# Exploring the Heart and Mind of Anxiety: A Multi-Modal Approach to Examining the Neurovisceral Integration Model in Clinically Anxious Adults

by

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B.A, McMaster University, 2011

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# Supervisory Committee

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# Abstract

Objective: The purpose of this dissertation was to reproduce Thayer and Lane's (2000) neurovisceral model by examining both tonic and phasic heart rate variability (HRV) and emotion regulation (ER), and explore the effects of brief evidence-based intervention techniques in a sample of adults with clinically elevated levels of anxiety. Methods: This was a comprehensive multi-methodological study of 34 adults (ages 19 to 63 years) with clinically elevated levels of anxiety. Study 1 examined subjective and physiological effects of implementing ER strategies in response to a well-validated emotion elicitation paradigm consisting of viewing emotion-eliciting aversive images and sentences. Study 2 employed a within-subject RCT design and compared the impact of cognitive restructuring (CR), a top-down ER technique, with open monitoring mindfulness (OM), a bottom-up ER technique. Effects of intervention on self-regulation were assessed at a physiological (i.e. HRV), behavioral (i.e. ER and executive function (EF) computerized task) and subjective (i.e. self-report questionnaires) level. Results: Study 1 revealed that tonic HRV significantly predicted perceived ER success for both top-down and bottom-up generated emotions, whereas phasic HRV only predicted perceived ER success under conditions of bottom-up emotion generation. Variability emerged in our findings depending on the unique ER strategy used. Study 2 indicated a significant time by intervention effect on phasic HRV on the ER task, where HRV decreased with CR and increased with OM. There was a main effect of age independent of intervention on the EF task, such that increased age was related to increased phasic reactivity. On the ER task, CR led to greater perceived success in cognitive reappraisal. On the EF task, CR became faster, whereas OM became slower but more accurate. Significant intervention effects were also found on self-reported anxiety and aspects of mindfulness, with greatest reductions in anxiety found in OM compared to CR. Conclusions: In keeping with the neurovisceral integration model, HRV was reduced in individuals' with clinically elevated levels of anxiety. Moreover, our findings illustrate that the method of emotion generation and regulation matters and has a significant impact on the degree to which persons with clinical levels of anxiety are able to successfully self-regulate. Finally, our results demonstrate the utility of multi-modal assessment of cognitive and emotional dysregulation in anxiety disorders, as well as the different pathways through which different interventions can impact HRV and ameliorate symptoms of anxiety.

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# Dedication

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# Chapter 1: Overview of Rationale and Objectives

Emotion regulation (ER) involves extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying ones' emotional responses in such a way that allows individuals to act in accordance with their own goals and to appropriately respond to environmental demands (Gross, 1998; Gross & Thompson, 2007). As a part of this, ER encompasses continuous changes and adaptations to one's emotional experiences, expressions, and subsequent physiological responses (Aldao, 2013). Emotional responses that are consistent with environmental demands and one's internal goals represent adaptive ER and are associated with positive outcomes (e.g., physical and mental health). In contrast, emotional responses that are inconsistent with environmental demands and one's own goals represent maladaptive ER, and predict poor outcomes (e.g., disease and mortality) (Thayer & Lane, 2000; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). These connections between ER and health have been reflected in recent literature that conceptualizes and understands health through comprehensive models that integrate cognitive, affective, behavioral, and physiological factors contributing to individual differences in physical health and disease. Specifically, the field of psychophysiology has made important contributions in this area, particularly with the use of heart rate variability (HRV) —the characteristic beat-to-beat variability in the heart rate time series— as a proxy for both physical and emotional health. It has been proposed that HRV is not only an index of healthy heart function (Thayer & Lane, 2007), but also an index and measure of ER capacity. One of the most widely cited and contemporary theoretical models relating HRV with ER is the neurovisceral integration model proposed by Thayer and Lane (2000, 2009).

This model highlights a flexible neural network associated with self-regulation and draws attention to the interplay between emotion, cognition, and autonomic physiology. In order to understand the neurovisceral integration model that links ER, executive functioning (EF), and HRV, it is important to first consider the physiological underpinnings of HRV.

## Physiological Underpinnings of HRV

Like many organs in the body, the heart is dually innervated. Although a wide range of physiologic factors determine cardiac functions such as heart rate, the autonomic nervous system includes two branches: the sympathetic nervous system, associated with energy mobilization, and the parasympathetic nervous system, associated with vegetative and restorative functions. The heart is under tonic inhibitory control by a relative dominance of the parasympathetic nervous system (Jose & Collison, 1970; Thayer & Lane, 2009; Thayer et al., 2012). Support for this comes from evidence of resting cardiac autonomic balance, which has been shown to favor energy conservation by way of parasympathetic dominance over sympathetic influences (Thayer & Brosschot, 2005). In addition, in studies that have pharmacologically blocked sympathetic and parasympathetic inputs, the intrinsic heart rate is higher than the typical resting heart rate (Jose & Collison, 1970). This is thought to be due to the disinhibition of the so-called “vagal brake” (Porges, 2001). In addition, beat-to-beat variability over a wide range has been shown to involve vagal dominance, whereas the sympathetic influence on the heart has been shown to be too slow to produce beat-to-beat changes (Thayer & Brosschot, 2005). Parasympathetic input to the heart via the efferent vagus nerve affects heart rate acceleration and deceleration related to respiration, such that the heart speeds up after inspiration and slows down after expiration. Thus, more parasympathetic input results in more pronounced acceleration and deceleration, and more variable intervals between heartbeats, (i.e., higher HRV). This has been viewed as adaptive in the way that vagal parasympathetic control represents the major descending inhibitory pathway which functions to adaptively regulate physiological functions (Thayer & Sternberg, 2006; Weber et al., 2010), shaped by psychological processes such as ER (Thayer & Lane, 2000; Thayer & Sternberg, 2010). Heart rate continuously fluctuates around a mean level that is itself fluctuating in response to energy demands (i.e., internal and external demands) (Thayer & Lane, 2000; 2009). Thus, healthy allostatic balance is characterized by rapid psychological and physical responses to one's internal and external environment followed by a quick return to an energy-efficient resting state (Thayer & Lane, 2000; 2009; Thayer & Sternberg, 2006). The generation of context appropriate responses are attained via prefrontal modulation of bottom-up sensory inputs and serves to regulate psychophysiological resources related to goal-directed behavior (Thayer & Friedman, 1997; Friedman & Thayer, 1998 a, b). Ultimately, this system represents bidirectional influences and relationships between the central autonomic nervous system and the autonomic nervous system.

**Calculating HRV.** The basic data for the calculation of all the measures of HRV is the sequence of time intervals between heart beats. This interbeat interval (IBI) time series can be used to calculate the variability in the timing of the heartbeat. As mentioned above, the heart is dually innervated by the autonomic nervous system such that relative increases in sympathetic activity are associated with heart rate increases and relative increases in parasympathetic activity are associated with heart rate decreases. Relative sympathetic increases cause the time between heartbeats (i.e., IBIs) to become shorter whereas, relative parasympathetic increases causes higher IBI and higher HRV. Therefore, the variability over time in the IBI can be used as an index of cardiac vagal output. The parasympathetic influences are pervasive over the frequency range of the heart rate power spectrum whereas the sympathetic influences confined below 0.12Hz (Bernston et al., 1997; Porges, 1995). Therefore high frequency HRV represents primarily parasympathetic influences while lower frequencies (below about 0.12 Hz) represent a mixture of sympathetic and parasympathetic autonomic influences (Bernston et al., 1997; Porges, 1995). The differential effects of the autonomic nervous system on the sinoatrial node, and thus the timing of heartbeats, are due to the differential effects of the neurotransmitters for the sympathetic (e.g., norepinephrine) and parasympathetic (e.g., acetylcholine) nervous systems. The sympathetic effects are slow, on the time scale of seconds, whereas the parasympathetic effects are fast, on the time scale of milliseconds. Therefore the parasympathetic influences are the only ones capable of producing rapid changes in the beat-to-beat timing of the heart (Berntson & Cacioppo, 2000). With this basic foundation of the physiological underpinnings of HRV in mind, in the section that follows the association between HRV and ER is explored, including how these processes interact in order to support adaptive self-regulation across the life span.

## Unfolding the Relationship between HRV and ER

It is widely held that ER is a life-span developmental process that is complex in nature. Research focused on the co-regulation of HRV between caregivers and infants has significantly contributed to uncovering the role of HRV in the development of self-regulation. Early in life, infants have very limited capacity to regulate their emotions and as a result are dependent on their caregivers to meet their goals (Stifter & Braungart, 1995). This is achieved through the co-construction of optimal emotional states that the caregiver extends and uses to scaffold the infant's emerging self-regulatory capacity (Feldman, 2007; Tronick, 1989; Tronick & Gianino, 1986). When a mismatch in caregiver-infant co-regulation occurs, it can have drastic and profound effects in derailing the development of self-regulation (Field, 1985) (e.g., can significantly impair allostatic balance and the child's ability to develop adaptive self-regulation skills; Luecken, Rodriguez, & Appelhans, 2005). This can manifest clinically in adulthood as various types of psychopathology, but most notably, anxiety disorders. Consequently, inadequate early caregiving is associated with dysregulated physiological stress responses including greater sympathetic dominance (i.e., ineffective self-regulation or application of the 'vagal brake'), which often sets these individuals up for greater risk of developing psychopathology in the long term (Hart, 2011; Luecken & Lemery, 2004). Thus, both internal resources of the caregiver and infant, as well as external demands of the environment, impact the infant's development of ER (Thayer & Lane, 2000; 2009), and may provide a developmental context for later emergence of certain forms of psychopathology.

As an individual develops across the lifespan and enters into adulthood, ER becomes dynamic, multidimensional, and very individualized. In terms of adult emotional functioning significant inter-individual variation exists, however, generally speaking different ER strategies have been identified. According to the work of James Gross (e.g., Gross, 2002), these include cognitive reappraisal (i.e., the ability to modify one's thinking about a potentially emotion-eliciting event in order to modify its emotional impact) and expressive suppression (i.e., increasing efforts to actively inhibit outward displays of affect in terms of motor and behavioural components such as facial expressions). Deployment of such ER strategies has been shown to co-vary with within-person variations in HRV (Butler, Chapman, Forman, & Beck, 2006; Denson, Grisham, & Moulds, 2011; Gillie, Vasey, & Thayer, 2015; Melzig, Weike, Hamm, & Thayer, 2009). Cognitive reappraisal has been conceptualized as an antecedent-focused strategy, which refers to attempts to regulate emotional tendencies at, or prior to, the onset of emotions. When used as an antecedent-focused strategy, cognitive reappraisal has been found to be more effective than expressive suppression in reducing distress, decreasing negative emotion, and physiological arousal in response to distressing stimuli (Gross, 1998; Gross & Levenson, 1996). However, initiating cognitive reappraisal late in the emotion process (i.e., once an emotional response has already been generated) has been found to pose greater self-regulation challenges. This is thought to occur because it would require individuals to override strong, well-established negative interpretations of a situation once the emotion has already been elicited. Research has shown support for this claim by demonstrating that this ‘online’ cognitive reappraisal is less effective than other ER strategies including distraction (Sheppes & Meiran, 2007). Further, research shows that ‘online’ cognitive reappraisal is often associated with impaired cognitive performance (Sheppes & Meiran, 2008) and often results in greater sympathetic nervous system activation (Sheppes, Catran, & Meiran, 2009). Consistent with these ideas, McRae and colleagues (2011) examined the impact of cognitive reappraisal on bottom-up generated emotions and found that when cognitive reappraisal was used to regulate bottom-up generated emotions (i.e., emotional responses that had already been elicited), a paradoxical increase of amygdala activity occurred. Thus, at a basic level, it shows that when strong emotions are already evoked and ‘online’, applying a top-down strategy like cognitive reappraisal can be maladaptive and actually may make things ‘worse’ than doing nothing at all. This is particularly evident when looking at physiological indicators including the association between increased sympathetic nervous system activity and increased amygdala activation.

On the other hand, expressive suppression has been conceptualized as a response-focused strategy, which refers to strategies that are utilized once an emotion is already underway where the aim is the management of existing or current emotions (Gross & John, 2003). Expressive suppression is focused on inhibiting behaviors associated with emotional responding (e.g., facial expressions, verbal comments, gestures) (Gross, 1998) and requires significant cognitive efforts (Richards & Gross, 1999). As a response-focused ER strategy, expressive suppression comes relatively late in the emotion generative process and requires the person to effortfully manage response tendencies. Thus, this ER strategy focusses on the active down regulation of emotion and requires active engagement and utilization of cognitive resources including inhibitory control, interoceptive, and emotional awareness (Giuliani, Drabant, & Gross, 2011; Richards & Gross, 1999). Expressive suppression can be viewed as a cognitive strategy as it requires tremendous cognitive resources to effectively modulate behavioural and physiological responses. Research suggests that, while they may serve a short-term purpose, suppression strategies have counterproductive effects because they typically lead to a paradoxical increase in the unwanted experience and physiological arousal (Gross, 1998; Gross, 2002). Thus, it is often viewed as the least successful strategy because it is associated with heightened subjective anxiety and physiological arousal (Gross, 1998; Campbell-Sills & Barlow, 2007).

Finally, appraisal, a third form of ER, is an elusive construct that has received various ambiguous definitions in the literature. For example, appraisal is often viewed as a control condition in empirical studies on emotion, with participants often being instructed to simply “do nothing” in response to an emotional stimulus. However, if ‘appraisal’ is conceptualized as doing nothing, or in other words, the acceptance and allowance of one’s emotion to run its unaltered course, then this would suggest that it is in fact a key component of effective ER and could be implicated in various forms of clinical treatment. In fact, as van der Kolk (2014) simply and eloquently stated “self-regulation depends on having a friendly relationship with your body”. This likely includes a willingness to sit with emotion as it arises in the body, and not feeling compelled to actively regulate these emotions via cognitive reappraisal and/or expressive suppression techniques, but instead tolerating or even welcoming one’s emotional experience. This is acceptance and allowance of one’s natural emotional response is also an active component of various third wave evidence-based psychotherapy treatments including Acceptance and Commitment Therapy (Hayes, Strosahl, & Wilson, 1999a) as well as mindfulness-based approaches.

**The role of HRV in ER.** The role of HRV in ER can be studied at two levels: tonic (trait) level and phasic (state) level (Thayer & Lane, 2009). Tonic HRV is usually measured during a resting state, and is conceptualized as an individual difference factor related to effective self-regulation, and more specifically, ER (Appelhans & Luecken, 2006; Diamond, Hicks, & Otter-Henderson, 2011; Oveis et al., 2009; Pu, Schmeichel, & Demaree, 2010; Park, Vasey, Van Bavel, & Thayer, 2013; Thayer & Lane, 2009). Research indicates that tonic HRV can be observed during a resting baseline period and appears to be relatively stable over time (Li et al., 2009). Given that ER largely depends on an individual’s ability to adjust physiological arousal on a momentary basis (Gross, 1998), a flexible autonomic nervous system (i.e., HRV) allows for rapid generation or modulation of physiological and emotional states. For instance, with higher levels of tonic HRV, such individuals appear to produce context appropriate responses including appropriate recovery after a stressor has ended (Melzig, et al., 2009; Ruiz-Padial, Sollers, Vila, & Thayer, 2003; Thayer and Brosschot, 2005). High tonic HRV has been shown to predict an increased likelihood to actively engage in common ER strategies including expressive suppression and cognitive reappraisal (Pu, Schmeichel, & Demaree, 2010; Volokhov & Demaree, 2010). It may seem counterintuitive that individuals with high tonic HRV are better able to engage in expressive suppression techniques given the fact that this ER strategy has largely been considered a maladaptive ER strategy in the literature. However, research suggests that given the relationship between cardiac vagal control and self-regulation, individuals with high tonic HRV are better able to comply with social display rules in certain contexts that would require expressive suppression techniques (Ekman & Friesen, 1969). For example, expressive suppression may be a valuable strategy in certain contexts that discourage the expression of negative emotion (e.g. anger; Butler et al., 2003). Even though research suggests that the habitual use of expressive suppression is generally linked to poor outcome (e.g., less subjective well-being, poorer social outcomes) (Gross & John, 2003), unlike habitual suppressors, individuals with high HRV are able to exhibit flexible, socially appropriate, and adaptive emotional responding using this strategy. Thus, it is unsurprising that people with high tonic HRV are better able at engaging in both types of ER strategies. Further, in addition to suppressing negative emotion when socially appropriate, people with high tonic HRV may more successfully hide their positive feelings when this is considered to be appropriate (e.g., a student not bragging about his A+ when his friend is upset about their failing grade). Higher tonic HRV is also associated with a number of additional indicators of adaptive ER, including better performance on EF tasks, less negative emotion during daily stress, more effective coping, and better impulse control (Allen, Matthews, & Kenyon, 2000; Fabes & Eisenberg, 1997; Hansen, Johnsen, & Thayer, 2003; Johnsen et al., 2003; Shook et al., 2007).

On the other hand, when the autonomic nervous system becomes rigid, one's ability to generate or alter physiological and emotional responses according to affective changes, or changes in the environment is lessened (Appelhans & Luecken, 2006; Lehrer & Eddie, 2013; Thayer & Brosschot, 2005). For instance, individuals with low tonic HRV show delayed recovery from psychological stressors compared to those with higher levels of tonic HRV (Weber et al., 2010), and show poorer self-regulation capacity (Thayer et al, 2009; Thayer & Lane, 2000). This association appears to be more pronounced in clinical populations such as anxiety disorders (Aldao & Mennin, 2012). Low tonic HRV is also associated with increased risk for mortality and greater psychosocial stress (Thayer & Lane, 2007; Thayer, Hansen, & Johnsen, 2010). In this way, tonic HRV can be viewed as a marker to examine the flexible dynamic regulation of autonomic activity (Porges, 2007; Thayer et al., 2012), such that higher tonic HRV signals the availability of context- and goal-based control of emotions whereas lower tonic HRV represents rigid and potentially maladaptive ER resources. As discussed above, tonic HRV represents an individuals overall self-regulatory *capacity*, whereas, phasic HRV represents an individuals online self-regulatory *ability* (i.e. actual exertion of self-regulatory effort and physiological reactivity in the moment).

Phasic HRV is measured by examining changes in HRV when individuals go from baseline to exposure conditions (e.g., when faced with a stressor) and back to baseline. This is considered to be an indicator of autonomic flexibility, with greater autonomic flexibility being associated with more adaptive outcomes as discussed above (Thayer & Lane, 2009). Although phasic changes in HRV within an individual is less well understood than tonic HRV, it has been characterized as reflecting shifts in emotional experience, cognitive engagement, and self-regulatory effort (Porges, 2007; Rottenberg et al., 2005; Salomon, 2005; Segerstrom & Nes, 2007; Thayer & Lane, 2009). For instance, evidence suggests that phasic increases in HRV occur in situations that require in-the-moment ER to facilitate effective self-regulation (e.g., increased stress) (Butler, Wilhelm, & Gross, 2006; Ingjaldsson, Laberg, & Thayer, 2003; Park, Vasey, Van Bavel, & Thayer, 2014; Segerstrom & Nes, 2007; Thayer & Lane, 2009). More specifically, phasic increases in HRV have been tied to state ER (Butler et al., 2006a; Elliot, Payen, Brisswalter, Cury, & Thayer, 2011) and are commonly associated with the ‘fight or flight response’ (Cannon, 1929). However, recent research suggests that phasic increases or decreases are context dependent and also impacted by the unique individual’s emotional experience (Park et al., 2014).

It has been argued that the “default” response to uncertainty, novelty, and threat is sympathoexcitatory preparation (i.e., fight or flight response) (Thayer & Lane, 2009; Herry et al, 2007). This system works to maximize survival and adaptive responses to the environment (LeDoux, 1996). Although evolutionarily speaking, this has been adaptive in history, it is crucial for an individual to determine if and when threat appraisals are truly appropriate depending on the context, rather than always being in a chronic state of apprehension or vigilance to perceived threats, as often seen in psychopathological disorders including anxiety. Structures implicated in ER and autonomic regulation including the prefrontal cortex (PFC), specifically the medial PFC (mPFC), are important in this process of evaluating the context and largely impact phasic HRV (Lane et al., 2009). However, as mentioned above, in comparison to tonic HRV, things are far less clear regarding the association between phasic modifications of HRV and ER. Studies tracking the stability of phasic HRV over time are scarce, and seem less consistent compared to tonic HRV (Li et al., 2009).

