measure of risk taking.*

Spearman’s rank-ordered correlations between psychological characteristics, executive performance, and risk taking

**Correlations**

| | | | Reactive Aggression | Proactive Aggression | Boldness | Meanness | Disinhibition | 2-back dependent variable | 3-back dependent variable | Porteus test | Balloon Analogue Risk Task |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Reactive Aggression | Correlation Coefficient | 1.000 | .691* | .316 | .733** | .328 | .047 | .068 | .108 | -.290 |
| | | Sig. (2-tailed) | . | .013 | .318 | .007 | .298 | .891 | .851 | .738 | .360 |
| | | N | 12 | 12 | 12 | 12 | 12 | 11 | 10 | 12 | 12 |
| | Proactive Aggression | Correlation Coefficient | .691* | 1.000 | .435 | .201 | .735** | -.318 | -.112 | .176 | -.646* |
| | | Sig. (2-tailed) | .013 | . | .158 | .531 | .006 | .341 | .758 | .585 | .023 |
| | | N | 12 | 12 | 12 | 12 | 12 | 11 | 10 | 12 | 12 |
| | Boldness | Correlation Coefficient | .316 | .435 | 1.000 | .059 | .426 | -.061 | .231 | .043 | -.085 |
| | | Sig. (2-tailed) | .318 | .158 | . | .848 | .147 | .852 | .494 | .889 | .782 |
| | | N | 12 | 12 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | Meanness | Correlation Coefficient | .733** | .201 | .059 | 1.000 | -.008 | .155 | -.233 | .121 | .289 |
| | | Sig. (2-tailed) | .007 | .531 | .848 | . | .979 | .631 | .490 | .695 | .338 |
| | | N | 12 | 12 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | Disinhibition | Correlation Coefficient | .328 | .735** | .426 | -.008 | 1.000 | -.498 | -.180 | .467 | -.403 |
| | | Sig. (2-tailed) | .298 | .006 | .147 | .979 | . | .099 | .597 | .107 | .172 |
| | | N | 12 | 12 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | 2-back dependent variable | Correlation Coefficient | .047 | -.318 | -.061 | .155 | -.498 | 1.000 | .736** | -.255 | .188 |
| | | Sig. (2-tailed) | .891 | .341 | .852 | .631 | .099 | . | .010 | .423 | .558 |
| | | N | 11 | 11 | 12 | 12 | 12 | 12 | 11 | 12 | 12 |
| | 3-back dependent variable | Correlation Coefficient | .068 | -.112 | .231 | -.233 | -.180 | .736** | 1.000 | .063 | -.410 |
| | | Sig. (2-tailed) | .851 | .758 | .494 | .490 | .597 | .010 | . | .853 | .210 |
| | | N | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| | Porteus test | Correlation Coefficient | .108 | .176 | .043 | .121 | .467 | -.255 | .063 | 1.000 | -.206 |
| | | Sig. (2-tailed) | .738 | .585 | .889 | .695 | .107 | .423 | .853 | . | .498 |
| | | N | 12 | 12 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | Balloon Analogue Risk Task | Correlation Coefficient | -.290 | -.646* | -.085 | .289 | -.403 | .188 | -.410 | -.206 | 1.000 |
| | | Sig. (2-tailed) | .360 | .023 | .782 | .338 | .172 | .558 | .210 | .498 | . |
| | | N | 12 | 12 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Reactive and Proactive aggression were measured with the Reactive Proactive Questionnaire. Boldness, Meanness, and Disinhibition were measured with the Triarchic Psychopathy Measure. The 2-back and 3-back variables are variants of the n-back working memory task. The Porteus test is a measure of impulsivity. The Balloon Analogue Risk Task is a measure of risk taking.*

Spearman’s rank-ordered correlations between psychological characteristics, executive performance, and the BART (cont.)