Given that the literature in phasic HRV is less understood compared to tonic HRV, it is unclear whether tonic and phasic HRV provide unique or overlapping contributions to ER. Research supporting the relationship between tonic and phasic indices is currently mixed. Some empirical evidence suggests that tonic HRV and phasic HRV represent distinct constructs that independently predict a variety of physical and mental health outcomes (Salomon, 2005). Conversely, other research suggests tonic HRV may in fact modulate phasic HRV (Berna, Ott, & Nandrino, 2014; Cribbet, Williams, Gunn, & Rau, 2011; Gaebler, Daniels, Lamke, Fydrish, & Walter, 2013), such that higher tonic HRV is associated with individuals showing greater phasic HRV enhancement (Beauchaine, 2001; Butler et al., 2006b). Finally, others argue that state- and process- specific relationships between HRV and self-regulation can explain any trait or individual differences in these relationships (Jennings et al., 2015). Therefore, these were clearly relevant concepts that provided rational for the design of the present study.

Interestingly, research identifies distinctive patterns in phasic HRV depending on the context, whereby changes in phasic HRV appear to be dependent on the situation at hand. For example, Park et al. (2014) found a positive association between high tonic HRV and greater phasic HRV suppression in response to stress. It is hypothesized that greater phasic HRV suppression in stressful or threatening contexts could reflect ER and provide a protective function against environmental challenges (Beauchaine et al., 2001; 2007; El-Sheikh, Hinnant, & Erath, 2011; Lyonfields, Borkovec, & Thayer, 1995; Weber et al., 2010). So, for example, when there is a perceived threat or stressor at hand, phasic HRV suppression is thought to allow for the more automatic, bottom-up, 'fight or flight' responses to kick in, and for adaptive regulation to quickly and efficiently take place in that moment. Research shows that when the stressor or threat is over, people with higher tonic HRV show increased phasic HRV during recovery (i.e., restoration of homeostasis) (Weber et al., 2010). On the other hand, lower tonic HRV is associated with reduced phasic HRV suppression to stress, which may increase the risk of developing behavioral or emotional problems (Appelhans & Luecken, 2006; El-Sheikh et al., 2011). This shows some consistencies with the neurovisceral integration model (Thayer et al., 2009), which proposes that low tonic HRV and either reduced phasic HRV suppression or excessive phasic HRV reactivity in the face of a real stressor, mark general vulnerability to psychopathology. When the stressors or threat is over, people with low tonic HRV show delayed recovery (i.e., HRV return to baseline). Overall, there is no general consensus in the literature regarding what changes in phasic HRV represent and thus this requires further investigation.

**Theoretical perspectives on ER and HRV.** Current theories of ER strongly support the role of HRV in flexible and adaptive autonomic processing (Cui et al., 2015;

Thayer et al., 2012; Thayer & Lane, 2000). For instance, during a state of physical or psychological stress, activity of the sympathetic nervous system has been shown to become dominant, and produce physiological arousal to aid in adapting to a challenge (Porges, 2001). The vagal response to stress functions as a "brake" to quickly regulate responses to environmental demands and individuals with higher resting vagal control are thought to exhibit greater vagal withdraw during stress (Porges, 1995). In support of this theory, emotional arousal has been linked with a decrease in HRV (Lane et al., 2009), which is consistent with a general inhibitory role of the PFC via the vagus (Nugent, Bain, Sollers, Thayer, & Drevets, 2008). Specifically, during emotional stress, the PFC is taken "offline" to let automatic, prepotent processes regulate behavior (Arnsten & Goldman-Rakic, 1998). This selective prefrontal inactivation may be adaptive by facilitating predominantly nonvolitional behaviors associated with subcortical neural structures such as the amygdala to organize responses without delay from the more deliberative and consciously guided PFC. However, inhibition, delayed response, and cognitive flexibility are vital for self-regulation, and prolonged prefrontal inactivity can lead to hypervigilance, defensiveness, and perseveration (Thayer & Lane, 2009). This is evident within various psychopathological disorders, particularly in anxiety disorders, which represent the key clinical topic of interest in this study. On the other hand, during periods of relative safety and stability, the parasympathetic nervous system becomes dominant and works to maintain a lower degree of physiological arousal and decreased heart rate (i.e., greater HRV). Thus, HRV ultimately serves as a physiological index of ER (Cacioppo, Tassinary, & Berntson, 2007) and therefore is a tool that can be used to understand integral mind-body connections related to emotional processes.

## The Role of EF

EF has many definitions and in general is often used as an “umbrella term” that captures a series of abilities recruited in order to achieve a goal (Damasio, 1995). Controversies surrounding EF have largely been fuelled by the debate as to whether EF can be described as a “unitary” or “diverse” construct, an idea originally proposed by Tueber (1972). It has recently been argued that EF represents both a “unitary” and “diverse” construct (Miyake et al., 2000; Miyake & Friedman, 2012). Different components of EF have been shown to correlate with one another, thus tapping some common underlying ability (unity), but they also show some separability (diversity). At a general level it is agreed that EF is required for independent, purposive, self-directed behavior, and includes processes of initiation, planning, purposive action, volition, inhibition, flexibility, as well as self-monitoring and self-regulation (Lezak, 1995; Stuss, 2011). EF by nature is deployed in novel, non-routine situations that require effortful cognitive processing. Although many influential models and theories of EF have been proposed, one of the most widely cited theories of EF is that by Miyake and colleagues (2000). This theory approaches EF from a cognitive psychology perspective and highlights three fundamental components of EF: shifting (i.e., shifting one’s attention to pertinent information in the environment), updating (i.e., updating and monitoring of working memory representations relevant to goal pursuit), and inhibition (i.e., inhibiting irrelevant information that does not contribute to one’s goal) (Miyake et al., 2000; Miyake & Friedman, 2012). These lower order and more circumscribed components of EF are implicated in the performance of complex, conventional EF processes and tasks including reasoning, problem solving, and planning (Collins & Koechlin, 2012). This conceptualization is one of the most extensively studied approaches to understanding EF in current literature and thus, was the focus of the present study. In the section that follows, several ways in which EF and ER are linked are examined and a necessarily selective review of recent research that has supported these connections is provided.

**Connections between EF and ER.** There is a growing body of research that suggests EF is involved in ER processes including the initial activation of a goal, the ability to continually update these goals in working memory (i.e., 'updating'), the ability to shift attention to pertinent information in the environment (i.e., 'shifting'), and the ability to simultaneously and actively inhibit irrelevant information that does not contribute to the goal at hand (i.e., 'inhibiting') (Berkman & Lieberman, 2009; Gross, Richards & John, 2006; Gross & Thompson, 2007; MacLeod & Bucks, 2011; Ochsner & Gross, 2008; Thompson, 2011). It is suggested that cognitive and emotional control processes continuously interact in order to allow individuals to engage in purposeful and efficient goal-directed behaviors that allow them to adaptively and flexibly cope with their emotions over time. From a developmental perspective, EF and ER both share similar trajectories across the lifespan (Thompson, Virmani, Waters, Raikes & Meyer, 2013). For instance, in childhood and adolescence, emotion pervasively interacts with cognition throughout the development of ER from simple preverbal strategies, to more sophisticated self-awareness and more complex ER strategies (Barrett, 2009; Izard, 2007). In line with this research, evidence suggests that children develop ER alongside the development of self-talk (Barrett, 2009; Thompson, 1994; 2011), an ability that facilitates effective use of ER strategies such as cognitive reappraisal (Gross, 2001). Thus, prevailing theories suggest that some of the variation observed in emotionality over development may be due to the maturation of cognitive processes including EF that can be applied to ER (Dahl, 2003; Luna, 2009; Steinberg, 2005). In support of this notion, McRae and colleagues (2012) showed a quadratic relationship between cognitive reappraisal ability and age over time. This finding suggests that cognitive reappraisal seems to develop later in life as an individual begins to develop the cognitive control processes (i.e., EF) necessary to support this particular strategy. Consistent with this finding, research has also indicated a linear relationship between age and activation in brain regions thought to subserve ER processes, including amygdala-frontal connectivity and the PFC. This shows support for the idea that areas in the brain associated with emotional control processes are also brain structures commonly implicated in EF processes (i.e., PFC), thus supporting a connection between EF and ER.

It is important to note that, while ER has traditionally been argued to be distinctly and differentially related to cognitive control processes including EF. However, available evidence does not clearly support these claims. This represents a longstanding and ongoing debate in the field, specifically regarding whether ER can be understood as one specific sub-function of EF, or whether these can be viewed as orthogonal constructs, a question that continues to remain unanswered. Thus, it is important to acknowledge that the relationship between ER and EF has implications that reach beyond what is clear in current research. However, there is evidence that suggest that the simple act of engaging in some form of ER can have taxing consequences on EF, and vice versa, and thus an association between these two constructs in some capacity exists (Beilock & Carr, 2005; Shamosh & Gray, 2007).

So far in this section relevant research that indicates how age related changes in the regulation of emotions parallel biological and cognitive maturation related to EF was reveiwed. Further, research demonstrating how brain maturation and patterns of neurological functioning related to emotional processes and EF continue to develop over the lifespan was discussed. I explored how these parallel developmental processes occurring between ER and EF highlight their mutual influence on self-regulatory abilities. Finally, I considered the EF vs. ER debate and considered some of the heterogeneities that exist in current research. In the section that follows, literature is presented discussing the links between HRV and EF, including how these processes relate to self-regulation.

**Theoretical perspectives on HRV and EF.** The relationship between HRV and EF has received significant support in the literature (e.g., Thayer & Lane, 2000; 2005; Thayer & Brosschot, 2005). Specifically, a growing body of research has systematically investigated the role of individual differences in vagal function (as indexed by resting HRV) in cognitive performance (i.e., EF tasks). For example, Thayer and colleagues (2009) found that resting HRV was related to working memory, sustained attention, mental flexibility, and inhibition. Research has also shown that persons with greater vagally mediated HRV perform better on EF tasks in a wide range of situations (Thayer & Hansen 2009), where better performance is thought to be due to the ability of HRV to index important aspects of prefrontal function. This is supported by research demonstrating that prefrontal cortical activity is associated with vagally mediated HRV (Ahern et al., 2001; Lane et al., 2001; 2009). Thus, the connections between cognitive performance and autonomic regulation are intrinsically overlapping, reciprocal, and dynamic. The three EF components presented by Miyake and colleagues (2000) (i.e., shifting, updating, and inhibition) have specifically been shown to be key mechanisms for supporting adaptive

HRV (Opitz, Lee, Gross, & Urry, 2014). However, despite advances in current research, there are inherent limitations that still exist including a lack of reliability in the operationalization of these constructs (e.g., EF), as well as measures employed. Further, an important component of understanding HRV and EF includes the question of whether EF has a role in HRV outside of maintaining ER. This has recently been brought to light by Jennings and colleagues (2015) who argued that there may be a distinct role of EF in HRV depending on the context, that is, within an emotional ("hot" EF) vs. non-emotional ("cold" EF) context. This study examined the role of tonic HRV in 'cold' cognitive EF tasks and the results failed to show evidence of an association between these constructs. This area of research has only recently begun to flourish, and at this point it is unclear whether EF pertains to HRV outside of facilitating adaptive emotional self-regulation. The results from Jennings et al. (2015) raised important questions relevant to the neurovisceral integration hypothesis, namely, the need to provide greater understanding of the conditions/contexts in which vagal and EF regulation may employ shared processes.

At present, the relationship between HRV and EF is partly explained by the common underlying neural basis for both functions (Lane et al., 2009). Direct and indirect pathways by which the frontal cortex modulates parasympathetic activity via subcortical inputs have been identified, and these circuits have been linked to HRV (Thayer & Lane, 2009). At rest, active cortical brain areas are indicative of greater inhibition (Thayer et al., 2012), suggesting that the amygdala is under inhibition from higher order areas in the brain including the PFC. Converging evidence suggests that these core sets of neural structures are not only responsible for inhibition, but also the regulation of the autonomic nervous system activity (Hansen, Johnsen, Sollers, Stenvik, & Thayer, 2004). Thus, it seems that

EF, particularly the role of inhibition, is mediated both synaptically in the brain and vagally in the periphery (Thayer & Friedman, 2002). Interestingly, the heart (and other peripheral organs) is under tonic inhibitory control by the autonomic nervous system (Jose & Collison, 1970), and this influence is characterized by a relative dominance of the parasympathetic nervous system over influences of the sympathetic nervous system (Thayer & Lane, 2009; Thayer et al., 2012). This has been viewed as adaptive in the way that vagal parasympathetic control represents the major descending inhibitory pathway which functions to adaptively regulate physiological functions (Thayer & Sternberg, 2006; Weber et al., 2010) shaped by psychological processes (e.g., ER; Thayer & Lane, 2000; Thayer & Sternberg, 2010). The PFC has also been inversely associated with activity in subcortical structures such as the amygdala (Davidson, 2000; Schiller et al., 2008; Thayer, 2006) highlighting the role of the PFC in complex cognitive-emotional control processes. Accordingly, mediated HRV may act as an index of the functional capacity (i.e., EF systems) of a set of brain structures that support the effective and efficient performance required for successful self-regulation.

Up until now I have discussed the relationship between vagal function and physiological regulation (i.e., HRV; Thayer & Brosschot, 2005; Thayer & Sternberg, 2006), vagal function and ER, and vagal function and EF. It is apparent that there have been parallel developments and discoveries within each of these three domains. In the section that follows attention is turned to Thayer and Lane’s (2009) neurovisceral integration theory, which has offered a succinct model to better understand the mechanisms of HRV by bridging these three domains. As discussed later in this paper, the integrity of this system becomes compromised in various psychopathological states – in particular, anxiety disorders. For the purpose of the present study, I have argued that the three EF components (i.e., shifting, updating, inhibition) proposed by Miyake and colleagues (2000) are important cognitive processes that overlay Thayer and Lane’s (2000; 2009) neurovisceral integration model. Although the role of EF is embedded in this model, it has been researched in a fragmented or isolated manner (e.g., examining one specific EF component at a time, examining one specific outcome variable rather than a dynamic and interconnected model). Further, the ongoing debate concerning the role of “hot” vs. “cold” EF in the context of the neurovisceral integration model remains unanswered. To the author’s knowledge the current study is the first to directly connect the neurovisceral integration model with Miyake’s three EF components including shifting, updating, and inhibition at this specific level of examination (i.e., both unique and interactive roles of tonic and phasic HRV) in a clinically anxious sample. The specifics of the neurovisceral integration model, and how this model ties provides us with a unifying framework that integrates both EF and ER with autonomic physiology (Thayer et al., 2009) is discussed below.

## Neurovisceral Integration Theory

The neurovisceral integration theory is strategically situated within a reciprocal system of functional connectivity within the brain and body. This model proposes that HRV can be used as a physiological measure that can serve as an index of the degree to which the autonomic system provides flexible, adaptive regulation of its component systems (Thayer & Lane 2000; 2009). More specifically, this model highlights a critical role for parasympathetically mediated inhibition or autonomic arousal in emotional expression and regulation. The central autonomic network is a key feature of the neurovisceral integration model and includes brain regions that coordinate autonomic, endocrine, and behavioral responses in goal directed action and in adaptation to environmental challenges (Hagemann, Waldstein, & Thayer, 2003; Thayer & Lane, 2000).

The overlap between HRV, EF, and ER has been put forth by the neurovisceral integration model, which claims that each of these processes may be related to each other in the service of goal-directed behavior (Thayer & Lane, 2000). Support for this theory comes from the wealth of research indicating cognitive, affective, and physiological regulation are all associated with vagally mediated cardiac function, as indexed by HRV and discussed in detail in the preceding sections (Thayer & Brosschot, 2005). Importantly, inhibitory functions have been linked with shared neural structures including the PFC (Aron, Robbings, & Poldrack, 2004) and serve to support adaptive functioning. The similarity of the structures and networks identified between those associated with physiological regulation of cardiac control and those associated with cognitive regulation, particularly inhibitory processes, lend additional support for a common neural basis for these processes. A recent meta-analysis by Thayer and colleagues (2012) argued that the heart and the brain are connected bi-directionally; efferent outflow from the brain affects the heart and afferent outflow from the heart affects the brain. Importantly, the vagus nerve is an integral part of this heart-brain system and vagally mediated HRV appears to be capable of providing valuable information about the functioning of this system.

The ease with which an individual can transition between high and low arousal states is dependent on the ability of the autonomic nervous system to rapidly vary HRV.

This process is largely related to and dependent upon the EF network, namely a system reliant on inhibitory control functions. Thus, effective ER depends on an individual's ability to adjust physiological arousal on a momentary basis and in accordance with one's own goals and changing contextual demands (Gross, 1998), and EF has been shown to aid this process. Therefore, a flexible autonomic nervous system has been shown to support effective modulation of physiological and emotional states (Porges, 1992; Thayer & Lane, 2000). In contrast, a rigid autonomic nervous system is associated with a reduced capacity to generate or alter physiological and emotional responses in accordance with changing goals and the environment. Therefore, in the context of physiological regulation (i.e., HRV), a balanced system is healthy, because the system can respond flexibly to physical and environmental demands (Thayer & Sternberg, 2006). A system that is "locked in" to a particular pattern is considered to be dysregulated. Support for this notion comes from research demonstrating how healthy hearts oscillate spontaneously (i.e., shows high HRV), while diseased hearts show almost no variability under certain conditions (Stein & Kleiger, 1999; Thayer, Yamamoto, & Brosschot, 2010). Without variability and flexible adaptation, the system is at a greater likelihood of becoming dysregulated and this may put an individual at greater risk for dysfunction. This is supported by research that has shown acute and chronic manifestations of imbalanced brain-heart interactions consistently have a negative impact on health.

To summarize, ER and EF are connected, and are implicated in HRV. As discussed in length above, the integral connections between ER and EF are thought to allow individuals' to adaptively respond to demands from the environment, and organize their emotional and behavioral responses effectively (Thayer et al., 2012). As a part of this process, individuals must flexibly shift their attention (shift), attend to pertinent information in the environment (update), and inhibit prepotent responses in the service of a more desirable or situationally appropriate one (inhibit) (Lane et al., 2009; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). These ER and EF processes are supported by a balanced HRV system that is able to respond flexibly to the demands of the environment. In the following section, anxiety disorders are introduced as the population of particular interest in the present study, and an understanding of how this population is often associated with dysregulated autonomic functioning and various maladaptive outcomes is explored.

# Study 1: Investigating the Neurovisceral Integration Model in a Clinically Anxious Sample

Anxiety disorders are a group of mental disorders, many of which are characterized by excessive and persistent feelings of fear, anxiety, and related behavioral disturbances that interfere with a person's functioning and cause significant distress. According to the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; American Psychiatric Association, 2013) anxiety disorders include the following: panic disorder, generalized anxiety disorder, social anxiety disorder, specific phobia, agoraphobia, separation anxiety disorder, selective mutism, substance/medication induced anxiety disorder, and anxiety disorder due to another medical condition. As a whole, anxiety disorders are understood as a diverse spectrum rather than a restrictive, unitary category, commonly associated with significant comorbidity (Kemp et al., 2012; Kessler, Chiu, Demler, & Walters, 2005). One crucial aspect of the diagnostic criteria is that fear and anxiety disorders are characterized by *changes in the patient's physiology*. The DSM-5 specifies that these fear responses to threat cues prompt "surges of autonomic arousal," and anxiety is described as being "associated with muscle tension and vigilance in preparation for future danger..." (APA, 2013, p. 189). In order to meet diagnostic criteria for an anxiety disorder the expression of anxiety must be excessive in magnitude, duration, or situation as a consequence of the interplay of the above-mentioned psychological and physiological components that work to maintain symptom expression. These emotional (e.g., fear, distress), cognitive (e.g., negative and worry thoughts), behavioral (e.g., avoidance), and physical (e.g., tachycardia, muscle tension, dizziness) symptoms of anxiety are shared by, and critical to this diagnostic group of disorders (APA, 2013; Rapport, Clary, Fayyad, &

Endicott, 2005; Sansone & Sansone, 2010). Anxiety disorders are the most prevalent mental illness affecting Canadian adults (Damsa, Kosel, Moussally, 2008; Kessler et al., 1996), with a 12-month prevalence rate over 12% (Kessler, Chiu, Demler, & Walters, 2005). Concerning the etiology of anxiety disorders, it is widely accepted that multiple and interrelated factors are involved in the development of pathological anxiety. These factors can be mainly categorized into biological vulnerabilities (e.g., neural indices, genetic markers, heightened interoception), psychological vulnerabilities (e.g., early learning experiences), and environmental influences (e.g., life experiences).

**Anxiety disorders and HRV.** Anxiety in all its forms can be seen as a failure of inhibition involving reduced capacity to inhibit cognitive (e.g., apprehension, vigilance, and worry), affective (e.g., fear, panic), behavioral (e.g., avoidance), and physiological (e.g., increased HR) responses, leading to reduced vagal outflow and lowered HRV (Chalmers, Quintana, Abbott, & Kemp, 2014). This is consistent with the neurovisceral integration model, which emphasizes the role for the PFC in inhibitory function of vagally-mediated HRV (Thayer & Brosschot, 2005). The inhibitory role of the PFC in HRV is further evident on functional magnetic resonance imaging (fMRI) scans in individuals with developmental trauma which show reduced neuronal activity in the medial PFC (i.e., the mPFC often "goes dark" on fMRI). This reduced involvement of the PFC is thought to lead to a failure at effectively regulating and putting the 'brake' on prepotent amygdala responses to fear and threat (van der Kolk, 2014). The amygdala's prepotent responses can trigger powerful stress hormones and nervous system responses (e.g., sweating, trembling, increase heart rate, elevated blood pressure) and without the mPFC, can lead these individuals to live life in an irritable or hypersensitive way. Thus, when the mPFC is not ‘online’, it is not able to counterweight the emotional intensity produced by the amygdala. This is corroborated by research showing that low tonic HRV is associated with poor self-regulatory capacity, including rigid, and hypervigilant responses that are common in anxiety disorders (Friedman, 2007; Thayer et al., 2009; Thayer & Lane, 2000). Thus, the neurovisceral integration model incorporates the qualities of inhibition and perseveration and their central nervous system mechanisms (i.e., role of PFC) as they relate to anxiety disorders. As a result, this conceptual framework predicts reduced vagal tone in anxiety disorders which is supported by robust findings in current literature indicating reductions in ANS functioning in patients with psychiatric disorders including pathological anxiety (Alvares, Quintana, Hickie, & Guastella, 2016).

Interestingly, research suggests that the role of the PFC in inhibitory functions have been linked more strongly with dominance of the right PFC (Ahern et al., 2001; Aron et al., 2004; Kalisch et al., 2005). This has been supported by studies that have shown that the right PFC is preferentially related to inhibitory processes across a wide range of cognitive, motor, and affective tasks (Aron et al., 2004; Garavan et al., 1999; Chambers et al., 2006; Kalisch et al., 2005; Lieberman et al., 2007). Given the predominant right hemispheric innervation of the sinoatrial node of the heart it has been suggested that the well-known right hemisphere advantage for emotion may be secondary to the relative right hemisphere innervation of the heart (Ahern et al., 2001). Similarly, research suggests that the relationship between EF performance and HRV is related to the common neural basis for both functions (Thayer & Lane, 2000, 2005; Thayer & Brosschot, 2005). Therefore, the right hemisphere specifically is thought to be a critical player in inhibitory processes involved in cognitive, affective, and physiological regulation (Thayer & Lane, 2000;

Thayer & Brosschot, 2005). However, it is important to note that other studies have shown left-sided dominance for cortical regulation of vagal regulation (Craig, 2005; Swick, Ashley, & Turken, 2008). Given these variations in the field, Thayer and Lane (2009) argue that a dynamical systems framework is most appropriate for understanding the neurovisceral integration model, whereby networks are recruited in response to challenges in the environment i.e., a view that encompasses an 'emergent' functional network that exists to support context specific moments that require self-regulation (Thayer, 2006; Thayer & Lane, 2000; 2005). This is supported by the fact that even the simplest tasks can evoke dynamic and distributed patterns of cortical activation (Gevins et al., 1999). Thus, the neurovisceral integration model is based on the assumption that the reciprocal interconnections between neural structures and the PFC exert an inhibitory influence on sub-cortical structures (e.g., the amygdala), that allow an individual to flexibility respond to demands from the environment, and organize their behavior effectively.

When this system does not optimally function, the parasympathetic-sympathetic balance becomes dysregulated leading to various maladaptive states including pathological anxiety. In the context of anxiety disorders sympathoexcitatory responses are often unable to be effectively inhibited (Chalmers et al., 2014). Interestingly, in anxiety disorders a link between prefrontal hypoactivity and a lack of inhibitory neural processes has been well established (Thayer & Brosschot, 2005). In healthy individuals when the environment is perceived as safe, vagal outflow increases, promoting regeneration and homeostatic functions. However, for individuals with anxiety disorders, 'false alarms' are often triggered which is commonly associated with the perception of danger in the absence of actual or 'real' danger (Van Bockstaele et al., 2014). This subsequently has been shown to throw the autonomic nervous system out of this ‘dynamic balance’. The inability to disengage from threat detection subsequently heightens the activation of the sympathetic nervous system, which can lead to a chronic withdrawal of parasympathetic activity and long-term reductions in HRV (Kemp & Quintana, 2013). Together, these characteristics represent rigidity in the autonomic nervous system and the inability to effectively modulate physiological and emotional states in anxiety disorders. A recent meta-analysis by Chalmers et al. (2014) showed support for this finding and indicated that overall, anxiety disorders were associated with significant reductions in HRV. Individuals struggling with anxiety disorders are characterized by low tonic HRV and show either phasic HRV suppression in response to emotionally negative stimuli or excessive phasic reactivity in response to stress (Berna, Ott, & Nandriono, 2014; Park et al., 2014). Individuals with anxiety disorders or those with trauma backgrounds often live in a chronic state of sympathetic activation (e.g., hypervigilant to the internal/external environment, perceiving neutral stimuli as negative and potentially threatening), which again represents a form of rigidity in HRV.

Given that reductions in HRV have been linked to predicting adverse future outcomes including cardiovascular disease and sudden cardiac death (Kemp & Quintana, 2013; Thayer, Yamamoto, & Brosschot, 2010), it is important to direct research efforts toward finding effective interventions for individuals with anxiety disorders as a way of taking a preventative focus toward treatment. Given the potential physical health concomitants of suffering from an anxiety disorder, there are clear implications concerning the importance of discovering whether successful treatments have been shown to increase HRV. This is especially important given that this population commonly suffers for 5-10 years before receiving a diagnosis and treatment (Ballenger et al., 2001). To date, the research in this area is relatively heterogeneous and thus, this question remains largely unanswered. For instance, despite the key role of physiological components in anxiety disorders, current clinical assessment does not routinely include measurement of these physiological variables beyond subjective reports of distressing somatic symptoms. Although subjective reports and observable behaviors are no less important than neurobiological measures, biological indicators of physiological arousal and self-regulation (e.g., HRV) among anxiety disorder populations may be particularly useful. Measuring such biological indicators may be useful not only in advancing current research and practice, but also as a way to provide a more complete picture of anxiety disorders themselves, including any response to subsequent intervention. This is especially true given the well-known significance of physiological factors in diathesis and symptom presentation among this diagnostic group. Although from a research standpoint, the work in psychophysiology and anxiety disorder populations has begun to flourish, this research has not yet led to incorporating any biological measurement in the way clinicians routinely clinically assess and diagnose anxiety disorders. Currently, the presence of these features is largely determined by the client's report of symptoms at interview and the clinician's evaluation of their significance. A recent study by Jarczok et al (2015) highlighted the value in self-report as a vital aspect of the evaluation of anxiety disorders. The results of this study showed that all measures of autonomic nervous system function were significantly more strongly associated with self-rated health than any other biomarker. Additionally, there has also been some promise within psychiatry where there has been increasing incorporation of biomarkers in an attempt to enhance diagnosis and treatments over and beyond self-report measures, which have led to increased investigation into the neurobiological, physiological, and neuroendocrine bases of anxiety disorders (Singh & Rose, 2009).

## Overview of Study 1

The primary aim of Study 1 was to experimentally validate the neurovisceral integration model in a clinically anxious sample by examining whether tonic and phasic HRV was related to participants' performance on a cognitively demanding computerized task where participants were asked to utilize specific ER strategies (i.e., cognitive reappraisal, expressive suppression, and appraisal) to regulate their emotions while viewing negative stimuli.

This study took the perspective of assuming variation within individuals and the purpose of Study 1 was to better understand and specifically examine this within-subject change. This was largely due to the considerable variation within individuals in terms of both level and rate of change in HRV. The literature indicates that this is a powerful way to capture HRV, particularly by studying tonic HRV given that the neurovisceral hypothesis has been derived from this measure (Britton et al., 2007; Kemp, Quintana, Felmingham, Matthews, & Jelinek, 2012). Compared to tonic HRV, relatively little is known about the role of phasic HRV in the context of self-regulation (Butler et al., 2006b; Ingjaldsson, Laberg, & Thayer, 2003; Segerstrom & Nes, 2007). However, it is widely agreed to be an implicit component of the neurovisceral integration model (Thayer & Lane, 2009). Thus, the present study employed a multi-method design and attempted to reproduce the neurovisceral integration model by examining both tonic and phasic HRV and ER in a sample of participants with clinically elevated levels of anxiety. Investigating HRV in several psychophysiological conditions allowed us to examine differences in HRV that may have been trait versus state-dependent. From a clinical perspective, it is important to examine the relationship between HRV and cognitive reappraisal, expressive suppression, and appraisal success in order to better understand the mechanisms that underlie tonic and phasic HRV as a psychophysiological marker of ER. The present study focused on cognitive reappraisal, expressive suppression, and appraisal because they comprise a well-validated model of ER (Gross, 1998) and are three strategies central to current mainstream psychotherapeutic treatment approaches to anxiety disorders. Specifically, cognitive reappraisal, conceptualized as the ability to modify one's thinking about a potentially emotion-eliciting event in order to modify its emotional impact (Gross, 2002), is an explicit target of traditional evidence-based treatment approaches such as cognitive-behavior therapy (CBT; Beck, Rush, Shaw, & Emery, 1979; Hofmann & Asmundson, 2008). Expressive suppression, conceptualized as increasing efforts to actively inhibit outward emotional expressions/reactions (Gross, 1998), is a frequently studied response-focused strategy. Finally, appraisal, conceptualized, as the acceptance and nonjudgmental allowance of emotions (Hayes, Bissett, Korn, & Zettle, 1999b) is a core component of third-wave as well as bottom-up/somatically-oriented approaches to treatment (e.g., through mindfulness and acceptance-based techniques). To the author's knowledge, these strategies have not been compared to each other in anxiety disorder populations before, particularly from a multi-methodological standpoint. Thus, by adding physiological measures to my behavioral assessment I drew inferences about ER by examining incongruence across these methods.

## Hypotheses

This study was guided by the following hypotheses: it was predicted that HRV would be positively correlated with performance on a cognitively demanding task of ER, and negatively correlated with self-reported anxiety. Specifically, it was expected that participants with higher tonic HRV to perform better on the ER task because high vagal tone is associated with the ability to self-regulate, greater flexibility, and adaptability to stressful situations. It was also predicted that for phasic HRV, greater autonomic flexibility (i.e., greater changes in HRV when going from baseline to exposure condition) would be associated with better-task based ER. The hypotheses used in the present study were in line with what would be expected based on the neurovisceral integration model. More precisely, a higher tonic (resting) level and a greater magnitude of change from rest to task (i.e., phasic HRV) is a good index of cardiac vagal control, and this is thought to underlie the ability to regulate emotions and respond appropriately.

To the author's knowledge, no prior study has directly investigated ER and correlated parasympathetic functioning including both tonic and phasic indices of HRV in a clinically anxious population. Thus, by examining whether the effects of ER strategies on autonomic parameters extend to anxiety disorder populations this study will begin to fill this gap in the literature, and better understand whether the neurovisceral integration model holds for populations where this system becomes largely dysregulated. The majority of research in this area has focused on healthy populations; however, there may be inherent limitations in assuming a perfect transition from healthy populations to clinical populations. Further, of the studies that have examined components of the neurovisceral model in anxiety disorders, several limitations and inconsistencies exist, and thus further research is warranted.

# Methods

## Participants

Fifty-one participants were recruited in the community (i.e., posters/flyers around campus at the University of Victoria, postings at local coffee shops and community centers in Victoria, British Columbia, postings through the Psychology Participant Pool –SONA, system, and recruitment adds on the University of Victoria campus, counselling services, etc.). For participants with no previous diagnosis of an anxiety disorder, a self-report inventory (i.e., the State Trait Anxiety Inventory; STAI) was used to assess their anxiety. Raw scores on the STAI range from 20-80, with higher scores indicating greater anxiety. In the current study, age and gender-based normative values were used for each participant in order to determine whether their scores fell within the clinically elevated range. Clinically elevated for the purpose of the present study was defined as having at least one score ≥ 90th percentile on the STAI. Prescreening was performed via phone call or email to ensure that all participants met the inclusion criteria: individuals were between 19 and 80 years of age, with a mix of gender and race/ethnic backgrounds that were reflective of the local population who had normal or corrected-to-normal vision, could speak and understand English. Exclusion criteria comprised of not actively receiving psychotherapy at the time of the study, did not endorse concurrent heavy drug or alcohol, and did not specifically use beta-blocker (e.g., Acebutolol (Sectral), Atenolol (Tenormin), Betaxolol (Kerlone), Bisoprolol/hydrochlorothiazide (Ziac), Bisoprolol (Zebeta), Metoprolol (Lopressor, Toprol XL), Nadolol (Corgard), Propranolol (Inderal) and Sotalol (Betapace), or anticholinergic drugs (e.g., benedryl, tricyclic antidepressants). Additionally, participants did not have a history of cardiac pathology (e.g., prior heart attacks). These criteria pertain to factors that could have affected the EKG recording. Usable data based on these inclusion and exclusion criteria were available for 34 participants. Data for 17 participants were excluded from analysis for the following reasons: they were receiving psychotherapy at the time of enrolment (n=2), moved out of the country (n=2), reported a heart abnormality and/or medical/respiratory condition that would impact EKG recording (n=5), did not endorse clinically elevated levels of anxiety (n=1), and reported becoming too busy with their academic commitments and declined to participate in this study (n=7). Therefore, the final sample for Study 1 consisted of thirty-four individuals (82.4% females). Participants in the final sample were between the ages of 19 and 63 years old (Mean age= 32). The ethnic composition of this sample included Caucasian (82.4%), Asian (5.9%), Indian (5.9%) and other (5.9%). Participants in this study either already had a previously diagnosed anxiety disorder from a healthcare professional upon entering the present study, or met criteria for clinically elevated levels of anxiety based on a standardized self-report measure (i.e., the STAI). Specifically, 26.5% of the sample had no prior diagnosis of an anxiety disorder, 41.2% had a diagnosis of generalized anxiety disorder (with or without co-morbid diagnoses), 14.7% had a diagnosis of post-traumatic stress disorder, 5.8% had a diagnosis of social anxiety disorder, and 11.8% had a primary mood disorder diagnosis in addition to clinically elevated levels of anxiety. Descriptive statistics associated with self-report and cognitive measures can be found in Table 1.

## Experimental Procedure

The Research Ethics Review Board at the University of Victoria approved the experimental protocol for this study. Once enrolled into the study, participants travelled to the Neuropsychology and Rehabilitation Laboratory at the University of Victoria. The procedures were explained and informed consent was obtained from the participants. In order to ensure confidentiality, data for each participant were stored anonymously, and were coded by the participant's randomly assigned identification number. Prior to the experiment, participants were also asked to fill out a record of participation, which required their name, date, and contact information to indicate that they showed up for the study and would receive either course credit or were entered into the draw to win a $50 gift card. At the first visit, participants met individually with the primary investigator (PI) for testing. Participants were tested in three different sessions: Study 1 included the first session (session 2 and 3 are described in Study 2 below). Each session was approximately 120 minutes. Participants completed various self-report questionnaires related to anxiety, stress, ER, and interoception/body awareness. This step took 15-20 minutes to complete, which also served as a laboratory adaptation period. The experimenter sat outside the room to ensure privacy when participants answered the surveys. Then, physiological recording equipment was presented, set up, and the emotional task was started. The experiment began with a 5-minute 'pre-any task' baseline period and participants were given the following instructions: "Before we begin, please just sit quietly with your eyes closed for 5 minutes. I will tell you when the 5 minutes are over." This baseline was used to capture tonic psychophysiological activity, which is typically computed toward the end of a movement- and stimulus-free baseline, which must be long enough to induce a wakeful resting state (Obrist, 1981). Next, participants completed an experimental emotion task. Additional recordings of HRV were taken before each task, continuously throughout the task and then at the end as a post-task recovery measure. See Figure 1 for an outline of the procedure of Study 1.

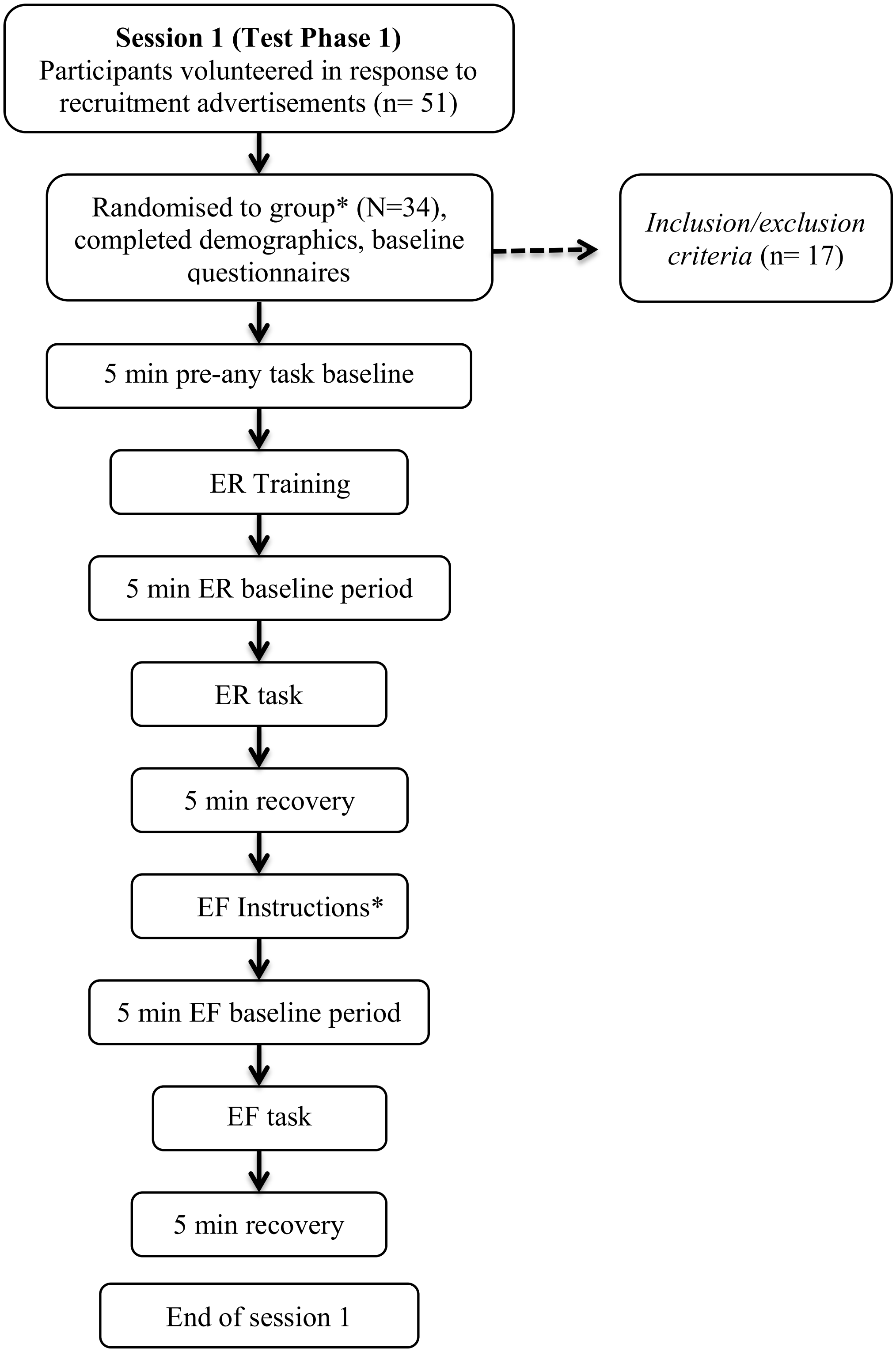

*Figure 1*. Session 1 procedure.

*Note.* ER= emotion regulation; EF= executive function; *While the EF task was given, results are not analyzed until Study 2; Group randomization is in the context of the intervention described/investigated in Study 2; All participants' data were analyzed in Study 1.