**Correlations**

| | | | Impulsivity i7 | Venturesomeness i7 | Empathy i7 | State Anxiety | Trait Anxiety | 2-back dependent variable | 3-back dependent variable | Porteus test | Balloon Analogue Risk Task |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Impulsivity i7 | Correlation Coefficient | 1.000 | .402 | -.069 | .235 | .264 | -.271 | .139 | .500 | -.196 |
| | | Sig. (2-tailed) | . | .173 | .823 | .439 | .384 | .394 | .684 | .082 | .521 |
| | | N | 13 | 13 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | Venturesomeness i7 | Correlation Coefficient | .402 | 1.000 | -.296 | .031 | -.108 | -.410 | -.158 | .055 | .045 |
| | | Sig. (2-tailed) | .173 | . | .326 | .919 | .726 | .186 | .642 | .859 | .883 |
| | | N | 13 | 13 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | Empathy i7 | Correlation Coefficient | -.069 | -.296 | 1.000 | .148 | .459 | -.249 | -.188 | .447 | .354 |
| | | Sig. (2-tailed) | .823 | .326 | . | .630 | .114 | .435 | .580 | .126 | .236 |
| | | N | 13 | 13 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | State Anxiety | Correlation Coefficient | .235 | .031 | .148 | 1.000 | .760** | -.661* | -.303 | -.024 | -.356 |
| | | Sig. (2-tailed) | .439 | .919 | .630 | . | .003 | .019 | .365 | .937 | .233 |
| | | N | 13 | 13 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | Trait Anxiety | Correlation Coefficient | .264 | -.108 | .459 | .760** | 1.000 | -.395 | -.258 | .131 | .129 |
| | | Sig. (2-tailed) | .384 | .726 | .114 | .003 | . | .204 | .444 | .670 | .674 |
| | | N | 13 | 13 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | 2-back dependent variable | Correlation Coefficient | -.271 | -.410 | -.249 | -.661* | -.395 | 1.000 | .736** | -.255 | .188 |
| | | Sig. (2-tailed) | .394 | .186 | .435 | .019 | .204 | . | .010 | .423 | .558 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 12 | 12 |
| | 3-back dependent variable | Correlation Coefficient | .139 | -.158 | -.188 | -.303 | -.258 | .736** | 1.000 | .063 | -.410 |
| | | Sig. (2-tailed) | .684 | .642 | .580 | .365 | .444 | .010 | . | .853 | .210 |
| | | N | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| | Porteus test | Correlation Coefficient | .500 | .055 | .447 | -.024 | .131 | -.255 | .063 | 1.000 | -.206 |
| | | Sig. (2-tailed) | .082 | .859 | .126 | .937 | .670 | .423 | .853 | . | .498 |
| | | N | 13 | 13 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |
| | Balloon Analogue Risk Task | Correlation Coefficient | -.196 | .045 | .354 | -.356 | .129 | .188 | -.410 | -.206 | 1.000 |
| | | Sig. (2-tailed) | .521 | .883 | .236 | .233 | .674 | .558 | .210 | .498 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 12 | 11 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*Note: The $I_7$ items were obtained with the use of the Sensation Seeking scale. State and Trait Anxiety were measured with the State Trait Anxiety Inventory. The 2-back and 3-back variables are variants of the n-back working memory task. The Porteus test is a measure of impulsivity. The Balloon Analogue Risk Task is a measure of risk taking.*

Spearman's rank-ordered correlations between cardiovascular activity and proportion of correct responses on the Stroop task

**Correlations**

| | | | mean Hear Rate | HRV (SDNN) | Stroop Proportion Correct | Stroop Proportion Correct Congruent | Stroop Proportion Correct Incongruent | Stroop Proportion Correct Control |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | mean Hear Rate | Correlation Coefficient | 1.000 | -.500 | -.277 | . | -.173 | -.309 |
| | | Sig. (2-tailed) | . | .082 | .360 | . | .573 | .305 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | HRV (SDNN) | Correlation Coefficient | -.500 | 1.000 | .283 | . | .142 | .386 |
| | | Sig. (2-tailed) | .082 | . | .350 | . | .645 | .193 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct | Correlation Coefficient | -.277 | .283 | 1.000 | . | .929** | .238 |
| | | Sig. (2-tailed) | .360 | .350 | . | . | .000 | .433 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Congruent | Correlation Coefficient | . | . | . | . | . | . |
| | | Sig. (2-tailed) | . | . | . | . | . | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Incongruent | Correlation Coefficient | -.173 | .142 | .929** | . | 1.000 | -.119 |
| | | Sig. (2-tailed) | .573 | .645 | .000 | . | . | .698 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Proportion Correct Control | Correlation Coefficient | -.309 | .386 | .238 | . | -.119 | 1.000 |
| | | Sig. (2-tailed) | .305 | .193 | .433 | . | .698 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Cardiovascular activity was measured with a wrist-worn Biocom 4000 USB device. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman’s rank-ordered correlations between cardiovascular activity and latency of correct responses on the Stroop task