## Measures

A telephone screen was used to verify participant eligibility for the study. Several questions were asked to elucidate whether participants fit the criteria (see Appendix A for eligibility requirements). Participants were asked not to consume caffeine or alcoholic beverages for 12 hours and not to exercise for 24 hours prior to each study visit. Fidelity to this instruction was also checked on the day of each study visit. Data from multiple levels of measurement (behavioural, self-report, and physiological) were examined which is consistent with current methodological approaches in this area (Adrian, Zeman, & Veits, 2011). Participants completed self-report questionnaires related to perceived stress, emotion, coping, interoception/body awareness, anxiety sensitivity, and cognition, and a demographic history questionnaire. Participants' HRV was recorded while they completed the ER and EF tasks. HRV measures were used as an index of individuals' capacity for aspects of regulated emotional responding.

## Clinical and Emotional Assessment

**Emotion regulation.** *The Difficulties in Emotion Regulation Scale* (DERS; Gratz & Roemer, 2004) was used to assess ER. This 36-item, self-report questionnaire is designed to assess multiple aspects of emotion dysregulation. The DERS consists of six subscales including Nonacceptance of Emotional Responses (nonacceptance), Engaging in Goal-Directed Behavior (goals), Impulse Control Difficulties (impulse), Lack of Emotional Awareness (awareness), Limited Access to Emotion Regulation Strategies (strategies), and Lack of Emotional Clarity (clarity). Problems in any of these areas would be indicative of perceived ER difficulties. The DERS is a multidimensional measure of ER, with established reliability and validity (Ehring, Fischer, Schnulle, Boserling, & Tuschen-Caffier, 2008).

The *Emotion Regulation Questionnaire* (ERQ; Gross & John, 2003), which assesses the typical use of emotion suppression (4 items, e.g., “I keep my emotions to myself”) versus cognitive reappraisal (6 items, e.g., “When I want to feel less negative emotion, I change the way I’m thinking about the situation”). Each item is rated on a scale from 1 (strongly *disagree)* to 7 *(strongly agree),* and subscales are summed with higher scores indicating more use of the strategy. This scale has been shown to possess good psychometric properties including high internal consistency and test-retest reliability for both subscales (Gross & John, 2003).

**Anxiety.** Anxiety was measured by using the *State Trait Anxiety Inventory (STAI) form Y* (Spielberger, 1983; 2010) which is a brief, easily administered scale. In the current study the STAI was used as both a diagnostic measure as well as an individual difference measure. Participants who did not self-identify as having a prior diagnosis were determined to have “clinically elevated” levels of anxiety if they scored ≥ 90th percentile on at least one of the STAI scales (i.e., either/or State/Trait scale). State anxiety is temporary anxiety in response to some threat that is perceived to be present. Trait anxiety describes a personality characteristic of being anxious on a day-to-day basis rather than a temporary feeling of anxiety. Form Y is the most popular version of the instrument and comprises a scale for assessing state anxiety and another scale for assessing trait anxiety. For state anxiety items, participants report how they feel right now by rating the intensity of their anxiety feelings on a 4-point Likert scale: (1) not at all, (2) somewhat, (3) moderately so, and (4) very much so. For trait anxiety items, participants report how they “generally” feel by rating themselves on a 4-point Likert scale: (1) almost never, (2) sometimes, (3) often, and (4) almost always. The 2 scales are not meant to be combined, and raw scores can range from 20 to 80 for each scale. The higher the state or trait score, the greater the anxiety level. The STAI form Y is a well-validated, international instrument (Carruble et al., 2010), sensitive to experimental manipulations of stress, which discriminates between stable and transient factors contributing to anxiety (Hishinuma et al., 2000). The STAI exhibits good internal consistency ($\alpha = 0.83–0.86$; Hedberg, 1972) and test-retest reliability ($\alpha = 0.73–0.86$; Spielberger, 1983).

*The Penn State Worry Questionnaire (PSWQ)* (Meyer, Miller, Metzger, & Borkovec, 1990) is a 16-item self-report questionnaire designed to assess a person’s tendency to worry and associated ability to control worry (i.e., trait worry). Items include “my worries overwhelm me” and “I worry all the time”, and are presented on a 5-point Likert-type scale. The PSWQ can be considered a content-nonspecific measure in that it assesses an individual’s tendency to worry independent of the topic of worry. Among patients with anxiety disorders, college students, and community samples, internal consistency of the PSWQ has been good ($\alpha$’s .86 to .93; Brown, Antony & Barlow, 1992; Fresco, Heimberg, Mennin & Turk, 2002; Molina & Borkovec, 1994). Adequate internal consistency also was demonstrated within a sample of older adults undergoing CBT for generalized anxiety disorder (GAD) ($\alpha$= .83; Stanley, Novy, Bourland, Beck & Averill, 2001). In addition, adequate test–retest reliability has been demonstrated across college samples ($r = .74$ to .93) but was poorer among older adults with GAD ($r = .54$; Stanley et al., 2001). Convergent validity of the PSWQ and other worry or anxiety measures was supported in previous research incorporating samples of younger (Brown et al., 1992) and older (Beck, Stanley & Zebb, 1995) adults with GAD. Among younger adults, correlations between the PSWQ and measures of anxiety and depression ranged between .36 and .74, although these relationships were weaker among clinically anxious individuals (Molina & Borkovec, 1994).

**Anxiety sensitivity.** Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007). The ASI- 3 is an 18-item measure designed to assess the tendency to fear arousal symptoms based on the belief that they may have harmful consequences. Items are rated on a 5-point Likert scale ranging from 0 (very little) to 4 (very much). Factor analytic studies support a three-factor structure corresponding to the theorized dimensions of AS (i.e., fears of somatic sensations, cognitive dyscontrol, and publicly observable anxiety reactions; Taylor et al., 1996; Zinbarg, Barlow, & Brown, 1997), all loading onto a higher order factor of AS (Taylor et al., 2007). The validity and reliability of the ASI-3 has been established (Taylor et al., 2007). Across groups, internal consistency was acceptable for the total ($\alpha$ = .94) and subscale scores (physical concerns, $\alpha$ = .87; cognitive concerns, $\alpha$ = .93; social concerns, $\alpha$ = .89).

**Interoception.** The *Multidimensional Assessment of Interoceptive Awareness* (MAIA; Mehling et al., 2012) is a 32-item self-report questionnaire, which measures interoceptive awareness across eight dimensions. The eight scales, and an example question for each are: Noticing (“I notice where in my body I am comfortable”), Non-distracting (“I distract myself from sensations of discomfort”), Not-worrying (“When I feel physical pain, I become upset”), Attention regulation (“I can return awareness to my body if I am distracted"), Emotional awareness ("I notice how my body changes when I am angry"), Self-regulation ("I can use my breathe to reduce tension"), Body listening ("I listen to my body to inform me about what to do"), and Trusting ("I trust my body sensations"). Each question is answered on a Likert-type scale ranging 0 (never) to 5 (always), and each scale is scored by calculating the average. Higher scores on each scale indicate a higher level of positive body awareness.

**Mindfulness.** Participants completed the *Five Facet Mindfulness Questionnaire* (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), a 39-item self-report questionnaire that measures trait levels of mindfulness according to five facets: observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. Participants respond to each item by selecting the number that is "most generally true" of his/her experience, on a scale of 1 ("never or rarely true") to 5 ("very often or always true"). Higher scores indicate greater levels of mindfulness. Each subscale of the FFMQ describes different areas of mindfulness and is correlated with different aspects of psychological functioning. For instance, the describing facet is most positively correlated with emotional intelligence and negatively correlated with alexithymia, which is characterized by difficulty identifying physical symptoms as somatic representations of emotions, while the non-reactivity facet is most positively correlated with self-compassion, and the observing facet with openness (Baer et al., 2006). The FFMQ is based on a factor analytic study of five independently developed mindfulness questionnaires, with good internal consistency (Baer et al., 2006) and construct validity (Baer et al., 2008). The FFMQ has been used as a measure of intervention effects (e.g., Curtis, Osadchuk, & Katz, 2011; Flook, Goldberg, Pinger, Bonus, & Davidson, 2013). A recent meta-analysis indicated that the FFMQ is a reliable measure of dispositional mindfulness that can be used to assess the effects of mindfulness interventions in adults (Quaglia, Braun, Freeman, McDaniel, & Brown, 2016).

**Perceived stress.** Participant's levels of perceived stress was measured using the *Cohen's Perceived Stress Scale* (PSS). This measure consists of 10 multiple choice questions that asks participants to rate various measures of their perceived stress level within the past month, using a 5-point scale (Cohen, Kamarck, & Memelstain, 1983). This questionnaire was used to assess the degree to which situations in one's life were appraised as stressful (e.g., "In the last month, how often have you felt nervous and "stressed"?) The PSS has adequate reliability, validity and internal consistency (Hewitt, Flett, & Mosher, 1992).

## Cognitive and Emotional Behavioural Tasks

**ER paradigm.** The ER paradigm utilized in this study is a paradigm employed in previous research (Cochrane, Smart, & Garcia-Barrera, 2017; McRae, Misra, Prasad, Pereira, & Gross, 2011; McCrae et al., 2012; Vanderhasselt, Kühn, & De Raedt, 2012). Participants were shown a series of aversive pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997) and linguistic stimuli, which were intended to generate temporary negative emotions[1]. The stimuli set consisted of 45 negative pictures of the IAPS (Lang et al., 1997) and 45 negative sentences (e.g., negative sentences such as "Her son is in the burning building."; McRae et al., 2011). Each stimulus

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[1] IAPS Picture Numbers used were as follows: 1022, 1120, 9252, 8230, 9423, 6560, 9910, 9181, 3051, 9911, 6350, 6825, 6313, 6230, 9421, 1310, 6370, 1304, 6211, 6312, 1070, 6213, 6550, 1525, 2811, 9050, 9921, 6834, 1205, 8485, 6212, 9254, 1050, 9400 9420, 9571, 6250, 6021, 6570, 2683, 6200, 1201, 9635, 1052, 9185jpgs.

was shown only once for each participant. Consistent with the originators of the ER paradigm (Vanderhasselt, Kühn, & De Raedt, 2012) participants were instructed to ‘suppress’, ‘reappraise’ or ‘appraise’ their emotions in response to aversive stimuli and provided a relative rating of their negative affect based on the application of the explicit ER strategy. All stimuli were generated by Acer Aspire 5741 laptop and were displayed on a 15.6-inch screen by means of E-Prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2002). Testing was done in a small quiet testing room, free of any distractions (e.g., windows or other visual distractions).

***Task training.*** To standardize how participants applied the different instructions (appraise/suppress/reappraise), they were trained for +/- 20 minutes on how to ‘suppress’, ‘reappraise’ or ‘appraise’ their emotions in response to aversive images/sentences. The number of practice trials differed between participants depending on when they achieved a minimum level of understanding or proficiency in suppression, reappraisal, and appraisal. The training instructions used in this study are those employed in previous research conducted by Vanderhasselt and colleagues (2012), and were refined primarily through minor revisions to the wording of instructions as well as the addition of stimuli presented in the paradigm (i.e., inclusion of both negative pictures and sentences).

Participants were also trained to enhance preparatory control supporting the specific strategy they were instructed to employ (i.e., suppression or reappraisal). During the preparation phase, participants were told that an affect-laden stimulus (picture or sentence) would appear in all trials. For the cognitive reappraisal and suppression instruction this mindset of control to down-regulate and maintain control over the expression of their feelings respectively was carefully trained. It was crucial to run through the practice block successfully (see Figure 2 for specific training instructions). For the appraisal instruction participants were instructed to do nothing specifically (no preparatory control), but wait until the picture/sentence was shown, knowing that they could react normally to the stimuli. Thus, the mindset of simply experiencing their feelings fully, without attempting to control or change them in any way, to let their feelings run their natural course, and to stay with their emotions as fully as possible, was carefully trained.

The same person (i.e., PI) instructed and trained all participants to adequately prepare for and apply reappraisal, suppression, and appraisal strategies. During the practice phase, participants were asked to verbally state what they were thinking during the preparation (cue) and picture/sentence (target) phase. This way, the preparation and actual target phase was standardized over all participants. Participants were asked to use the ER strategies as they were being taught, and otherwise report this at the end of the trial. For all the stimuli, participants were told not to look away and to concentrate on the stimuli during the time it was projected on the computer screen. During the practice phase, participants first received a couple of examples to illustrate the reappraisal instruction (e.g., how to generate reinterpretations). Subsequently, participants were asked to verbally state what they were thinking during the preparation (cue) and picture/sentence (target) phase.

| Task Training Instructions | | |
|---|---|---|
| **Suppress** | **Reappraise** | **Appraise** |

| | | |
|---|---|---|
| “This means that you should suppress your emotional response. One way to do this is to keep your face motionless so that someone who can see your face cannot infer what you feel at that moment. Try not to show emotional facial expressions.” | “This means that you should apply a strategy to reduce your negative emotions elicited by the unpleasant picture or sentence so that it no longer elicits negative feelings. Do so by thinking about the picture or sentence in a less negative way so that your negative emotions are reduced.” | “This means that you will experience the emotion as elicited by the picture or sentence. Look carefully at the stimuli without trying to change your emotions. Experience your emotions as they are provoked, try not to change.” |
| *Goal*: Suppress displaying negative feelings elicited by the aversive stimuli | *Goal*: Down-regulate negative feelings elicited by the negative image or sentence and decrease emotional reactivity | *Goal*: Do nothing; respond naturally to the aversive stimuli and do not intentionally apply any explicit ER strategy |

*Figure 2.* Training instructions for the emotion task.

***Task.*** During the ER paradigm participants were cued to suppress, reappraise and appraise a series of 90 randomly intermixed trials in 3 blocks. The order of the instructions was randomized between blocks and for each participant. Each trial started with a fixation cross (0-1.5s, the latency of the fixation cross was randomized 500-1500 ms) followed by a cue word (suppress, reappraise or appraise). This cue word appeared centrally on the screen for 3 s, after which a blank screen was presented (3s). This cue-offset time enabled participants to prepare for the instructed ER strategy. Subsequently, a negative, high arousing image or sentence appeared centrally for 10 s. Although the image or sentence remained on the screen, participants performed the ER or appraisal specified by the prior instructional cue. Then, a rating scale appeared immediately after presentation of the stimuli. Participants provided a relative rating of their negative affect indicating how successful they were based on the application of the explicit ER strategy to control their negative emotions (“How successfully were you able to reappraise/suppress/appraise your negative feelings elicited by the picture/sentence?”). A Likert scale allowed participants to rate how successful they were in regulating or appraising their negative emotions (1=not at all to 5=very well) following the presentation of each aversive stimulus. Successful ER was indexed as a mean rating of >5 on a Likert scale from 1-5, which suggests that participants were able to regulate their emotions elicited by the stimuli presented (i.e., ER success indexed by down regulation of negative emotion). Successful cognitive reappraisal implies that the participants were able to down-regulate negative feelings, whereas successful expressive suppression implies that participants were able to not show their feelings on an outward level. All together, the success rating is indicative of an evaluation of ‘relative negative affect’ based on the application of an explicit ER strategy. Participants were also asked to rate valence and arousal following the presentation of each picture/sentence. Specifically they were asked to indicate how they felt while looking at the pictures/sentences using 5-point Likert scales for mood (1= negative, 3= neutral, and 5= positive) and arousal (1= nothing, 3= calm, and 5= stimulated). Participants’ ratings of each picture/sentence reflected their immediate personal experience. These ratings were gathered as research indicates that psychological activation/arousal can speed heart rate, and faster heart rate is related to less HRV, thus it was important to account for potential variables that may influence HRV during the ER paradigm (Billman, 2013). Finally, the word ‘RELAX’ appeared on the screen for 4s, which allowed participants to relax until the presentation of the next trial. The above-mentioned ER paradigm is that of Vanderhasselt and colleagues (2012) with the addition of negative sentences as stimuli to be appraised. The duration of the ER task period was approximately 45 to 60 minutes.

## HRV Recording and Analysis

**HRV recording.** Cardiac data was collected using MindWare Technologies BioNex 8-Slot amplifier (electrocardiography, sampled at 1000 Hz, continuous acquisition mode, gain 500), accompanied by a laptop computer running BioLab software (MindWare Industries; www.mindwaretech.com). EKG patches with continuous leads were applied in a standard lead-II setup. The participant was seated in a comfortable chair (in the laboratory) and 3 different electrodes were placed on the skin in a Lead II configuration (as demonstrated below see Figure 3). These electrodes were 1 1/2" in diameter and had been soaked in conducting gel.

*Figure 3.* Einthoven's triangle Lead II standard electrode placement

Berntson, G. G., Bigger, J. T., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., et al. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology, 34*, 623-648.

Prior to commencing the EKG recording/computerized tasks, participants were asked several questions to elucidate whether they had consumed alcohol/substances that may impact the EKG recording (e.g., "Have you consumed alcohol in the last 12 hours?", "Have you consumed caffeine in the last 12 hours?"). Participants were informed *not* to consume these substances for 12 hours prior to HRV recording; as mentioned above, any affirmative answer to these questions resulted in termination of the experimental session however, all participants in the present study complied with these parameters.

Vagally mediated HRV was assessed during each of the previously described tasks, as well as at baseline periods: an initial 5 minute resting baseline before any task, as well as a separate 5 minute pre-task baseline and post-task baseline for each of the computerized tasks (i.e., ER and EF task).

**HRV analysis.** EKG sampled at 1000 Hz was processed offline using BioLab MindWare Technology (Mindware HRV Module, Gahanna, OH) to identify the timing of each heartbeat. HRV was derived using MindWare HRV Analysis 3.1.2 program. Each of the 5-minute events (i.e., baseline, task, recovery) were divided into 60-second epochs, with the mean taken across epochs to increase the reliability of the analysis. Heart rate data were first checked manually for artefacts (electrode noise, movement, and extraordinary peaks). Vagally mediated HRV was assessed using the root mean square of successive differences in R-R intervals (RMSSD), measured in milliseconds. RMSSD has good validity for capturing vagally mediated HRV (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology 1996; Li et al., 2009; Thayer & Sternberg, 2006; Thayer, Yamamoto, Brosschot, 2010; Williams et al., 2015). Conceptually speaking, RMSSD is the square root of the mean of the squared successive differences between IBIs, with larger numbers reflecting greater beat-to-beat variability in heart rate. In this way RMSSD is a standardized measure. For the present study, to compute the RMSSD, the difference between successive IBIs was taken (IBI (n+1) – IBI (n)) and then all of those values were squared. More beat-to-beat variability yields larger squared values. The mean across those values was then computed, and then the square root to get the final RMSSD metric used in this study. Thus, for each 60-second epoch, the RMSSD was provided, and the average RMSSD across all available segments (i.e., across five 60 second epochs) provided an estimate of RMSSD for that period.

RMSSD was thought to be the best index of vagally mediated HRV in the sample in the present study as it is sensitive to short-term, and high frequency cardiac control. Further, some researchers suggest that RMSSD is superior to spectral methods as it is less sensitive to variations in respiratory patterns (Penttila et al., 2001); although some researchers identify limitations to this approach (e.g., Berntson et al., 2005).

# Results

First, descriptive statistics associated with self-report and cognitive measures for the entire sample (N=34) can be found in Table 1. To highlight some important areas: overall, the sample exhibited mild to severe levels of state anxiety and severe levels of trait anxiety, as expected given recruitment and eligibility criteria. Further, participants in this study exhibited a high level of emotion regulation difficulty, with the greatest area of concern being a limited access to emotion regulation strategies. They perceived their overall success on the behavioural emotion regulation task to be on average adequate on a scale that ranged from 1= not at all to 5= very well. Participants in the present study also exhibited high levels of worry, and endorsed experiencing their body as unsafe and untrustworthy.

Next, hierarchical regression analyses were conducted in order to examine whether tonic HRV predicted performance (i.e., self-rated ER success) on the ER task. In the first step, age, gender, self-reported anxiety based on questionnaires, arousal, and valence were entered to examine the amount of variance accounted for by these variables, in predicting self-rated ER success. Of note, arousal and valence ratings were calculated separately for each relevant analysis by taking the average rating across the pertinent stimuli/trials (e.g., arousal rating calculated for all sentence stimuli vs. picture stimuli separately). Next, tonic HRV (i.e., 5 min pre- any task baseline measure) was entered into the model. A separate hierarchical regression analysis was used to examine whether phasic HRV (HRV change scores from baseline to task engagement; i.e., introduction of a stressor) predicted perceived success on the ER task. Similar to above, in the first step age, gender, anxiety, arousal, and valence were entered and in the second step, phasic HRV was entered. In this way I controlled for the amount of variance accounted for by age, gender, anxiety, valence and arousal, and examined the unique contribution of HRV in predicting ER success (total average success rating, as well as for each condition (i.e., reappraisal, suppression, appraisal) for both picture and sentence stimuli respectively.