**Correlations**

| | | | mean Hear Rate | HRV (SDNN) | Stroop Mean Latency | Stroop Mean Latency Congruent | Stroop Mean Latency Incongruent | Stroop Mean Latency Control |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | mean Hear Rate | Correlation Coefficient | 1.000 | -.500 | -.033 | -.066 | .060 | -.033 |
| | | Sig. (2-tailed) | . | .082 | .915 | .831 | .845 | .915 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | HRV (SDNN) | Correlation Coefficient | -.500 | 1.000 | -.500 | -.231 | -.626* | -.489 |
| | | Sig. (2-tailed) | .082 | . | .082 | .448 | .022 | .090 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency | Correlation Coefficient | -.033 | -.500 | 1.000 | .901** | .951** | .989** |
| | | Sig. (2-tailed) | .915 | .082 | . | .000 | .000 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Congruent | Correlation Coefficient | -.066 | -.231 | .901** | 1.000 | .791** | .896** |
| | | Sig. (2-tailed) | .831 | .448 | .000 | . | .001 | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Incongruent | Correlation Coefficient | .060 | -.626* | .951** | .791** | 1.000 | .929** |
| | | Sig. (2-tailed) | .845 | .022 | .000 | .001 | . | .000 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Stroop Mean Latency Control | Correlation Coefficient | -.033 | -.489 | .989** | .896** | .929** | 1.000 |
| | | Sig. (2-tailed) | .915 | .090 | .000 | .000 | .000 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Cardiovascular activity was measured with a wrist-worn Biocom 4000 USB device. The Stroop task measures selective allocation of attention and inhibition of inaccurate responses.*

Spearman’s rank-ordered correlations between cardiovascular activity, executive performance, and the BART

**Correlations**

| | | | mean Hear Rate | HRV (SDNN) | 2-back dependent variable | 3-back dependent variable | Porteus test | Balloon Analogue Risk Task |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | mean Hear Rate | Correlation Coefficient | 1.000 | -.500 | -.011 | -.318 | .379 | .247 |
| | | Sig. (2-tailed) | . | .082 | .974 | .341 | .202 | .415 |
| | | N | 13 | 13 | 12 | 11 | 13 | 13 |
| | HRV (SDNN) | Correlation Coefficient | -.500 | 1.000 | .366 | .161 | -.433 | -.132 |
| | | Sig. (2-tailed) | .082 | . | .242 | .636 | .139 | .668 |
| | | N | 13 | 13 | 12 | 11 | 13 | 13 |
| | 2-back dependent variable | Correlation Coefficient | -.011 | .366 | 1.000 | .736** | -.255 | .188 |
| | | Sig. (2-tailed) | .974 | .242 | . | .010 | .423 | .558 |
| | | N | 12 | 12 | 12 | 11 | 12 | 12 |
| | 3-back dependent variable | Correlation Coefficient | -.318 | .161 | .736** | 1.000 | .063 | -.410 |
| | | Sig. (2-tailed) | .341 | .636 | .010 | . | .853 | .210 |
| | | N | 11 | 11 | 11 | 11 | 11 | 11 |
| | Porteus test | Correlation Coefficient | .379 | -.433 | -.255 | .063 | 1.000 | -.206 |
| | | Sig. (2-tailed) | .202 | .139 | .423 | .853 | . | .498 |
| | | N | 13 | 13 | 12 | 11 | 13 | 13 |
| | Balloon Analogue Risk Task | Correlation Coefficient | .247 | -.132 | .188 | -.410 | -.206 | 1.000 |
| | | Sig. (2-tailed) | .415 | .668 | .558 | .210 | .498 | . |
| | | N | 13 | 13 | 12 | 11 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: Cardiovascular activity was measured with a wrist-worn Biocom 4000 USB device. The 2-back and 3-back variables are variants of the n-back working memory task. The Porteus test is a measure of impulsivity. The Balloon Analogue Risk Task is a measure of risk taking.*

Spearman's rank-ordered correlations between accidental injuries and psychological characteristics

**Correlations**

| | | | Accidental Injury | Reactive Aggression | Proactive Aggression | Boldness | Meanness | Disinhibition |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Accidental Injury | Correlation Coefficient | 1.000 | .489 | .168 | .178 | .618* | .161 |
| | | Sig. (2-tailed) | . | .106 | .601 | .560 | .024 | .599 |
| | | N | 13 | 12 | 12 | 13 | 13 | 13 |
| | Reactive Aggression | Correlation Coefficient | .489 | 1.000 | .691* | .316 | .733** | .328 |
| | | Sig. (2-tailed) | .106 | . | .013 | .318 | .007 | .298 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 |
| | Proactive Aggression | Correlation Coefficient | .168 | .691* | 1.000 | .435 | .201 | .735** |
| | | Sig. (2-tailed) | .601 | .013 | . | .158 | .531 | .006 |
| | | N | 12 | 12 | 12 | 12 | 12 | 12 |
| | Boldness | Correlation Coefficient | .178 | .316 | .435 | 1.000 | .059 | .426 |
| | | Sig. (2-tailed) | .560 | .318 | .158 | . | .848 | .147 |
| | | N | 13 | 12 | 12 | 13 | 13 | 13 |
| | Meanness | Correlation Coefficient | .618* | .733** | .201 | .059 | 1.000 | -.008 |
| | | Sig. (2-tailed) | .024 | .007 | .531 | .848 | . | .979 |
| | | N | 13 | 12 | 12 | 13 | 13 | 13 |
| | Disinhibition | Correlation Coefficient | .161 | .328 | .735** | .426 | -.008 | 1.000 |
| | | Sig. (2-tailed) | .599 | .298 | .006 | .147 | .979 | . |
| | | N | 13 | 12 | 12 | 13 | 13 | 13 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The measure of accidental injuries was designed to reflect some of the questions asked in the tenth version of the International Statistical Classification of Diseases and Related Health Problems. Reactive and Proactive aggression were measured with the Reactive Proactive Questionnaire. Boldness, Meanness, and Disinhibition were measured with the Triarchic Psychopathy Measure.*

Spearman's rank-ordered correlations between accidental injuries and psychological characteristics (cont.)

**Correlations**

| | | | Accidental Injury | Impulsivity i7 | Venturesomeness i7 | Empathy i7 | State Anxiety | Trait Anxiety |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | Accidental Injury | Correlation Coefficient | 1.000 | .143 | .127 | .371 | .076 | .245 |
| | | Sig. (2-tailed) | . | .642 | .680 | .212 | .804 | .420 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Impulsivity i7 | Correlation Coefficient | .143 | 1.000 | .402 | -.069 | .235 | .264 |
| | | Sig. (2-tailed) | .642 | . | .173 | .823 | .439 | .384 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Venturesomeness i7 | Correlation Coefficient | .127 | .402 | 1.000 | -.296 | .031 | -.108 |
| | | Sig. (2-tailed) | .680 | .173 | . | .326 | .919 | .726 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Empathy i7 | Correlation Coefficient | .371 | -.069 | -.296 | 1.000 | .148 | .459 |
| | | Sig. (2-tailed) | .212 | .823 | .326 | . | .630 | .114 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | State Anxiety | Correlation Coefficient | .076 | .235 | .031 | .148 | 1.000 | .760** |
| | | Sig. (2-tailed) | .804 | .439 | .919 | .630 | . | .003 |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |
| | Trait Anxiety | Correlation Coefficient | .245 | .264 | -.108 | .459 | .760** | 1.000 |
| | | Sig. (2-tailed) | .420 | .384 | .726 | .114 | .003 | . |
| | | N | 13 | 13 | 13 | 13 | 13 | 13 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Note: The measure of accidental injuries was designed to reflect some of the questions asked in the tenth version of the International Statistical Classification of Diseases and Related Health Problems. The $I_7$ items were obtained with the use of the Sensation Seeking scale. State and Trait Anxiety were measured with the State Trait Anxiety Inventory.*

# APPENDIX 2

*Informal profiles*

Underneath are brief informal profiles of the ten incarcerated individuals with drug misuse difficulties who took part in the *Relaxing Rhythms* biofeedback intervention (Study 3). Seven of these participants successfully completed the programme. These informal profiles are presented first. They also contributed to the quantitative analysis as shown above. Three partakers dropped out half way into the course for reasons briefly described in their profiles. These cases are portrayed last.

***Completers***

*Participant number one*

Participant one (P1) was over 50 year old, polite, tall and slim male. He was clinically diagnosed with reactive anxiety and low mood. This was his first imprisonment, during which he was convicted for burglary and conspiracy to supply class A drugs. This individual has an extensive history of poly drug use. In the prison he was assigned to a methadone reduction programme design to stabilise his addiction issues. He started receiving methadone several days before the breathing biofeedback sessions began. During the biofeedback course he did not engage in other therapeutic activities. However, his key worker had occasionally seen him on a one-to-one basis to discuss matters including his mental state and medical plans.

When the biofeedback course began it became obvious that P1 had poor experience of using a laptop device. Therefore, his initial sessions were supervised and technical help was offered. This included guidance and demonstration on how to switch the laptop on, how to operate the software, and how to make use of the biofeedback. It took several sessions for P1 to acquire skills essential to independently operate the biofeedback software. Eventually, his skills improved to a level that did not require assistance in any course related tasks.

During our first encounter P1 appeared to have a minor movement impairment. His body jerked in a very spontaneous and erratic manner. His walk was unsteady and he struggled to prevent his head and arms from moving spontaneously when completing simple tasks, including filling out questionnaires. He could not construct a single sentence without stuttering, which might have been related to his motor difficulties. Benefits of the course became evident when the rate of his spontaneous involuntary body movements rapidly declined. These effects were clear during and immediately after each session, when he appeared much calmer. The rate of his involuntary movements was declining on a regular basis. His face wore a relaxed expression and he reported feeling slightly calmer every time he used the biofeedback software. However, even at the end of the course the jerky movements were still present.