Table 1

*Descriptive Statistics*

| | | *M* | *SD* | *Range (Possible range)* |
|---|---|---|---|---|
| **Self-Report Measures (N=34)** | | | | |
| STAI | | | | |
| | State Percentile | 70.47% | 19.52% | 34-97% (0-100%) |
| | Trait Percentile | 92.74% | 9.44% | 65-100% (0-100%) |
| PSS | | 24.65 | 3.65 | 15-35 (0-40) |
| DERS | | | | |
| | Non-acceptance of Emotional Responses | 18.03 | 6.33 | 7-28 (6-30) |
| | Difficulties Engaging in Goal-Directed Behaviour | 18.85 | 4.63 | 10-25 (5-25) |
| | Impulse Control Difficulties | 14.59 | 5.71 | 6-26 (6-30) |
| | Lack of Emotional Awareness | 14.5 | 4.18 | 8-28 (6-30) |
| | Limited Access to Emotion Regulation Strategies | 22.53 | 7.96 | 9-37 (8-40) |
| | Lack of Emotional Clarity | 12.18 | 3.64 | 7-21 (5-25) |
| | Total Score | 100.68 | 23.78 | 49-145 (36-180) |
| ASI | | | | |
| | Physical | 7.56 | 6.01 | 0-19 (0-24) |
| | Cognitive | 10.18 | 6.97 | 0-21 (0-24) |
| | Social | 13.56 | 5.53 | 1-24 (0-24) |
| | Total Score | 31.29 | 14.62 | 1-58 (0-72) |
| ERQ | | | | |
| | Reappraisal | 23.79 | 7.89 | 7-40 (6-42) |

| | | | | |
|---|---|---|---|---|
| | Suppression | 15 | 6.35 | 4-27 (4-28) |
| | Total Score | 38.79 | 9.42 | 15-53 (10-70) |
| FFMQ | | | | |
| | Observe | 26.29 | 4.96 | 18-37 (8-40) |
| | Describe | 26.15 | 5.46 | 5-36 (8-40) |
| | Awareness | 26.06 | 5.62 | 10-32 (8-40) |
| | Non-Judge | 26.59 | 6.17 | 12-32 (8-40) |
| | Non-React | 19.47 | 4.55 | 7-31 (7-35) |
| | Total | 124.56 | 15.54 | 66-157 (0-195) |
| PSWQ | | 65 | 10.52 | 25-76 (16-80) |
| MAIA | | | | |
| | Noticing | 3.26 | .78 | 1-5 (0-5) |
| | Non-Distracting | 3.13 | .90 | 1-5 (0-5) |
| | Not Worrying | 2.69 | .76 | 1-4 (0-5) |
| | Attention Regulation | 2.63 | .86 | .29-4.57 (0-5) |
| | Emotional Awareness | 3.49 | .81 | 2-5 (0-5) |
| | Self-Regulation | 2.63 | .95 | .5-4.75 (0-5) |
| | Body Listening | 2.84 | .99 | 0-9.67 |
| | Trusting | 2.00 | 1.21 | 0-4.33 (0-5) |
| **Behavioural Task Data** | | | | |
| Emotion Regulation Task (N=34) | | | | |
| | | | | (1-5) |
| | Sentence Success | 3.69 | 0.64 | 2.07-4.84 |
| | Picture Success | 3.19 | 0.68 | 1.87-4.76 |
| | Total Success | 3.44 | 0.64 | 1.97-4.8 |
| | Reappraisal Picture | 3.34 | 0.61 | 2.06-4.56 |
| | Reappraisal Sentence | 3.86 | 0.61 | 2.23-4.87 |
| | Total Reappraisal | 3.6 | 0.55 | 2.14-4.7 |
| | Suppression Pictures | 3.28 | 0.78 | 1.25-4.71 |
| | Suppression Sentences | 3.6 | 0.78 | 1.39-4.79 |
| | Total Suppression | 3.44 | 0.75 | 1.32-4.71 |
| | Appraisal Picture | 3.05 | 0.77 | 1.87-5 |
| | Appraisal Sentence | 3.6 | 0.75 | 2-4.93 |
| | Total Appraisal | 3.32 | 0.73 | 1.96-4.96 |
| Arousal and Valence Ratings (n=23) | | | | (1-5) |

| | | | |
|---|---|---|---|
| Sentence Arousal | 3.02 | 0.35 | 2.09-3.78 |
| Picture Arousal | 3.35 | 0.42 | 2.29-4 |
| Sentence Valence | 2.74 | 0.32 | 1.98-3.49 |
| Picture Valence | 2.32 | 0.34 | 1.67-3.05 |
| **Physiological Data** | | | |
| HRV (RMSSD; msec) | | | |
| Tonic HRV (n=34) | 36.73 | 28.72 | 6.17-153.46 |
| ER Phasic (n=34) | 0.8497 | 6.67 | -11.74 - 20.49 |

*Note:* STAI= State Trait Anxiety Inventory; PSS= Cohen's Perceived Stress Scale; DERS= Difficulties in Regulation Emotion Scale; ASI= Anxiety Sensitivity Index; ERQ= Emotion Regulation Questionnaire; FFMQ= Five Factor Mindfulness Questionnaire; PSWQ= The Penn State Worry Questionnaire; MAIA= Multidimensional Assessment of Interoceptive Awareness; HRV= heart rate variability; ER= emotion regulation.

Due to a computer program error during the ER task, 11 subjects were dropped from ER paradigm analyses. In addition, three subjects were identified as outliers on the tonic HRV variable and one subject was identified as an outlier on the phasic HRV variable and was removed. Therefore, a total sample size of 22 was available for the tonic HRV and ER analyses below. Outlier removal criteria for the current study included an initial screen of the data for any errors in data entry including missed values. Next, a thorough review of the transcription logs was conducted in order to identify whether there were any activities that occurred during the experiment that impacted the quality of the data. Relevant plots and graphs were then reviewed and extreme cases were identified. Specifically, extreme outliers on any measure relevant to the pertinent analysis (i.e., those identified at 3 x the inter-quartile range) were removed. Finally, variables of interest were standardized and cases that were greater or less than 2.5 were then examined to identify whether inclusion or exclusion of these extreme variables had a significant impact on the results. If there was a significant difference, the outlier was removed, and if there was no significant impact on the results, the variable remained in the data set given the small sample size in the current study.

## Hierarchical Regression Analyses

Correlation and hierarchical regression analyses were conducted to examine the relationship between HRV and ER in clinically anxious adults. A summary of correlations between relevant variables for the analyses below can be found in Table 2.

Table 2

*Correlation Summary*

| | Tonic HRV (RMSSD; msec) | ER Reactivity | Age | Gender | State Anxiety | Trait Anxiety | Arousal | Valence |
|---|---|---|---|---|---|---|---|---|
| Tonic HRV (RMSSD; msec) | | | | | | | | |
| ER Reactivity | .034 | | | | | | | |
| Age | -.273 | .198 | | | | | | |
| Gender | -.185 | .245 | .184 | | | | | |
| State Anxiety | -.320 | .041 | .201 | .009 | | | | |
| Trait Anxiety | -.281 | -.105 | -.006 | .146 | **.339**$^{*}$ | | | |
| Arousal | .097 | .053 | .017 | -.143 | .098 | .006 | | |
| Valence | -.044 | -.063 | .058 | .098 | .166 | -.241 | **-.681**$^{**}$ | |

*Note:* * $p$ <.05 ** $p$ < .01; HRV= heart rate variability; RMSSD= root mean square of successive differences; ER= emotion regulation

**Total ER success.** Firstly, collapsing across generation and ER strategy conditions, I examined whether tonic HRV predicted overall or 'total' perceived success on the ER task. Tonic HRV (*r* = .488, *p* = .011), and valence (*r* = .524, *p* = .006) were both positively and significantly correlated with perceived success on the ER task, and arousal was negatively and significantly associated with perceived ER success on the emotion task (*r* = - .514, *p* = .007). Tonic HRV was not significantly associated with state anxiety (*r* = -.123, *p* = .510) or trait anxiety (*r* = -.073, *p* = .698). The multiple regression model with all 6 predictors produced an $R^2$= .523, *F* (6, 15) = 2.739, *p* = .053. As can be seen in Table 3, tonic HRV had a significant positive regression weight, indicating that participants with higher tonic HRV perceived themselves at being better at regulating their emotions elicited by ER task, after controlling for the other variables in the model. Anxiety, age, gender, arousal and valence ratings did not significantly predict participants' perceived ER success. For this model, tonic HRV (*t* (15) = 2.325, *p* = .034, *d* = 1.2, *r* = .51) predicted overall perceived ER success on this computerized task over and beyond the other 6 predictors in the regression model.

Table 3

*Tonic HRV and Total Success (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Total ER Success (DV) | 3.39 | 0.57 | |
| Age | 37.64 | 16.20 | -.14 |
| Gender | | | .12 |
| Trait Anxiety | 93.36 | 8.64 | -.21 |
| Total Arousal | 6.34 | 0.65 | -.51** |
| Total Valence | 5.07 | 0.57 | .52** |
| Tonic HRV | 29.28 | 16.01 | .49* |

** p <.05 ** p < .01*

Hierarchical Regression Analysis: Tonic HRV and Total ER Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 4.244 | 3.48 | |
| Trait Anxiety | -0.007 | 0.015 | -0.106 |
| Age | -0.004 | 0.007 | -0.114 |
| Gender | 0.095 | 0.26 | 0.076 |
| Arousal | -0.261 | 0.247 | -0.296 |
| Valence | 0.293 | 0.299 | 0.289 |
| | | | |
| Step 2 | | | |
| Constant | 4.328 | 3.082 | |
| Trait Anxiety | -0.008 | 0.013 | -0.121 |
| Age | -0.001 | 0.007 | -0.016 |
| Gender | 0.184 | 0.233 | 0.146 |
| Arousal | -0.286 | 0.219 | -0.325 |
| Valence | 0.188 | 0.269 | 0.185 |
| **Tonic HRV** | **0.016** | **0.007** | **0.438*** |

*Note:* $R^2 = .351$ *for Step 1,* $\Delta R^2 = .172$ *for Step 2 (*$p < .05$*). ** $p < .05$

I also examined whether phasic HRV predicted overall perceived success on the ER task (see Table 4). Results showed that valence ($r = .53$, $p = .004$) and arousal ($r = -.52$, $p = .005$) were significantly associated with overall perceived success on the ER task. Phasic HRV was not significantly associated with state anxiety ($r = -.055$, $p = .769$) or trait anxiety ($r = -.140$, $p = .454$). The multiple regression model with all 6 predictors was non-significant and produced an $R^2 = .011$, $F$ (6, 16) = 1.965, $p = .131$. Further results showed that phasic HRV did not uniquely predict overall perceived ER success over and beyond the other variables in the model ($t$ (16) = .545, $p = .593$, $d = .27$, $r = .14$).

Table 4

*Phasic HRV and Total ER Success (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Total Success (DV) | 3.38 | 0.57 | |

| | | | |
|---|---|---|---|
| Age | 36.83 | 16.29 | -.11 |
| Gender | | | .13 |
| State Anxiety | 68.13 | 20.39 | -.23 |
| Arousal | 6.36 | 0.65 | -.52* |
| Valence | 5.05 | 0.56 | .53* |
| Phasic HRV | 0.51 | 6.04 | .02 |

** p < .01*

Hierarchical Regression: Phasic HRV and Total Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 2.402 | 2.593 | |
| State Anxiety | -0.008 | 0.006 | -0.299 |
| Age | 0 | 0.007 | 0.005 |
| Gender | 0.107 | 0.238 | 0.085 |
| Arousal | -0.149 | 0.234 | -0.17 |
| Valence | 0.464 | 0.271 | 0.459 |
| | | | |
| Step 2 | | | |
| Constant | 2.446 | 2.65 | |
| State Anxiety | -0.009 | 0.006 | -0.314 |
| Age | -0.001 | 0.008 | -0.022 |
| Gender | 0.051 | 0.263 | 0.04 |
| Arousal | -0.149 | 0.239 | -0.17 |
| Valence | 0.48 | 0.279 | 0.475 |
| **Phasic HRV** | **0.011** | **0.02** | **0.119** |

*Note:* $R^2 = .414$ *for Step 1,* $\Delta R^2 = .011$ *for Step 2.*

**Emotion generation.** Next, I examined the role of HRV in predicting perceived ER success in regulating negative emotion elicited from both the top-down (i.e., in response to negative sentences) and bottom-up (i.e., in response to aversive images).

***Sentence success.*** A hierarchical regression analysis was conducted in order to examine whether tonic HRV predicted perceived success on the sentence trials of the ER task collapsing across ER strategy conditions. Results indicated that tonic HRV was positively and significantly correlated with participants' perceived success on these trials (*r*

= .55, *p*= <. 01), suggesting that those with higher tonic HRV were better at regulating their emotions elicited by negative sentences in the ER task. Additionally, participants' arousal ratings were negatively and significantly correlated with sentence success (*r* = -.70, *p*= < .001), suggesting that greater arousal was associated with lower perceived success on these trials. The multiple regression model with all 6 predictors (i.e., age, gender, anxiety, arousal, valence and tonic HRV) produced an $R^2$ = .684, *F* (6, 15) = 5.405, *p* = .004. As can be seen in Table 5, tonic HRV had a significant positive regression weight, indicating that participants with higher tonic HRV perceived themselves at being better at regulating their emotions elicited by the negative sentences in the ER task, after controlling for the other variables in the model. Sentence arousal ratings had a significant negative weight indicating that after accounting for the other variables in the model, those participants who reported higher arousal perceived themselves to be worse at regulating their emotions elicited by the negative sentences. In summary, anxiety, age, gender, and valence ratings did not significantly predict participants' perceived success on the sentence trials of the ER task. For this model, tonic HRV (*t* (15) = 2.982, *p* = .009, *d* = 1.54, *r* = .61), and arousal (*t* (15) = -3.671, *p* = .002, *d* = -1.9, *r* = .69) predicted participants' overall perceived success on the sentence trials.

Table 5

*Tonic HRV and Sentence Success (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Sentence Success (DV) | 3.62 | 0.63 | |
| Age | 37.64 | 16.20 | -0.18 |
| Gender | | | 0.06 |
| Trait Anxiety | 93.36 | 8.64 | -0.20 |
| Sentence Arousal | 3.01 | 0.36 | -.68** |

| | | | |
|---|---|---|---|
| Sentence Valence | 2.74 | 0.33 | 0.30 |
| Tonic HRV | 29.28 | 16.01 | 0.55* |

** p < .01 ** p<.001*

Hierarchical Regression Analysis: Tonic HRV and Sentence Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 8.534 | 2.442 | |
| Trait Anxiety | -0.014 | 0.014 | -0.192 |
| Age | 0.002 | 0.007 | 0.038 |
| Gender | 0.026 | 0.261 | 0.018 |
| Sentence Arousal | -1.219 | 0.372 | -0.685* |
| Sentence Valence | -0.003 | 0.397 | -0.002 |
| | | | |
| Step 2 | | | |
| Constant | 7.636 | 2.021 | |
| Trait Anxiety | -0.013 | 0.011 | -0.181 |
| Age | 0.005 | 0.006 | 0.118 |
| Gender | 0.11 | 0.215 | 0.079 |
| Sentence Arousal | -1.125 | 0.306 | -0.632* |
| Sentence Valence | -0.083 | 0.326 | -0.043 |
| **Tonic HRV** | **0.18** | **0.006** | **0.456*** |

*Note:* $R^2 = .496$ *for Step 1,* $\Delta R^2 = .187$ *for Step 2 (p < .01). * p < .01.*

A hierarchical regression analysis was also conducted in order to examine whether phasic HRV predicted perceived success on the sentence trials of the ER task (see Table 6). Results indicated that the multiple regression model with all 6 predictors (i.e., age, gender, anxiety, arousal, valence and phasic HRV) produced an $R^2 = .466$, $F(6, 16) = 2.327$, $p = .083$. Anxiety, age, gender, valence, and phasic HRV did not significantly or uniquely predict participants' perceived success on the sentence trials of the ER task. For this model arousal ($t(16) = -2.776$, $p = .013$, $d = -1.39$, $r = .57$) predicted participants' overall perceived success on the sentence trials. The unique contribution of phasic HRV to perceived sentence success was non-significant ($t(16) = .180$, $p = .859$, $d = .09$, $r = .04$).

Table 6

*Phasic HRV and Sentence Success (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Sentence Success (DV) | 3.61 | 0.62 | |
| Age | 36.83 | 16.29 | -.15 |
| Gender | | | 0.07 |
| State Anxiety | 68.13 | 20.39 | -0.20 |
| Sentence Arousal | 3.02 | 0.35 | -.68* |
| Sentence Valence | 2.74 | 0.32 | 0.31 |
| Phasic HRV | 0.51 | 6.04 | 0.03 |

** $p <.001$*

Hierarchical Regression: Phasic HRV and Sentence Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 6.752 | 2.028** | |
| State Anxiety | -0.002 | 0.007 | -0.057 |
| Age | 0.002 | 0.008 | 0.045 |
| Gender | 0.024 | 0.265 | 0.018 |
| Sentence Arousal | -1.154 | 0.399 | -0.646* |
| Sentence Valence | 0.133 | 0.427 | 0.07 |
| | | | |
| Step 2 | | | |
| Constant | 6.76 | 2.09** | |
| State Anxiety | -0.002 | 0.007 | -0.063 |
| Age | 0.001 | 0.008 | 0.036 |
| Gender | 0.007 | 0.288 | 0.005 |
| Sentence Arousal | -1.146 | 0.413 | -0.642* |
| Sentence Valence | 0.141 | 0.441 | 0.073 |
| **Phasic HRV** | **0.004** | **0.021** | **0.038** |

*Note: $R^2 = .465$ for Step 1, $\Delta R^2 = .001$ for Step 2. *$p < .05$, **$p <.01$.*

***Picture success.*** Next, a hierarchical regression analysis was used to examine perceived success on the picture trials of the ER task. Valence ($r = .680$, $p = < .001$) and tonic HRV ($r = .388$, $p = .04$) were positively and significantly related to picture success. The multiple regression model with all 6 predictors (same as above) produced an $R^2$ =

.565, *F* (6, 15) = 3.242, *p* = .03. For this model, valence was a significant predictor of perceived success on the picture trials (*t* (15) = 2.788, *p* = .014, *d* = 1.44, *r* = .58) over and above the other 6 variables (see Table 7). Tonic HRV did not uniquely predict perceived ER success on the picture trials (*t* (15) = 1.745, *p* = .101, *d* = .90, *r* = .90).

Table 7

*Tonic HRV and Picture Success (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Picture Success (DV) | 3.16 | .55 | |
| Age | 37.64 | 16.20 | -.07 |
| Gender | | | 0.18 |
| Trait Anxiety | 93.36 | 8.64 | -0.22 |
| Picture Arousal | 3.33 | 0.42 | -0.32 |
| Picture Valence | 2.33 | 0.35 | 0.68** |
| Tonic HRV | 29.28 | 16.01 | 0.39* |

**p <.05 ** p<.001*

Hierarchical Regression Analysis: Tonic HRV and Picture Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 0.561 | 2.138 | |
| Trait Anxiety | 0.002 | 0.013 | 0.026 |
| Age | -0.003 | 0.006 | -0.099 |
| Gender | -0.084 | 0.246 | -0.07 |
| Picture Arousal | 0.004 | 0.279 | 0.003 |
| Picture Valence | 1.143 | 0.381 | 0.717** |
| | | | |
| Step 2 | | | |
| Constant | 0.543 | 2.013 | |
| Trait Anxiety | 0.001 | 0.012 | 0.013 |
| Age | -0.001 | 0.006 | -0.033 |
| Gender | 0.002 | 0.237 | 0.002 |
| Picture Arousal | -0.033 | 0.263 | -0.025 |
| Picture Valence | 1.019 | 0.366 | 0.639* |
| **Tonic HRV** | **0.011** | **0.006** | **0.314** |

*Note:* $R^2 = .476$ *for Step 1,* $\Delta R^2 = .088$ *for Step 2.* *$p < .05$, **$p < .01$.

Next, a hierarchical regression analysis was used to examine whether phasic HRV uniquely predicted participants' perceived ER success on the picture trials of the computerized ER task. As can be seen in Table 8, valence ($r = .69$, $p = <. 001$) was positively and significantly related to ER success on the picture trials. The multiple regression model with all 6 predictors produced an $R^2 = .572$, $F (6, 16) = 3.563$, $p = .02$. Results also indicated that valence significantly and uniquely predicted ER success on the picture trials over and above the other variables in the model ($t (16) = 3.591$, $p = .002$, $d = 1.80$, $r = .67$), whereas phasic HRV did not significantly or uniquely predict perceived ER success on the picture trials ($t (16) = .662$, $p = .518$, $d = .33$, $r = .16$).