Improvements in his mental state were also manifested in responses to psychological questionnaires. For example, before the course P1 scored lowest of all participants on *reappraisal*. After the course, this score had increased. Furthermore, his self-report scores for *anger out* declined strongest compared with the rest of the group.

During the post-course interview P1 stated that in effect of participation he felt less angry and less judgemental outside of sessions. P1 indicated that before the course he was argumentative and would “get wound up” very quickly, whereas during the course he managed to refrain from arguments and did not escalate in response to conflict as he did before. He also remarked having less intrusive thoughts and thought ruminations, which can be interpreted as an improvement in emotion control. Seemingly, he acquired certain emotion control abilities due to the course as he reported applying the slow-paced breathing strategy to calm himself in non-session related situations. However, when asked if he was able to focus better, he was uncertain whether that was the case.

At the end of the course, P1 displayed symptoms of methadone withdrawal. He reported feeling worse and appeared more prone to distractions. He also mentioned that if the course would have continued for longer than planned, it would have helped him to feel better during this difficult period. Due to his unhealthy state, his performance during the final sessions declined slightly and this was evident in the reduced graphical representation of coherence score. Nevertheless, his personal situation in the prison was improving. He applied for an enhanced prisoner status which is granted to settled individuals only. This status allowed prisoners to keep some of their personal belongings in their cells.

*Participant number two*

Participant two (P2) was an approximately 50-year-old slim male. He had a clinical diagnosis of anxiety and depression. His records describe an extensive history of poly substance misuse. He was receiving Sertraline 50mg twice each morning. This medication is an antidepressant of the serotonin reuptake inhibitor (SSRI) class. He was also assigned to a methadone detoxification programme which entailed him receiving daily doses of methadone. Prison records indicated he did not partake in other therapies whilst on the biofeedback course. He was sentenced for burglary with intent to steal.

He presented himself as a quiet individual. Most of the times he replied to questions with very short, sometimes irrelevant, phrases. Out of the whole group, he struggled the most with operating the laptop equipment. Even during the simplest laptop tasks, he appeared anxious and jittery. The facilitator observed that P2 did not initially use the feedback to regulate his breath. Therefore, additional time was dedicated to explain how to use the biofeedback software. The participant had improved his coherence scores after this intervention. It had taken more than two weeks for him to become accustomed with the session procedure. These difficulties suggest problems with encoding and retaining of information.

Since the start of the course, P2 actively participated in most sessions. Nevertheless, at times he was observed staring at the screen, seemingly without commitment. When asked about his odd presentation, he replied: “It’s because of medication.”. Indeed, whenever he took a dose of methadone before the session, his performance declined compared to the times when he was not medicated. To alleviate this unexpected interaction the facilitator considered changing the time slots. However, changing the time slots was not possible due to the strict prison routine. P2 accordingly continued to attend his sessions straight after receiving methadone.

Prior to end of the course P2 was informed that his sessions were about to finish. This information apparently made him sad as he stated: “I would like the course to last longer.”. During a post-course interview, he stated experiencing less intrusive thoughts immediately after the exercise, more control over emotions and less angry and anxious feelings in general. He mentioned that after a morning biofeedback session, the day was easier for him to get by. Similarly to the previously described participant, P2 used skills learned during sessions to calm himself in stressful situations. Exploration of self-report responses to questionnaires revealed that before the course P2 scored highest out of the entire sample on all three subscales of the DASS-21. Following the biofeedback course these scores declined, most prominently for anxiety.

*Participant number three*

Participant three (P3) was an over 20-year-old physically active male of average height and build. His clinical diagnosis indicated a history of depressive illness and poly drug use. He indicated that a close relative also suffered from depressive illness. During the biofeedback course, he was receiving Omeprazole and Citalopram 20mg each morning. The former medicine is commonly used in treatment of gastric illness, whereas the latter is an SSRI class antidepressant. In the prison he was assigned to the methadone detoxification programme. He did not attend other organised therapies during the biofeedback course but did have one-to-one consultations with his key worker. Half way in the course he was convicted of burglary and theft with violence.

P3 presented himself as a very energetic, physically active individual. On several occasions, he stated that physical exercise supports his psychological wellbeing. However, there were times when he gave the impression of being anxious and worrying. This was his first imprisonment and an upcoming court case was likely to have influenced his mood. Shortly after receiving the sentence he appeared less anxious and more confident. Despite this being his first incarceration, P3 seemed accustomed with the prison environment. Later in the course he stated being in an unstable relationship with a female, which according to him, was very detrimental to his mental health.

On the whole, P3 had a positive opinion about the project. However, after the first few sessions he stated feeling anxious about taking deep breaths. His key worker later explained that P3 was afraid that he won’t be able to exhale after taking a deep breath. This was interpreted as a specific phobic response called asphyxophobia. Individuals suffering from asphyxophobia may have hypersensitive specialised cells which are responsible for detecting changes in levels of carbon dioxide in the body. This hypersensitiveness is linked to feelings of tension but is not indicative of a real threat to the organism (Asmundson & Stein, 1994; Klein, 1993). In line with this interpretation, the participant was advised that it was highly unlikely he would not be able to exhale after taking a deep breath. The participant continued his sessions as planned following reassurances.

During a post-course interview, he declared that the biofeedback exercise raised his awareness of intrusive thoughts and increased control over them. He also described that the increased awareness made him realise that he suffered from depression at that time. Previously, he struggled accepting that he was depressed even though he had a clinical diagnosis of depression. He acknowledged his illness with calmness and acceptance. Other benefits of the sessions included lowered anxiety in general and less angry feelings. P3 also mentioned using the breathing technique in non-session circumstances. An examination of his responses to personality questionnaires indicated that before the course P3 scored lowest of the entire sample on the *anger control in* subscale of the STAXI-2. However, immediately after the course this score had strongly increased.

*Participant number four*

Participant four (P4) was male in his twenties. He had a clinical diagnosis of personality disorder and was addicted to opiates. Whilst on the biofeedback course he was assigned to a Lofexidine detoxification programme. Lofexidine is a medicine commonly used to tackle opioid withdrawal symptoms. Compared to the rest of the group, he appeared more absorbed by his medication regime. Aside from the biofeedback course he did not engage in other psychological therapies. He was sometimes seen by a key worker on a one-to-one basis to discuss ongoing issues. P4 was sentenced for burglary with intent to steal.

During the sessions, P4 was often observed being bored and not looking at the screen. The facilitator presumed that P4 did not understand how to use the software. To increase his engagement in the course, the facilitator arranged a one-to-one meeting with the participant. During the meeting P4 was diligently instructed how to use the biofeedback. Possible benefits of the exercise were also briefly discussed. Afterwards, only minor improvements in task performance were observed. However, P4 continued to attend his sessions with somewhat surprising vigour, even after he was moved to a different house block.

Outside of the session, P4 was impulsive, manipulative, and did not follow house block rules. The prison officers and nursing personnel repeatedly highlighted his antisocial nature. Despite the ongoing participation in the course, P4 was eventually moved to a different house block. This was arranged because he was no longer receiving medication and his detoxification programme has finished. However, it was obvious that his delinquent behaviour contributed to this decision. Shortly after the move, he was accused of smuggling illegal substances to his previous house block. The smuggling allegedly took place when P4 attended the biofeedback sessions. Nevertheless, P4 was allowed to continue his participation but only under strict supervision of the facilitator.

Eventually, to the surprise of prison staff members, he managed to complete the course. However, after the successful completion, he was involved in breaking and entering to a nursing office on his new house block. His intention was to steal some medicine from the office. As a result of this action he was moved to a segregation unit. There, he was involved in another violent incident. Consequently, he was transported to a different prison. This chain of violence strongly suggests that his antisocial tendencies escalated throughout the biofeedback course.

During the post-course interview, he was quite pessimistic and reported fewer positive effects of participation compared with the rest of the group. He vaguely mentioned two benefits, namely improvements in sleep quality and reduced anxiety. According to P4, the later positive effect was evident only immediately after a session, and lasted for a short while. His comment that summarised the course was: “It’s not as good as you think.”. During this interview P4 was abrupt, flamboyant, manipulative, and eager to leave. His antisocial attitude was well reflected in self-report responses on the STAXI-2. Compared to the rest of the group, before the course P4 scored higher on *anger out*, and lower on *anger control out* and *anger control in*. After the course his responses on these subscales had improved. Despite improvement on the *anger control out* scale, his scores on the STAXI-2 remained poor compared to other completers.

*Participant number five*

Participant five (P5) was an athletically built male in his twenties. The obtained medical data indicated he was not diagnosed with a mental illness. Nonetheless, he had a history of poly drug misuse and his case notes mentioned several anxiety related episodes. He was referred by a key worker to take part in the biofeedback course. Whilst on the course, P5 was receiving Vareniciline for his nicotine addiction. Additionally, he was receiving auricular acupuncture. During the biofeedback course, he took part in various therapeutic activities, including substance misuse support groups, and Recovery Champion supervision and training sessions. His offences were arson, assault, and destruction of property.

P5 presented himself as the least disturbed participant on the biofeedback course. Most of the time he appeared bright in mood and settled in presentation. He was known to other prisoners and confident in the prison environment. An exception to his typical presentation was a mildly reduced ability to communicate verbally. He frequently gave an impression of being “blocked” when questioned about something. At times, he did not respond to questions at all. Later in the course his verbal communication improved as he became more confident in speaking. Thereafter, he mainly spoke in an optimistic manner. An exception to this positive behaviour occurred when he had an argument with his female partner. On that day P5 refused to take part in the session. However, he adhered to his remaining sessions adequately.