Table 8

*Phasic HRV and Picture Success (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Picture Success (DV) | 3.14 | 0.55 | |
| Age | 36.83 | 16.29 | -.03 |
| Gender | | | .19 |
| State Anxiety | 68.13 | 20.39 | -.25 |
| Picture Arousal | 3.35 | 0.42 | -.34 |
| Picture Valence | 2.32 | 0.34 | .69* |
| Phasic HRV | 0.51 | 6.04 | .004 |

* *p<.001*

Hierarchical Regression: Phasic HRV and Picture Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 1.09 | 1.374 | |
| State Anxiety | -0.008 | 0.005 | -0.31 |
| Age | 0.002 | 0.006 | 0.057 |
| Gender | -0.045 | 0.21 | -0.037 |
| Picture Arousal | -0.007 | 0.248 | -0.005 |
| Picture Valence | 1.133 | 0.315 | 0.71* |

Step 2

| | | | |
|---|---|---|---|
| Constant | 1.237 | 1.415 | |
| State Anxiety | -0.009 | 0.005 | -0.322 |
| Age | 0.001 | 0.006 | 0.024 |
| Gender | -0.111 | 0.236 | -0.091 |
| Picture Arousal | -0.028 | 0.254 | -0.021 |
| Picture Valence | 1.16 | 0.323 | 0.727* |
| **Phasic HRV** | **0.011** | **0.017** | **0.127** |

*Note:* $R^2 = .560$ *for Step 1,* $\Delta R^2 = .012$ *for Step 2.* $^*p < .01$.

Given the results discussed above, which identified a central role of arousal and valence in explaining the relationship between HRV and ER, a post hoc analysis was run to examine whether the range of valence differed for sentences compared to pictures. Results indicated a significant difference in arousal between sentence and picture trials: $F$ (1, 43) = 7.17, $p$ = .01, $d$ = .8. Examining the means and standard deviations, I found that overall pictures (M= 3.33; SD= .42; range 2.29-4) evoked greater arousal compared to the sentence trials (M= 3.01; SD= .36; range: 2.09-3.78). Next I examined whether there was a difference between valence on the picture vs. sentence trials, and again found a significant difference: $F$ (1, 43) = 16.42, $p$ = < .001, $d$ = 1.21 such that pictures (M= 2.33, SD= .35; Range: 1.67 – 3.05) were rated as being more negative than the picture trials (M= 2.74; SD= .33; Range: 1.98-3.49).

**Specific ER strategies.** The following analyses pertain to the role of tonic and phasic HRV in predicting perceived ER success when utilizing specific ER strategies including cognitive reappraisal, expressive suppression, and appraisal were also examined (see Appendix D for details of these results). For tonic HRV, the multiple regression model with all 6 predictors (same as analyses described above) was significant for expressive suppression ($R^2$ = .541, $F$ (6, 15) = 2.950, $p$ = .042) and appraisal ($R^2$ = .574, $F$ (6, 15) =

3.363, *p* = .026) conditions. Interestingly, tonic HRV significantly and uniquely predicted perceived success over and beyond the other predictor variables only for the appraisal condition (*t* (15) = 3.226, *p* = .006, *d* = 1.67, *r* = .64). On the other hand, for phasic HRV all models were non-significant. Of note however, the multiple regression model with the same 6 predictors as above was trending toward significance for expressive suppression ($R^2$ = .494, *F* (6, 16) = 2.599, *p* = .059).

**Interaction between emotion generation and regulation.** The following analyses are focused on examining the match between emotion generation (i.e., bottom-up vs. top-down) and regulation strategies (cognitive reappraisal, expressive suppression, appraisal). For a detailed explanation of these results see supplementary materials included in Appendix D. Overall, for tonic HRV the multiple regression model with all 6 predictors (same as analyses described above) was significant for suppression of sentences ($R^2$ = .775, *F* (6, 15) = 8.606, *p* = <. 001), suppression of pictures ($R^2$ = .619, *F* (6, 15) = 4.061, *p* = .013), appraisal of sentences ($R^2$ = .705, *F* (6, 15) = 5.985, *p* = .002), and appraisal of pictures ($R^2$ = .524, *F* (6, 15) = 2.753, *p* = .052). Tonic HRV uniquely and significantly predicted perceived success on the suppression of sentences trials (*t* (15) = 2.297, *p* = .036, *d* = 1.19, *r* = .51), and for both appraisal of pictures (*t* (15) = 2.6, *p* = .02, *d* = 1.34, *r* = .56) and appraisal of sentences (*t* (15) = 3.84, *p* = .002, *d* = 2.0, *r* = .70). For phasic HRV, the multiple regression model was significant for reappraisal of pictures ($R^2$= .563, *F* (6, 16) = 3.442, *p* = .022), suppression of sentences ($R^2$ = .703, *F* (6, 16) = 6.298, *p* =. 001), suppression of pictures ($R^2$ = .604, *F* (6, 16) = 4.06, *p* = .012.), and appraisal of pictures

($R^2$ = .529, *F* (6, 16) = 2.99, *p* = .037). Phasic HRV uniquely and significantly predicted perceived ER success for only the appraisal of pictures condition (*t* (16) = 2.234, *p* = .04, *d* = 1.12, *r* = .49).

## Discussion

The purpose of the present study was to examine whether the neurovisceral integration model applied to a population of adults with clinically elevated levels of anxiety by examining the effects of HRV on ER.  This study examined both tonic/trait and phasic/state HRV in a clinically anxious sample. It was hypothesized that HRV would be positively associated with ER ability as measured by perceived success on an ER task, and negatively associated with self-reported anxiety symptoms. It was also predicted that greater phasic HRV would be associated with better task-based ER. Overall, the present study found partial support for the neurovisceral integration model. Specifically, variability emerged in the findings depending on how the participants' emotion was generated, the regulation strategy that was used, and the interaction between these variables. First, the results pertaining to the omnibus effect of HRV on ER, collapsing across both generation and regulation conditions will be considered. Then findings pertaining to the role of HRV in ER when method of emotion generation is considered (i.e., the main effect of emotion generation: top-down vs. bottom-up) will be discussed, and then the role of HRV in the use of specific ER strategies (i.e., the main effect of strategy: cognitive reappraisal, expressive suppression, and appraisal) will be examined. Lastly, the role of HRV in the interaction between method of emotion generation and regulation will be discussed.

Recall that the sample in the current study exhibited mild to severe levels of anxiety, a high level of emotion regulation difficulty, with the greatest area of concern being a limited access to emotion regulation strategies. Participants perceived their overall emotion regulation ability to be on average adequate, with their preferred strategy being cognitive reappraisal. Participants in the present study also exhibited high levels of worry, and below average body awareness, with lowest scores on body listening scales, indicating difficulty actively listening or being aware of what is going on in their body.

**HRV and emotion regulation.** Firstly, findings of the current study revealed that collapsing across methods of generation and regulation, the overall omnibus effect of HRV on ER was significant (see Table 9). Specifically, results demonstrated that tonic HRV significantly predicted participants' overall perceived ER success. The present study found that tonic HRV was reduced in individuals' with clinically elevated levels of anxiety, and lower tonic HRV was likewise associated with poorer perceived ER ability. A wealth of research demonstrates that difficulties in ER are a central element underlying anxiety disorders (Aldao & Mennin, 2012). In the current study, this was observed at both a physiological level (i.e., lower tonic HRV) and a behavioral level (i.e., lower perceived ER success on a behavioural task of ER). Overall, findings of the present study are in line with the neurovisceral integration model which proposes that tonic HRV is an important index of ER, such that higher tonic HRV is associated with adaptive and more successful ER, and negatively associated with anxiety (Thayer et al, 2009; Thayer & Lane, 2000). Results of the current study show that anxiety symptoms and HRV are not redundant, but rather, HRV appears to contribute unique variance to ER success, which underscores the importance of using HRV as an index of one's ER abilities. Further, this viewpoint also highlights that HRV is not necessarily a 1:1 marker of anxiety (i.e., 'low HRV' does not necessarily equal an anxiety disorder), but rather, represents one component or one *index*, of ER ability. Overall these findings are consistent with current literature that suggests tonic HRV is important in facilitating the flexible modulation of emotional responses (Cui et al., 2015; Thayer et al., 2012; Thayer & Lane, 2000) that is critical for successful regulation of emotion. In contrast, low tonic HRV is associated with poor ER (Williams et al., 2015). In the context of anxiety disorders this can often include rigid and hypervigilant responses (Chalmers et al., 2014; Friedman, 2007).

Table 9

*Predictors of Overall ER*

| | | |
|---|---|---|
| **Tonic HRV** | Model | ✓ ($R^2$= .523) |
| | Tonic HRV | ✓ (*d* = 1.2) |
| | | |
| **Phasic HRV** | Model | × ($R^2$= .424) |
| | Phasic HRV | × (*d* = .27) |

*Note:* Model= all 6 predictor variables; ✓ = significant; ER= emotion regulation

On the other hand, there was a non-significant relationship between phasic HRV and individuals' overall perceived ER ability. This finding may not be surprising, however, given the fact that phasic HRV is thought to be an index of 'state-like' self-regulatory ability, whereas the index of total ER described above represents a global index of one's overall ER capacity (i.e., collapsed across generation and strategy type), much like tonic HRV is considered a trait-like marker of self-regulation. Thus, the non-significant association between phasic HRV and individuals' overall perceived ER ability makes conceptual sense based on current research and what is known to date about phasic HRV. Accordingly, results of the current study demonstrate that HRV is a promising psychophysiological indicator that can assist in gaining a deeper understanding of ER capacity, especially in adults with clinically elevated levels of anxiety. Tonic HRV appears to play an important role in supporting adaptive ER, which is strongly supported within the literature (Beauchaine, Gatzke-Kopp, & Mead, 2007; Thayer et al., 2012); whereas the search continues for better understanding the role of phasic HRV in ER, as much less research has been done in this area.

There has been much debate in the literature regarding the role of HRV in various forms of psychopathology. Several proponents argue that HRV is a specific biomarker of the anxiety and related disorders (e.g., Goncalves et al., 2015; Walker et al., 2017), whereas others discuss the role of HRV not as a specific biomarker of anxiety disorders per se, but rather a transdiagnostic biomarker of psychopathology at a broader level (e.g., Beauchaine & Thayer, 2015). The findings of the current study in combination with the current state of the literature support the idea that HRV can be understood as a general diathesis, upon which environmental stressors may/may not act, and consequently may/may not precipitate an anxiety disorder. However, as mentioned above, it does not suggest a clear 1:1 ratio, such that low HRV in and of itself confirms a clinical diagnosis of an anxiety disorder. In fact, activity in the ANS is dynamic and complex. Not only does the ANS impact cardiac functioning but also organ and tissue regulation (Janig & Habler, 2000). Given that RMSSD is an index of cardiac vagal control specifically, future research should examine additional parameters that could help to understand vagal/parasympathetic influences on other organs. This would help to better understand this complex dynamical system between the body and mind within the context of anxiety disorders. There has been some research that suggests there may be several modifiers of the magnitude of relative risk of developing anxiety disorders, including neurophysiological indicators such as HRV (Maier, 2003). Within this line of research, it is generally thought that sustained autonomic imbalance in response to stress may increase susceptibility of developing subsequent psychopathology such as an anxiety disorder (Wulsin, Herman, & Thayer, 2018). For instance, prolonged autonomic imbalance may include a pattern of sustained sympathetic overactivity or parasympathetic underactivity (or both), which can be measured via HRV, but also imbalance existing in other organ systems. It is thought that this imbalance initially develops in childhood or early adulthood primarily as a result of both a genetic vulnerability to sympathetic overactivity and/or parasympathetic underactivity (Gehi et al., 2009; Singh et al., 1999; Lemche et al., 2016) and persistent exposure to chronic or episodic stress (e.g., early trauma, mental illness). For instance, early attachment problems have been thought to have a prominent role in setting up this lowered HRV as a risk for later psychopathology. This is supported by research that has linked negative developmental events such as early trauma with adult anxiety (Schimmenti & Bifulco, 2015). This research argues that many of the adulthood anxiety disorders as well as other psychological syndromes can be traced back to this early autonomic susceptibility (e.g. developmental trauma, deficient early attachment) with an associated failure to develop self-regulation. Thus, it is likely that HRV represents a generic diathesis or risk factor, in combination with several of these other factors including biological/genetic predisposition and environmental/social stressors for anxiety disorders. Future research should examine potential resiliency or protective factors that may serve to prevent or reduce the likelihood of progression from anxiety symptoms to clinical diagnosis through interventions that directly target autonomic imbalance (e.g., Walker et al., 2017). Of course resiliency is multifactorial and can be organized in different levels including psychological, behavioral, neuroendocrine, and brain circuitry phenotypes (Horn, Charney, & Feder, 2016). HRV, however, continues to be under-explored when compared to other psychological, behavioral, and biomarkers. Given that the autonomic nervous system is associated with resiliency and susceptibility, future research can continue to measure or explore these parameters by continuing to measure HRV, at both tonic and phasic levels. This also opens a new pathway for therapeutic intervention to focus on modulating the action and function of the autonomic nervous system. As such, interventions that target HRV may prove to be useful in supporting and treating individuals with pathological anxiety. In Study 2, two specific types of interventions and their impact on HRV are examined and discussed.

***Emotion generation.*** The current study examined the main effect of emotion generation, including bottom-up generated emotions (i.e., emotions elicited in response to negative images) and top-down generated emotions (i.e., emotions elicited in response to aversive sentences). Exploring the association between HRV and specific forms of emotion generation is critical in order to contribute to current research and further elucidate current understandings of HRV and ER. The current study found that tonic HRV played an important role in perceived ER success for both top-down (i.e., emotions elicited by negative sentences) and bottom-up generated emotions (i.e., emotions elicited by negative pictures); however, unique contributions were found within each generation modality (see Table 10 for a summary of these findings). For top-down generated emotions, tonic HRV was significantly and positively associated with perceived ER success over and beyond the other variables in the model, such that higher tonic HRV was associated with greater perceived ER ability, whereas lower tonic HRV was associated with poorer perceived ER ability. Arousal also played a unique role in this relationship such that greater arousal was associated with poorer perceived ER success. Top-down generated emotions are those elicited largely by cognitions, specifically, an individual's appraisal of a stimulus which is thought to utilize various cognitive abilities including executive control. Greater vagal function (i.e., greater tonic HRV) has been linked with a variety of psychological and behavioral variables including greater capacity for ER (e.g., Lane, 2008; Melzig et al., 2009; Thayer & Brosschot, 2005) and greater performance on cognitive tasks (e.g., Hansen et al., 2009; Thayer et al., 2005) whereas, greater emotional arousal has been linked with reductions in HRV (Thayer & Lane, 2009). Findings of the current study are in line with this research. For individuals with pathological anxiety it is often the case that these individuals typically have an attentional bias towards real or perceived threat. As a result these individuals are often functioning in a high arousal or hypervigilant state the majority of the time, which is typically associated with a less efficient use of cognitive resources (Cisler & Koster, 2010). Within current research higher arousal and lower tonic HRV is indicative of poorer vagal function and inflexibility (Thayer & Friedman, 2002; Thayer & Lane, 2000). Findings of this study are in line with these ideas.

Table 10

*Main Effect of Emotion Generation*

| **Tonic HRV** | | |
|---|---|---|
| Top- Down (Sentences) | Model | ✓ $R^2 = .684$ |
| | Tonic HRV | ✓ $d = 1.54$ |
| | Arousal | ✓ $d = -1.9$ |
| Bottom- Up (Pictures) | Model | ✓ $R^2 = .565$ |
| | Valence | ✓ $d = 1.44$ |
| | Tonic | × $d = .90$ |
| **Phasic HRV** | | |
| Top- Down (Sentences) | | |
| | Model | × $R^2 = .466$ |
| | Phasic HRV | × $d = .09$ |
| | Arousal | ✓ $d = -1.39$ |
| Bottom- Up (Pictures) | Model | ✓ $R^2 = .572$ |
| | Valence | ✓ $d = 1.80$ |

*Note:* Model= all 6 predictor variables; ✓ = significant; × = non-significant

For bottom-up generated emotions, findings of this study showed that together, gender, age, trait anxiety, arousal, valence and tonic HRV were significantly associated with perceived ER success for bottom-up generated emotions. In this case, however, valence was the only *unique* predictor of perceived ER success over and beyond the other predictor variables in the model. Specifically, valence was positively and significantly associated with perceived ER success demonstrating that those participants who felt less negative when viewing the stimuli perceived themselves to be better at regulating their negative emotions. In this case, tonic HRV did not account for a significant amount of unique variance in perceived ER success for bottom-up generated emotions. Interestingly, post-hoc analyses demonstrated differences in arousal and valence between the different methods of emotion generation (i.e., the picture stimuli vs. the sentence stimuli). These findings are important to consider in understanding the results of the current study. Given that emotions are characterized by valence (i.e., the pleasantness of an emotion) and arousal (the intensity of an emotion; Bradley & Lang, 1994; Russell, 2003), this was an important additional analysis to run in order to further account for the findings and understand why tonic HRV and arousal played a unique role in top-down generated emotions, whereas valence made the unique contribution to perceived ER success in the case of bottom-up generated emotions. Overall, the present study found significant differences in valence and arousal ratings between the two methods of emotion generation (i.e., top-down vs. bottom-up stimuli). Specifically, in this study, participants found the bottom-up stimuli to evoke greater arousal and greater negative emotion compared to the top-down stimuli. This significant difference between methods of generation may in part account for this finding that tonic HRV uniquely predicted perceived ER success in one context (i.e., top-down generated emotion) but not the other (bottom-up generated emotion). This finding has several important clinical implications. Tonic HRV findings also shed light on the importance of appreciating individual differences in valence and arousal associated with emotional experiences triggered in situations where emotions are generated from the top-down and bottom-up. This can be further illuminated if specific anxiety disorders are considered. For example, an individual with a specific phobia of snakes will generally be more triggered in situations that include snakes or stimuli associated with snakes (e.g., images of snakes or snakelike phenomena). By contrast, an individual with generalized anxiety disorder typically experiences high degrees of worry (i.e., maladaptive cognitions) and may be more likely to experience greater arousal and negative emotions in a variety of situations or contexts that may trigger his/her anxious rumination. Thus, individuals differ in the extent to which they experience and express their emotions, even within the broad class of anxiety disorders. This includes the ways in which individuals appraise their emotions and deem them aversive, and this appraisal of emotion subsequently impacts the way in which their emotions are regulated. For example, if an emotion is considered to be aversive or undesirable (e.g., a snake) it is more likely to be the target of regulation than an emotion that is deemed positive or nonaversive (e.g., a puppy). The sample in the present study was limited in size, and included a mixed group of anxiety disorders which limited the power and ability to examine these relationships within specific diagnostic categories. As such, future studies should replicate these analyses for separate disorders individually as results may vary.

Aside from potential differences and/or range restrictions in valence and arousal, another explanation for the inability to show that tonic HRV *uniquely* predicted perceived success on bottom-up trials over and beyond the other predictor variables in the model in the present study might be related to the fact that tonic HRV may not be the most appropriate index of autonomic functioning in this circumstance. For instance, in the case of bottom-up generated emotion, tonic HRV may not be the optimal gauge of autonomic functioning. In contrast, phasic HRV although still not well understood in current research, is thought to be a better index of more automatic, ‘online’ or real-time autonomic responses/reactions to stressors in the environment and perhaps could have better accounted for perceived success on the bottom-up trials. This finding is important as it demonstrates that Thayer and Lane’s neurovisceral integration model may be applied differently depending on the underlying generated emotion. The current study also brings a multi-dimensional approach to measuring HRV, as both tonic and phasic metrics were utilized. This is important for future research to better ascertain the similarities and/or differences between these metrics because they may shed light on current understandings of the role of HRV in the neurovisceral integration model. This finding also establishes the importance of individual differences in understanding the utility of HRV, including both tonic and phasic indices, as an indicator of self-regulation and the need to better understand phasic HRV as currently very little is known. Interestingly, in a recent study by Park and Thayer (2014), tonic HRV was found to be positively associated with both top-down and bottom-up processing including the ability to visually discriminate emotion in fearful faces. Of note, this study utilized stimuli with different spatial frequency ranges, which were designed to tap into either top-down or bottom-up neural mechanisms of emotional processing. Stimuli with high spatial frequencies were regarded as relating to bottom-up processing of emotion, and were associated with greater activity in cortical structures including the anterior cingulate, motor cortex, medial prefrontal cortex, and the lateral orbitofrontal cortex (Park & Thayer, 2014). This study, although one of the few that provides some initial evidence for the role of tonic HRV in bottom-up processing, appears to be modulated or confounded by top-down processing (i.e., having the explicit goal to discriminate between fearful faces which would likely involve some higher order cognition). This highlights an important issue in the field related to determining what is considered as 'bottom-up' vs. 'top-down' processing. At the present time there does not seem to be a widely accepted viewpoint or general consensus on defining these constructs. This makes it particularly difficult to understand why tonic HRV in the present study was not uniquely related to bottom-up generated emotions. In contrast to Park and Thayer's (2014) study, participants in the present study were only regulating their elicited emotion, they were not tasked with any sort of cognitive or discrimination task, and thus, may be more representative of 'true' bottom-up generated emotion (e.g., more automatic less cognitively demanding processing). Another possible explanation for the inability to show that tonic HRV *uniquely* predicted perceived success on bottom-up trials in the current study might be due to the limited power in the current study. This likely impacted the lack of effects and magnitude of effects found in the current study, and therefore future work should examine these associations in a larger sample. In addition, in order to better understand the underlying mechanisms of emotion generation, future studies should directly compare and examine the interactions between HRV and methods of emotion generation (i.e., top-down and bottom-up), as it seems that the neurovisceral integration model may not be ubiquitous to all emotions.

With regards to phasic HRV, the current study showed that the overall model including gender, arousal, valence, state anxiety and phasic HRV significantly predicted perceived ER success for bottom-up generated emotions but not for top-down generated emotions. On bottom-up trials, greater phasic HRV was positively associated with greater perceived ER success. However, further examination of the results showed that phasic HRV did not uniquely predict perceived success on bottom-up trials, but instead valence was the unique contributor to this relationship. Specifically, it was found that the more negative emotion participants felt while viewing the stimuli, the worse they perceived themselves to be at regulating their undesirable emotions. In addition, there was a positive association between valence and phasic HRV, such that those participants who felt more negative emotion while viewing the aversive stimuli also showed greater phasic HRV. Recall that phasic HRV represents a change in one's HRV between one's baseline or 'resting state' to when there is an introduction of a stressor in one's environment. As such, greater phasic HRV is thought to represent a greater vagal withdrawal to stress (i.e., greater emotional reactivity). These results are consistent with the neurovisceral integration model, which argues that it is adaptive to show a greater vagal withdrawal in the face of a real stressor or threat (Thayer & Lane, 2000). This is thought to allow for more of the biologically prepared, automatic response to occur and is adaptive in supporting survival, promoting safety, and generating quick responses when it is appropriate to do so (e.g., fight or flight response) (Schwerdtfeger & Derakshan, 2010; Thayer, Friedman, & Borkovec, 1996). A greater magnitude of change from rest to task is a good index of cardiac vagal control, and this is thought to underlie the ability to regulate emotions and respond appropriately (Beauchaine, 2001; Butler, Wilhelm, & Gross, 2006). Thus, the current study shows support for understanding phasic HRV as a ‘state-like’ index of self-regulation. This is consistent with Thayer and Lane’s (2000; 2009) neurovisceral model suggesting that phasic HRV is important for ‘in the moment’, online, self-regulation, where greater vagal withdrawal in the face of a stressor is seen as adaptive. Phasic HRV has been shown to be associated with brain regions such as the amygdala that are important for the automatic processing of emotional or salient information, and less involved with higher order brain regions including the prefrontal cortex. It is likely that in the current study, on trials where emotions were generated in a bottom-up or more automatic way, greater phasic HRV supported participants’ in the moment responding and regulation of their negative emotion.

***Specific ER strategies.*** The current study also examined the main effect of HRV on specific ER strategies including both antecedent and response-focused strategies (i.e., cognitive reappraisal, expressive suppression, and appraisal). The results of the present study showed that tonic HRV was significantly associated with perceived ER success when utilizing expressive suppression and appraisal, but not cognitive reappraisal, whereas phasic HRV was not significantly associated with any of the ER strategies (see Table 11 for summary of results). Interestingly, tonic HRV only had a *unique* contribution over and beyond the other predictor variables in the model for the utilization of appraisal as an ER strategy.

Table 11

*Main Effect of Emotion Regulation Strategies*

| **Tonic HRV** |
|---|

| | | |
|---|---|---|
| Reappraisal | Model<br>Tonic HRV | × $R^2 = .30$,<br>× $d = .60$ |
| Suppression | Model<br>Tonic HRV | ✓ $R^2 = .54$<br>× $d = .82$ |
| Appraisal | Model<br>Tonic HRV | ✓ $R^2 = .57$<br>✓ $d = 1.67$ |
| **Phasic HRV** | | |
| Reappraisal | Model<br>Phasic HRV | × $R^2 = .37$<br>× $d = -0.37$ |
| Suppression | Model<br>Phasic HRV | × $R^2 = .49$<br>× $d = .21$ |
| Appraisal | Model<br>Phasic HRV | × $R^2 = .43$<br>× $d = .82$ |

*Note:* Model= all 6 predictor variables; ✓ = significant; × = non-significant; all other effects presented in the table represent unique contributions over and beyond other predictor variables in the model

These findings are important for several reasons. Firstly, the finding that tonic HRV was associated with perceived ER success when using expressive suppression and appraisal to regulate negative emotion and not for cognitive reappraisal is not necessarily consistent with what was expected based on the Thayer and Lane's neurovisceral integration model. The neurovisceral integration model relates executive control to ER and HRV, yet in the present study, the association between HRV and cognitive reappraisal was not significant. It is surprising that tonic HRV was significant for all ER strategies except for cognitive reappraisal, which, presumably of the three ER strategies used in the study, likely required the greatest amount of executive control. This is clinically relevant given that one of the current frontline evidence-based treatments for anxiety disorders is cognitive behavioral therapy (CBT), which centers on cognitive reappraisal as being the active ingredient to this treatment approach, yet as an ER strategy it does not appear to be associated with resting autonomic functioning in individuals' with clinical anxiety in the present study. However, it is important to acknowledge that at baseline, participants in the current study perceived themselves to be most successful at using cognitive reappraisal to regulate their negative emotion. Thus, it is possible that a large proportion of individuals in the current study may have had greater prior experience with this ER strategy and as a result may not have required as much executive control. Another possible explanation comes from research that has shown that many individuals with anxiety disorders have difficulty using cognitive reappraisal. Research from a recent meta-analysis by Picó-Pérez and colleagues (2017) showed that compared to healthy controls, individuals with pathological anxiety are often not able to recruit some of the cognitive control processes necessary to support them in their utilization of cognitive reappraisal which may in part help to explain why the present study did not find a significant association in this clinical sample. For instance, they often fail to recruit some of the fronto-parietal regions implicated in the top-down regulation of negative emotions. Instead in anxiety disorders, increases in activation in regions involved in emotional experience are often found. Thus, these studies suggest that many individuals with anxiety disorders tend to have trouble using cognitive reappraisal. This is supported by neuroimaging studies that show structural and functional abnormalities in the prefrontal cortex circuits related with top-down inhibitory control, which is not only necessary to deploy cognitive reappraisal strategies, but also important for vagally mediated HRV. Instead, what is typically found in anxiety disorders is hyperreactivity in limbic structures implicated in emotion generation (Etkin & Wager, 2007). These are important considerations that should be kept in mind when understanding the role of specific ER strategies within the context of anxiety and in terms of interventions that should be considered when treating these disorders. However, it is also important to consider other potential factors that may have contributed to this surprising finding (or lack thereof) in the current study. For example, this finding may be unique to this population (i.e., adults with clinically elevated levels of anxiety as opposed to healthy adults), may be impacted by the fact that the current study examined clinically elevated levels of anxiety as a whole instead of separating out specific anxiety disorder diagnoses, and/or may have been impacted by the nature of the stimuli (perhaps cognitive reappraisal ability was attenuated by the range restrictions on arousal/valence in the stimuli used in the ER paradigm). Nonetheless these findings hold important clinical implications. For instance, these findings suggest that teaching cognitive reappraisal might help some individuals with anxiety disorders, however, it may not fundamentally alter their autonomic nervous system flexibility. This is an important finding and shows a potential limitation of treatments such as CBT. This is especially significant given that cognitive reappraisal has traditionally been viewed as the more adaptive strategy, yet findings of the present study show in this sample, it does not relate to baseline autonomic flexibly in adults with pathological anxiety. Thus, findings of the present study highlight the fact that the success of cognitive reappraisal, an active ingredient of CBT, *alone*, is not related to resting HRV, that is, one’s baseline self-regulatory ability.

Given that the present study examined anxiety disorders as a whole, it will be important for future work to examine the relationship between tonic HRV and cognitive reappraisal within specific anxiety disorders. For instance, anxiety disorders with more cognitive symptoms (e.g., worry) may benefit more from cognitive reappraisal, but not those who have more bottom-up emotions, who may benefit more from exposure-based treatments. Therefore, the results of the present study suggest that CBT may still be effective for a large proportion of individuals with anxiety; however, tonic HRV may not *uniquely* predict who will respond to this modality of treatment however. Interestingly however, recent research has identified a promising avenue for the utility of physiological markers including HRV in predicting treatment response in anxiety disorders. A recent systematic review by Lueken and colleagues (2016) examined the current state of the evidence on the predictive value of biomarkers for treatment response in anxiety disorders. Of particular interest for the current study were eight studies identified in the review that examined physiological biomarkers. Although limitations regarding heterogeneity across these studies were noted, results demonstrated an association between HRV and treatment outcome. The direction of the effect was observed to differ depending on the treatment type and parameter used, however, overall results indicated that low HRV predicted better outcome in the psychotherapy studies (Leuken et al. 2016). Compared to other biomarkers that are more commonly studied (e.g., genetic markers) there is far less research available for HRV. At present there does seem to be a value of using HRV to predict treatment response in individuals with anxiety disorders. This may be a preferable method given that HRV is non-invasive and relatively simple to acquire. Future research in this area is warranted in order to better understand the utility of HRV as a biomarker in identifying patients that may respond more or less favorably to specific therapeutic approaches. In doing so, this may offer better outcomes for otherwise nonresponsive patients.

Secondly, findings of the main effect of HRV on ER strategies showed that greater tonic HRV was associated with perceived ER success through the use of expressive suppression and appraisal. However, tonic HRV only had a *unique* role over and beyond the other variables for perceived ER success when using appraisal to regulate their emotions. This is important given that appraisal has often been viewed as a control condition in empirical studies on emotion, and yet in the current study, it was the only ER strategy to be significantly and uniquely associated with tonic HRV. ‘Appraisal’ is conceptualized as doing nothing, or in other words, the acceptance and allowance of one’s emotion to run its unaltered course, and is in fact a key component of effective ER. For instance, the acceptance and allowance of one’s natural emotional response is an active component of various third-wave evidence-based psychotherapy treatments including Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1990), Mindfulness Based Cognitive Therapy (MBCT) and Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999a). Findings of the current study have important clinical implications for treating anxiety disorders. For instance, given that tonic HRV has a critical role over and beyond the other variables in the model, this suggests that evidence-based treatment modalities that use this type of ER may be particularly effective for those individuals with higher resting HRV. The finding that greater tonic HRV was associated with perceived ER success through the use of expressive suppression is also interesting for several reasons. Expressive suppression involves increasing efforts to actively inhibit the outward display of affect, thus involving aspects of executive functions including inhibitory control. Findings in the present study are consistent with previous research who demonstrated that individuals with high tonic HRV are more likely to engage in the use of expressive suppression (Pu, Schmeichel, & Demaree, 2010; Volokhov & Demaree, 2010). Although this may seem counterintuitive, research suggests that given the relationship between cardiac vagal control and self-regulation, individuals with high tonic HRV are better able to comply with social display rules in certain contexts that would require expressive suppression techniques (Ekman & Friesen, 1969). For example, expressive suppression may be a valuable strategy in certain contexts that discourage the expression of emotion. Thus it is unsurprising that participants in the current study with high tonic HRV were better at engaging in expressive suppression to regulate their negative emotions. Thus, findings in the present study have possible clinical implications in terms of using this information to match treatment modality to the individual based on their HRV. In Study 2, interventions for autonomic dysfunction in anxiety disorders are discussed and examined in detail.

With regards to phasic HRV, findings of the current study showed that phasic HRV was not significantly associated with perceived success using any of the ER strategies. That is, when the method of emotion generation was collapsed across, and the use of these specific ER strategies (irrespective of how one's negative emotion was generated) was examined, phasic HRV did not seem to play a significant role. Given that research on the topic of phasic HRV is novel and little has been done in the area, it is challenging to fully conceptualize why the current study failed to find a significant association between phasic HRV and any of the three ER strategies employed. There is a body of literature that suggests that phasic HRV is linked with self-regulatory effort (Butler et al., 2006b; Segerstrom & Nes, 2007; Gaebler et al., 2013; Park et al., 2014), which may in turn depend on the context in which changes in phasic HRV occur (Park et al., 2014). Despite several previous studies showing an association between phasic HRV and ER strategy use (e.g., Beauchaine et al., 2007; Butler et al., 2006b; El-Sheikh et al., 2011; Segerstrom & Nes, 2007) it may be that in the current study participants may have expended less effort on this lab-based task. For instance, it is possible that participants did not feel the need to expend significant levels of effort utilizing these ER strategies given the fact that this was a lab-based task and not a real world context, or perhaps the emotional stimuli did not evoke high enough stress levels or negative affect that required such significant effort expenditure. Future studies should incorporate methods of assessing and measuring effort in order to understand how it may impact HRV and ER. It is also possible that the present study may have been underpowered to identify any significant effects thus, future research with larger sample sizes and/or the ability to assess these associations within specific diagnostic groups is needed.

***Interaction between emotion generation and regulation.*** The intersection between how one's emotions are generated and subsequently regulated holds a promising avenue for understanding how HRV impacts ER in both clinical and non-clinical populations. Findings from previous research showed that the ways in which emotions are generated have an influence on the success of the subsequent ER strategy used (Cochrane, Smart, & Garcia-Barrera, 2017). This research has shown that concordance between generation and regulation facilitates regulation and when this concordance is not present, it may actually have counterproductive effects, increasing negative affect (Cochrane, Smart, & Garcia-Barrera, 2017; McRae et al., 2012). For the purpose of elucidating this relationship further, the present study examined the interaction between method of emotion generation and use of specific ER strategies (see Table 12 for a summary of these results).

Table 12

*Interaction between Emotion Generation and Emotion Regulation*

| | **Tonic HRV** | | **Phasic HRV** | |
|---|---|---|---|---|
| Reappraisal Sentences | | | | |
| | Model | × $R^2$ = .404 | Model | × $R^2$ = .208 |
| | Tonic HRV | × $d$ = .70 | Phasic HRV | × $d$ = -0.39 |
| Reappraisal Pictures | | | | |
| | Model | × $R^2$= .506 | Model | ✓ $R^2$= .563 |
| | Tonic HRV | × $d$ = .31 | Valence | ✓ $d$ = 1.6 |
| | Valence | ✓ $d$ = 1.58 | Phasic HRV | × $d$ = -.324 |
| Suppression Sentences | | | | |
| | Model | ✓ $R^2$ = .775 | Model | ✓ $R^2$ = .703 |
| | Arousal | ✓ $d$ = -2.78 | Arousal | ✓ $d$ = -2.44 |
| | Tonic HRV | ✓ $d$ = 1.19 | Phasic HRV | × $d$ = .17 |
| Suppression Pictures | | | | |
| | Model | ✓ $R^2$ = .619 | Model | ✓ $R^2$ = .604 |
| | Valence | ✓ $d$ = 1.79 | Valence | ✓ $d$ = 2.02 |
| | Tonic HRV | × $d$ = .58 | Phasic HRV | × $d$ = .08 |
| Appraisal Sentences | | | | |
| | Model | ✓ $R^2$ = .705 | Model | × $R^2$ = .426 |
| | Arousal | ✓ $d$ = 2.0 | Phasic HRV | × $d$ = .44 |
| | Tonic HRV | ✓ $d$ = -1.65 | | |
| Appraisal Pictures | | | | |
| | Model | ✓ $R^2$ = .524 | Model | ✓ $R^2$ = .529 |
| | Tonic HRV | ✓ $d$ = 1.34 | Phasic HRV | ✓ $d$ = 1.12 |

*Note:* Model= all 6 predictor variables; ✓ = significant; × = non-significant; all other effects presented in the table represent unique contributions over and beyond other predictor variables in the model

In summarizing the major findings, for tonic HRV, the present study found a significant association with participants' perceived ER success when using expressive suppression and appraisal to regulate both top-down and bottom- up generated emotions;

however, tonic HRV only uniquely contributed to perceived ER success in specific instances which are discussed in detail below. Phasic HRV was positively associated with perceived success using cognitive reappraisal, expressive suppression, and appraisal to regulate bottom-up generated emotion, with the additional unique finding of supporting expressive suppression for top-down generated emotion. Further, phasic HRV was only found to uniquely contribute to ER success for the appraisal of bottom-up stimuli.

The current study showed that tonic HRV was uniquely associated with participants' perceived success when using expressive suppression and appraisal to regulate their negative emotions elicited from bottom-up and top-down stimuli. Within this interaction, tonic HRV played a *unique* role over and beyond the other variables in the model in predicting perceived ER success using expressive suppression on top-down generated emotion. This concordance between using this effortful ER strategy that requires significant cognitive resources on emotions generated in a top-down manner was facilitated by greater tonic HRV (i.e., greater self-regulatory resources). This finding is consistent with that found in previous research, specifically the idea of concordance between emotion generation and regulation, and when that concordance is present, regulatory abilities are facilitated (e.g., Cochrane, Smart, & Garcia-Barrera, 2017; McRae et al., 2012). This finding is also in line with previous work that showed that expressive suppression within the context of the ER paradigm functioned as a top-down strategy, and this may be why it was successful at regulating top-down generated emotion in the current study as well. On the other hand, in the case of utilizing expressive suppression to regulate bottom-up generated emotion, valence was the only unique contributor to perceived success on these trials, whereby the less negative participants felt the better they perceived themselves to be at regulating their emotions. This mirrors some of the earlier discussions in that valence seems to be an important contributor to one's emotional experience and accounts in part for the degree to which tonic HRV facilitates ER. Particularly in the context of expressive suppression, a response-focused ER strategy that is known to provide short-term benefits but long-term maintenance of negative affect and other negative consequences. It makes conceptual sense that the less negative emotion a participant felt, the better they perceived themselves to be at regulating their bottom-up generated emotions using expressive suppression.

Next, the finding that tonic HRV uniquely facilitated the use of appraisal for both top-down and bottom-up stimuli is interesting for several reasons. Appraisal as an ER strategy is one in which requires the acceptance and allowance of emotional experience without judgment. The current results suggest that the method in which one's emotion was generated may be less important in the context of this ER strategy, as in any case, that emotional experience is treated in the same accepting and non-judgmental manner. In both cases, tonic HRV significantly and uniquely predicted perceived success on these trials. This finding sheds lights on this idea of concordance between emotion generation and regulation. In the context of appraisal, generation is open to encompassing any and all generated emotions, such that findings of the present study indicate a strong concordance between the acceptance and allowance of emotions generated in the present moment facilitated subsequent regulation success through the use of appraisal.

The lack of significance between tonic HRV and cognitive reappraisal for any of the generation conditions is of great importance and again surprising given that the neurovisceral integration model is grounded on the idea that executive control, HRV and ER are intricately linked. Again these findings (or lack thereof) are important in demonstrating the unique nuances of the neurovisceral integration model and some differences that arise when looking at specific clinical populations, in this case anxiety disorders. Also, these findings suggest that CBT may work independently of individual's basal levels of vagally-mediated physiological regulation. In Study 2 these clinical implications are further addressed, and specifically the impact of intervention techniques on HRV is examined.