During the post-course interview, he stated the biofeedback course made him feel less anxious and more aware of own breath. He used the technique in circumstances unrelated to the course. This included attempts to calm down before going to sleep. No other benefits were obvious to him. However, investigation of his responses to personality questionnaires provided additional information. This included reduced scores for *depression* and *anxiety.* Furthermore, his improvement on the *non-judgement* subscale of the FFMQ-SF was strongest, compared to the rest of the sample.

*Participant number six*

Participant six (P6) was an approximately 40 years old, tall and slim male. His medical files described a history of anxiety featuring night terrors related to childhood trauma. Similarly to the rest of participants, he had an extensive history of poly drug use. During the course, he was receiving Sertraline 50mg each morning, Olanzapine 10mg at night and was assigned to a methadone detoxification programme. Olanzapine is an antipsychotic medication used in the treatment of schizophrenia and bipolar disorder. Whilst on the course, he did not participate in other therapeutic activities. Occasionally, he was seen by a key worker, whom administered his auricular acupuncture treatment. He was sentenced for attempted robbery, false imprisonment, and possession of a class A drug.

P6 appeared to be well accustomed with the prison rules and environment. He presented himself as a well-mannered person. He mentioned having some business opportunities prepared for him outside of the prison. During the course, he appealed to the court with a request for early release providing a large bail was made. This request was denied, which had an impact on his mental presentation. Consequently, he had a strong anxiolytic prescribed for a number of days. This anxiolytic had a significant impact on his performance during the relaxation sessions. This happened at the end of the course and P6 appeared drowsy over three final sessions.

P6 attended his sessions promptly and was a quick learner. He had no problems with operating the laptop devise. He appeared to have developed a good breathing technique from the beginning of session two. His opinion about the exercise, disclosed to the facilitator, was very positive. According to him, the positive effects that he experienced were a consequence of few factors. These factors were the slow and deep pattern of breathing, the gentle sound generated by the software, and the peaceful, distant from the "wings" session environment. These factors combined, as he mentioned, made him feel very relaxed during and after the sessions.

During the post-course interview, P6 stated that the purpose of the course was to "… control temper." However, it was difficult for him to appreciate any changes in his presentation. Later in the interview, he declared feeling more relaxed and less angry as a result of participation in the exercise. He added that these qualities emerged only in certain circumstances. However, he did not specify which circumstances were relevant. He suggested that at times it was difficult for him to focus on the task, and that might have had an impact on how he felt afterwards. The quantitative investigation revealed that compared to the rest of the group, before the course P6 scored lowest on *non-judgement*. This score had increased after the course. Furthermore, his score for *suppression* decreased strongly, which is interpreted as a desirable effect. Lastly, his scores on all three DASS-21 subscales decreased. However, this shift may be contributed to the before mentioned change in medication.

*Participant number seven*

Participant seven (P7) was an over 30-year-old slimly built male. His medical notes described a history of clinical depression and poly drug use. His presentation was very erratic, similar to behaviour displayed by individuals with attention deficit hyperactivity disorder (ADHD). During the biofeedback course, he was taking part in a methadone maintenance programme. His key worker had worked occasionally with him on a one to one basis. Apart from the biofeedback course, he had no other therapeutic engagements. He was convicted for assault by beating. His imprisonment was due to complete just after completion of the biofeedback course.

His ability to focus attention on a single task appeared very poor. During conversations, he would easily get distracted by random stimuli such as noises outside the door. His speech and thought pattern appeared very chaotic as if his thoughts were racing. At times, he would struggle to make up his mind about something. Before each session, he needed to take some time to “Get into the zone.”, as he explained. This would comprise of a short time of silence and concentration before turning the biofeedback software on. If disturbed during that preparation phase, he would easily drift away from the intended task.

Half way into the course P7 arrived for the session with a bruised face. At that time, P7 was very distressed. The facilitator allowed him to spend some time in the therapy room without engaging in the exercise. After several minutes, he was asked about how he acquired the bruises. He mentioned having problems with his cell mate, and that the fight had resolved the disagreement. Later that day he was taking an English exam, which he passed successfully despite the recent conflict. An additional session was organised for P7 to compensate for the lost one. He continued the following sessions according to the previously planned schedule.

At the end of the course, P7 reported using the breathing technique outside of sessions, particularly when he was trying to get a better sleep during night time. He believed that the course aimed to improve his behaviour. In his own words: “Mind over body – that’s the message.” Other benefits that he mentioned were a reduced amount of anxious and angry feelings. He disclosed that his ability to focus has improved and that he paid more attention to bodily sensations. Examination of responses to psychological questionnaires revealed that compared to the rest of the group P7 scored highest on the *anger in* subscale of the STAXI-2. After participation in the course his score for *anger in* was lower. No other participant reported a bigger shift on this scale. Shortly after completion of the course, P7 was released from the prison.

***Drop-outs***

*Participant number eight*

Participant eight (P8) was a well built, approximately 40-year-old male. He was clinically diagnosed with depression and had a history of alcohol and drug use. He was receiving a large variety of medication on a daily basis during the relaxation course, including Mirtazipine 15mg, Omeprazole 20 mg, Simvastatin 40 mg, Rampril 10mg, and Bisoprorol 5mg. The latter three medications are used to treat heart conditions, whereas Mirtazipine belongs to a group of atypical antidepressants. Additionally, he was assigned to a Methadone detoxification programme. He did not take part in any other therapy whilst on the course. Like the other participants, he was meeting one-to-one with his key worker. He was convicted of arson, carrying a bladed article in public, and inflicting fear of violence.

P8 came across as a well-spoken and bright individual. He was quite accustomed with the prison environment). At the beginning of the course, he was somewhat reluctant to continue his participation. However, after several sessions, he reported feeling more relaxed. He explained that the relaxed state was dependent on whether he took medication before the session. If he did ingest medication, the positive effects of the exercise would last longer. However, without taking a dose of medication, he would remain relaxed only for a short while after a session.

Half way in the course, he contracted a respiratory tract infection. This caused him to cough every time when taking a deep breath. Consequently, he could not perform the exercise effectively and was suspended from the course. Shortly after the suspension he was seen with heavy bruises on his face. When asked about the bruises, he stated that it was an incident and that he had fallen and hit his face against a sink. This explanation was obviously a deception designed to protect his perpetrator. Several days after the incident his throat infection faded and he requested to be readmitted on the course. However, the course was about to finish and his request was refused. P8 completed only nine sessions of the biofeedback exercise.

Although P8 did not complete the course, a post-course interview and testing session was arranged to take place six weeks after the initial session. During the conversation, he said that the breathing exercise had lowered his anger and anxious feelings. Furthermore, he felt that he might have more control over his thoughts. P8 was asked to provide an example of how the exercise worked for him. He recalled talking to himself one day: “Something will happen. I have to do something about it…”. His explanation suggested that he was thinking about behaving antisocially. During that day, shortly before a session he was feeling angry. However, after that session, he gained a different approach. This was expressed by a phrase: “It’s not worth doing.” By this he meant that he felt less angry after the exercise, and that he decided to abandon plans that could have caused him nuisance. However, examination of quantitative outcomes revealed that compared to completers his scores for *depression*, *anxiety*, *stress*, and *anger out* had increased after, compared to before the course.

*Participant number nine*

Participant 9 (P9) was a roughly 30-year-old, white male of a small body stature. He had a clinical diagnosis of general anxiety disorder (GAD) and experienced paranoid thoughts concerning his future behaviour. There was also some history of mental illness in his family. His medical notes mentioned a history of opiate addiction. Whilst inside the prison he was assigned to a methadone maintenance program. During the biofeedback course he was receiving 150mg of Pregabalin. This is a medication prescribed for treatment of general anxiety disorder and sometimes for epilepsy. He was convicted of robbery and possession of a bladed article. At times, he appeared drowsy and a smell of a “legal high” called “Mamba” was coming out of his cell.

After attending eight biofeedback sessions P9 decided to terminate his participation. He decided on this after several consultations with the facilitator and a key worker. His main reason for quitting was that the biofeedback exercise did not bring any positive effects. However, during his second week of participation, P9 mentioned that the exercise made him feel more relaxed. A short while later he joined a type of group psychotherapy. The post-course interview was not arranged for P9 because of the small amount of sessions attended.

*Participant number ten*

Participant 10 (P10) was male, around 30 years of age. The nursing staff reported that he suffered from clinical depression and psychosis. This participant had a history of poly drug misuse. He was assigned to a methadone detoxification programme and received 7.5mg of

Zopiclone and 300mg of Quetiapine at night. The former medication is commonly used in treatment of insomnia, whereas the latter is an antipsychotic drug used in treatment of schizophrenia and bipolar disorder. His offence was multiple thefts from shops, use of threatening words and causing fear.

The prison staff reported P10 was noncompliant with house block rules on many occasions. He also had a negative reputation amongst some of the prisoners. Some of this reputation allegedly came from borrowing items and not returning them. P10 was well known in the establishment both by prisoners and staff. He was repeatedly released and imprisoned again after short periods of time. After completing eight sessions P10 decided to terminate his participation. This occurred in part because he regained his old job in the prison laundry, which he enjoyed. After the decision to terminate was made, he did not participate in other therapeutic activities.