Concerning phasic HRV, results of the current study demonstrated that phasic HRV was important in the use of all three strategies for bottom-up stimuli, but played a *unique* role when using appraisal to regulate negative emotion on bottom-up trials. Interestingly findings showed that phasic HRV had an important role across all three ER strategies for regulating bottom-up generated emotions, however, it was only in the association between bottom-up regulation and generation (i.e., appraisal of bottom-up generated emotion) that phasic HRV played a *unique* role over and beyond the other predictor variables. It is striking that in the case of appraisal, participants were not actively trying to change or alter their emotional experience (e.g., in contrast to actively altering one's emotional experience as in the case of cognitive reappraisal) and an association with autonomic functioning was observed. It was the interaction between this bottom-up ER strategy and bottom-up method of generation that phasic HRV played a unique role in supporting perceived ER success. In other words, individuals with greater phasic HRV perceived themselves at being more successful at sitting with and tolerating their emotional experience that was generated from the bottom-up. In the case of bottom-up generated emotions, emotional information is often automatically elicited by physical or perceptual properties of the stimulus. Thus, it makes sense that phasic HRV, as a 'state-like' measure of self-regulation would be related to how individuals experience and express their emotions in situations that call for quick, efficient, and adaptive responding. In recent research poor acceptance of emotions have been associated with lower HRV (Visted et al., 2017), which was also found in the present study. It seems that acceptance, a major component of appraisal, is a critical factor in using this strategy successfully. These findings are a novel contribution to the field of ER as 'appraisal' has typically been used in the past as a 'throwaway' or control condition in emotion studies, but here the extent to which appraisal was perceived to be effective, was related to changes in phasic HRV. These findings underscore the adaptive value of knowing how to use appraisal, and supports the application of third-wave therapeutic approaches such as Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1990), Mindfulness Based Cognitive Therapy (MBCT) and Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999a).

***Limitations and future directions.*** Although this study provides a novel and relatively holistic assessment of the relationship between HRV and ER in a sample of adults with clinically elevated anxiety, there are several limitations that should be considered. First, given the small sample size in the current study, there was likely limited power to detect significant effects. There was also insufficient power to examine how the observed results may differ as a function of separate anxiety diagnoses. Future studies would benefit from examining these relationships within a larger clinical sample that includes a greater proportion of specific anxiety disorders. It is relevant to examine anxiety disorders separately in order to understand the role of how autonomic dysregulation may uniquely present and perpetuate suffering within each disorder specifically, including differences in emotion generation and regulation dynamics. Second, although an attempt was made to obtain measures of emotional reactivity and self-reported affect during the ER paradigm, due to a computer error data for 11 participants were lost. Thus, as a result, some of the analyses in the current study may be under-powered and future research should aim to examine these variables in a larger clinical sample. It is also important to acknowledge the lack of consensus that exists in current research as to what the most appropriate language and terminology should be to best capture and reflect various ER strategies. In the current study, although the primary investigator trained all participants and ensured that they were proficient in the use of each strategy, it is possible that it could have led to confusion had that additional one-to-one support not be present. Specifically, the instruction “appraise” may have implied evaluation or assessment of emotion despite reflecting a non-judgmental natural experience of one’s emotion. As such, future research should continue to identify the most appropriate language and descriptive labels to best capture the various ER strategies. This may help to reduce methodological heterogeneity and improve the ability to accurately measure the underlying ER process.

Third, the sample in the present study included participants that had either a previously diagnosed anxiety disorder or met criteria for clinically elevated levels of anxiety as assessed using a standardized self-report questionnaire assessing anxiety; however, many participants also had comorbid mental health difficulties. Although the comorbid presentation of psychopathology is common in anxiety disorders and reflective of what is typically encountered in clinical practice, it adds to the challenges of understanding the role of HRV as a physiological index of self-regulation specifically in the context of anxiety. In addition, there was a mild range restriction of valence and arousal ratings for the stimuli used in the ER paradigm. Further, some participants in this study reported that the stimuli were not nearly as negative as some of their real world, lived experiences. As such, this is considered to be a limitation, and future research should consider how to adapt current ER paradigms to appropriately assess HRV and ER processes in clinical samples. Future studies should examine ecologically valid measurement approaches such as ambulatory devices for monitoring HRV (e.g., smartphone apps, portable devices), which can be used naturally as emotions are generated and regulated in one's normal environment. These measurement approaches have recently come to the forefront of the commercial market and may also become more easily incorporated into clinical practice. These methods of assessment may be more realistic in terms of their ability to acquire real-time EKG recordings in a cost friendly and timely manner outside of the laboratory environment which may be more indicative of one's true emotion generation and regulation ability. Lastly, although the root mean square of successive differences in R-R intervals (RMSSD) is considered to be a valid measure of vagally mediated HRV (Li et al., 2009; Thayer & Sternberg, 2006; Williams et al., 2015), future work may also wish to account for the impact of respiration rate on HRV as well as a measure of HR itself. Although there is still great contention and debate in current research around gold standards of measuring HRV, respiration rate and HR may have provided an additional piece of information in understanding and interpreting this physiological tool and additional information around ER in anxiety disorders may have been gained. For instance understanding whether vagally mediated HRV was associated with respiration rate and HR would provide us better understanding of the dynamic connections between these systems and whether they are associated or become dissociated in anxiety disorders.

Finally, although it was not an explicit aim of the present study, it would be important for future work to test the above mentioned effects in one model in order to determine whether there is a difference between top-down and bottom-up interventions on the various components of self-regulation in anxious adults. Similarly, although the purpose of the present study was to examine tonic and phasic HRV separately in order to contribute to current understandings of HRV, it would be useful for future research with greater sample sizes to determine whether there is a difference between these two indices of autonomic functioning within various psychopathological conditions including anxiety disorders.

**Summary of study 1.** This study sought to replicate the neurovisceral integration model by examining the effects of HRV on ER in a population of individuals with clinically elevated levels of anxiety. By experimentally testing the neurovisceral integration model, this work aimed to help refine current knowledge of ER and HRV for individuals with pathological anxiety. Although tonic/trait and phasic/state HRV have been considered in relationship to healthy and regulated emotional responding, research has largely focused on the former while not as diligently examining the latter. The present study examined both aspects of HRV in hopes of better understanding their influence on ER. The findings in Study 1 showed that the neurovisceral integration model holds in this clinical sample, and HRV was reduced in individuals' with clinically elevated levels of anxiety. Interestingly, differences emerged depending on the way emotions were generated, and how they were subsequently regulated.

# Chapter 2: Interventions for Autonomic Dysfunction in Anxiety Disorders

There is a growing body of empirical research that shows that low HRV is associated with higher anxiety (Chalmers et al., 2014). In Study 1 HRV was found to be important for ER success, which is in line with the neurovisceral integration model (Thayer & Lane, 2000). The next step is working towards identifying interventions that can effectively work to ameliorate these deficits in HRV in anxiety disorder populations.

## Current intervention approaches

**Top-down interventions.** Cognitive-behavioural therapy (CBT) is a frontline evidence-based treatment for a variety of anxiety disorders. This treatment approach has significant empirical data available to support its efficacy (Almeida et al., 2013; Otte, 2011; Stewart & Chambless, 2009). Interventions within CBT are based on the basic premise that anxiety disorders are maintained by cognitive factors, and that psychological treatment leads to changes in these factors through cognitive (e.g., cognitive restructuring) and behavioral (e.g., exposure) techniques (for a review, see Deacon & Abramowitz, 2004). Of particular interest for the purpose of the current study, cognitive reappraisal (or what is referred to in the CBT framework as cognitive restructuring) is at the foundation of CBT (Beck, 1979; 1989; Hofmann & Asmundson, 2008). Cognitive restructuring primarily alters the control of negative emotions via top-down processes (Beevers, 2005; Goldapple et al., 2004; Ouimet et al., 2009). This therapeutic strategy includes identifying the core maladaptive thoughts and beliefs of emotional disturbance and then modifying them by evaluating their accuracy and generating more adaptive, alternative modes of thinking that compete with the dysfunctional perspective. Cognitive restructuring within the CBT model has been consistently shown to optimize well-being in mental health disorders and among anxiety disorder populations over time (Butler et al., 2006a). More specifically, CBT for anxiety disorders has been shown to reduce amygdala reactivity (Fonzo et al., 2014; Taylor et al., 2014; Lipka, Hoffmann, Miltner, & Straube, 2014), increase activity in PFC regions supporting cognitive reappraisal (Taylor et al., 2014; Goldin et al., 2013), and enhance inverse functional connectivity between amygdala and dmPFC over time (Goldin et al., 2013). Thus, the efficacy of CBT in anxiety disorders has well been well-established (Hans & Hiller, 2013; Hofmann & Smits, 2008; Norton & Price, 2007; Olatunji, Cisler, & Deacon, 2010; Watts, Turnell, Kladnitski, Newby, & Andrews, 2015).

However, even though CBT is considered to be among the most effective treatments for anxiety disorders, it is still far from perfect (Craske et al., 2014; Hofmann & Smits, 2008) as non-response, attrition, and relapse continue to be problems in a significant proportion of these individuals (Taylor, Abramowitz, & McKay, 2012; Loerinc et al., 2015). Cognitive restructuring is a top-down mode of processing, which includes slower, more deliberate, explicit, and strategic forms of rational processing that uses rule-based knowledge to guide how an individual processes the information (Garrett et al., 2007; Ochsner & Gross, 2005). A large body of research suggests that this top-down form of intervention requires greater cognitive resources to support the use of this more complex strategy. Cognitive restructuring has been found to involve a “top-down” regulation of prefrontal brain regions on emotion-generative brain regions, such as the amygdala (Lorenz, Minoshima, & Casey, 2003; Quirk & Beer, 2006). However, individuals with anxiety disorders often have deficiencies in these cognitive abilities (i.e., executive functions, or EF). For instance, anxiety symptoms are commonly associated with abnormalities in prefrontal activation and altered relationships between activity of the prefrontal regions and amygdala (Kim et al., 2011a; Kim, Gee, Loucks, Davis, & Whalen, 2011b). In addition, a significant amount of behavioural and self-report evidence corroborates these findings highlighting dysfunctional EF in people with anxiety disorders including reduced working memory (Balderston et al., 2016), inhibitory control difficulties (Moore, Gómez-Ariza, & Garcia-Lopez, 2016; Moriya & Sugiura, 2013), and attentional biases (Cisler & Koster, 2010). Given the fact that CBT is a highly intellectualized and cognitively demanding therapeutic approach, it is not surprising that some individuals with anxiety disorders do not seem to benefit, given the fact that EF difficulties are common in this population (Taylor, Abramowitz, & McKay, 2012). Moreover, persons with anxiety disorders often incur a greater cognitive cost associated with regulating emotions as compared to healthy controls, whereby individuals with pathological anxiety often times rigidly suppress their emotions, distract, or avoid (Wang et al., 2016) rather than engage in a more effortful ER strategy (e.g., cognitive reappraisal). Individuals with anxiety disorders also often perceive danger in the environment and fail to recognize safety signals (i.e., the 'negativity bias') and have the tendency to prioritize negative information over positive (Aue & Okon-Singer, 2015; Cacioppo et al., 1999; Shook et al., 2007; Thayer & Friedman, 2002). Thus, negative cognitive biases and catastrophic misinterpretations retain a central role in shaping the perception and interpretation of bodily arousal, and play a key role in causing and maintaining anxiety disorders (Mobini, Reynolds, & Mackintosh, 2013). Studies have also consistently demonstrated that anxiety disorders are often associated with poor emotional understanding, non-acceptance of emotions, and limited access to ER strategies (Amstadter, 2008; Campbell-Sills & Barlow, 2007; Cisler, Olatunji, Feldner, &

Forsyth, 2010 for a review; Gross & Jazaieri, 2014). There is evidence to suggest that some individuals who do not respond favorably to CBT may engage in cognitive techniques as a defense against anxiety provoking situations (i.e., as a way of avoiding the raw affect associated with the emotion). It has been suggested that certain cognitive strategies (e.g., worry, rumination) may serve as a form of "body disengagement" or experiential avoidance in anxiety disorders (Borkovec, Alcaine, & Behar, 2004; Paulus & Stein, 2006), particularly in generalized anxiety disorder, where worry acts as a strong perpetuating factor in this disorder.

A recent meta-analysis by Carpenter and colleagues (2018) examined randomized placebo controlled trials of CBT for anxiety disorders and found that CBT was efficacious with large effect sizes found for obsessive-compulsive disorder (OCD), generalized anxiety disorder (GAD), and acute stress disorder, and small to moderate effect sizes were found for post-traumatic stress disorder (PTSD), social anxiety disorder (SAD), and panic disorder (PD). Interestingly the authors noted that their recent review identified smaller effects than have been previously reported (e.g., Hofmann & Smits, 2008). This study also found that CBT interventions that primarily used exposure strategies had the largest effect sizes compared to those using cognitive or cognitive and behavioral techniques; however, this difference did not reach significance. It is apparent from this recent work that CBT approaches for some anxiety disorders may be more effective than either cognitive or behavior therapy alone, and in fact, the largest effects may be driven by bottom-up based components including exposure. It appears that more works needs to be done in order to continue to dismantle the key components of CBT in order to establish which active features of CBT may be more or less helpful for specific anxiety disorders. The results suggest that, while a large proportion of individuals suffering from an anxiety disorder benefit from CBT, there are still a large proportion of individuals that do not. Given the theoretical reasons discussed above, it is reasonable that some individuals would likely struggle with the CBT approach, particularly if treatment focused primarily on top-down modalities (i.e., cognitive restructuring) to the exclusion of other active ingredients such as bottom-up components including exposure. It is therefore clear that something else needs to be done for those individuals who do not favorably respond to this current frontline treatment approach.

**Bottom-up interventions.** As can be seen from Study 1, bottom-up approaches to self-regulation such as appraisal, have important effects on both perceived success at regulatory ability, but also at a physiological level within the body. This highlights the importance of better understanding alternative approaches to self-regulation, including what is referred to as bottom-up approaches, which was in part the motivation for incorporating such a technique in Study 2. One alternative method for treating anxiety disorders that is slowly gaining more traction in current research is what is referred to as "bottom-up" based approaches. These methods often have a focus on the body or somatic responses to psychological distress and include – but are not limited to – somatic experiencing (e.g., Payne, Levine, & Crane-Godreau, 2015), sensorimotor psychotherapy, Hakomi therapy (e.g., Barstow, 1985), as well as various mindfulness-based approaches (e.g., Chiesa & Serretti, 2009). Bottom-up approaches are often described as the more primitive, automatic, and implicit ways of processing information often driven by salient features of a relevant stimulus, or environment as well as their associations (Garrett et al., 2007; Ochsner & Gross, 2005). These interventions currently lack the wealth of empirical evidence available for top-down approaches such as CBT. Notably, however, several of these approaches draw on robust theories in emotion and autonomic nervous system function, including Porges' (1995) polyvagal theory and Damasio's (2000) somatic marker hypothesis (van der Kolk, 2014).

In anxiety disorders specifically, a key component of bottom-up, body-based approaches to intervention is the focus on somatic symptoms. Somatic symptoms in anxiety disorders are linked to an acute activation of the sympathetic nervous system and to the withdrawal of parasympathetic tone (i.e., lower HRV). Such symptoms include multiple systems such as musculoskeletal (e.g., muscle tension, shakiness), respiratory (e.g., dyspnea), cardiovascular (e.g., tachycardia), gastrointestinal (e.g., diarrhea), skin (e.g., sweatiness), and genitourinary (e.g., frequent urinary urgency) organs. From a general standpoint, enhanced and unregulated psychophysiological reactivity to emotional stimuli is common in anxiety disorders (Friedman & Thayer, 1998; Gurguis, Vitton, & Uhde, 1997; Lundh, Wikstrom, Westerlund, & Ost, 1999; Monk et al., 2001; Pauli, Amrhein, Muhlberger, Dengler, & Wiedemann, 2005). This augmented psychophysiological arousal is accompanied by a heightened experience of emotions as reflected in an increase in the intensity of those emotions (Wiens, Mezzacappa, & Katkin, 2000). The perception and interpretation of these symptoms are dependent on the individual's emotional state, and together play an important role in the pathogenesis of anxiety disorders. Given that anxiety disorders are largely associated with physiological symptoms, it only makes sense that bottom-up focused interventions are gaining increased interest. This is clear even within predominantly top-down approaches such as CBT, where the efficacy and integration of bottom-up approaches including exposure are being more heavily weighted (e.g., see previous discussion on Carpenter et al., 2018). Another recent systematic review and meta-analysis that focused on dismantling CBT for PD showed that interoceptive exposure (i.e., exposure to somatic symptoms) in a face-to-face setting was associated with the greatest treatment efficacy and acceptability (Pompoli et al., 2018). Similar to Carpenter and colleagues (2018) bottom-up treatment components within the CBT context are gaining increasing traction and support in recent research. Therefore, although a large proportion of individuals with anxiety disorders do not appear to benefit from CBT, it may be related to the focus of the CBT treatment. Before discussing specific bottom-up based interventions for anxiety disorders, it is important to consider the role of interoception more closely (e.g., Damasio, 1994, 1999; James, 1884; Schachter & Singer, 1962), as it is a key element underlying these bottom-up methods.

Interoception is defined as the sense of the physiological condition of the entire body (Craig, 2002) and includes two important components. The first component is that interoceptive sensations are often associated with affect and motivation, and the second component is the evaluative component of the bodily signal that is highly dependent on the homeostatic state of the individual (Paulus & Stein, 2006). Interoception is critical for self-awareness because it provides the link between cognitive and affective processes and one's current body state. The neural system that underlies interoception can be conceptualized as a homeostatic neural system that conveys signals from primary afferents (Craig, 2002) and creates an internal representation of the entire body. The insular cortex is an important area in the brain that is placed in a position to receive information about the salience (both appetitive and aversive) and relative value of the stimulus environment. The primary role of the insular cortex is to integrate this information with the effect that these stimuli may have on the body state. Altered insular function is a common feature of many of the anxiety disorders, specifically, heightened activity in the anterior insula (Bruhl, Delsignore, Komossa, Weidt, 2014; Stein, Simmons, Feinstein, & Paulus, 2007). In anxiety disorders, homeostasis is typically disrupted leading to maladaptive representations of signals from the body (Craig, 2002). This often includes an altered signal of an impending aversive body state, which provides the basic link between altered interoception and anxiety. Anxious individuals often focus on the likelihood of future aversive bodily states in certain contexts and often have the tendency to view interoceptive sensations as dangerous or threatening (i.e., fear of somatic symptoms) (Paulus & Stein, 2006). Interoception plays a unique role in various forms of psychopathology including but not limited to anxiety disorders (e.g., Domschke, Stevens, Pfleiderer, & Gerlach, 2010), but also in eating disorders (Dodd et al., 2017), addiction (Verdejo-Garcia, Clark, & Dunn, 2012; Paulus & Stewart, 2014), and post-traumatic stress disorder (Van der Kolk, 2014). A commonality among these disorders is the connection between interoceptive deficits and poor self-regulation and greater maladaptive emotional and behavioral coping strategies. Thus, interoception appears to play a critical role in the pathogenesis of various psychopathological disorders. As such, bottom-up approaches to treatment may hold a central role in helping individuals become better able at attending to and responding to their body in an adaptive way.

Developing this idea further, interoceptive awareness has been an essential variable in many theories of emotion including that of James (1884), who was one of the first to postulate that visceral-afferent feedback is closely associated with emotional experience. Several theorists that followed in these footsteps provided additional influential theories, and the somatic marker hypothesis formulated by Damasio (1994; 1999; Damasio et al., 2000), is one of particular interest to the present study. The somatic marker hypothesis highlights the importance of incorporating feedback from the peripheral nervous system (somatosensory and visceral) in effective decision-making where emotion is relevant to the context at hand. Individuals who perceive bodily signals with a high level of accuracy are thought to experience emotions more intensely (Damasio, 2000; James, 1994). Further, several studies have demonstrated a positive relationship between interoceptive awareness and the experience of emotions (Critchley et al., 2004; Katkin, Wiens, & Ohman, 2001; Wiens, Mezzacappa, & Katkin, 2000) especially in individuals with anxiety disorders (Pineles & Mineka, 2005; Wald & Taylor, 2005; White, Brown, Somers, & Barlow, 2006). In this view, somatic marker signals from the body are thought to impact emotion and subsequent ER.

More recent research has focused on the "interoceptive sensitivity" hypothesis (Ehlers & Breuer, 1992; Reiss, Peterson, Gursky, & McNally, 1986), which states that anxiety disorders and individuals with high anxiety sensitivity are characterized by an enhanced ability to accurately detect arousal-related bodily sensations usually through tasks like heart-beat detection (Domschke, Stevens, Pfleiderer, & Gerlach, 2010). Interoceptive sensitivity is a term that refers to the accurate self-perception of visceral activity and changes arising from the body (Craig, 2003). Interestingly, the enhanced interoceptive sensitivity found in anxiety disorders is thought to actually increase the probability that such individuals experience arousal-related somatic sensations and then respond to them with anxiety (Ehlers, 1993). In line with these views, several studies have shown that patients with anxiety disorders generally report hypervigilance for somatic sensations (De Berardis et al., 2007; Ludewig et al., 2005; Olatunji, Deacon, Abramowitz, & Valentiner, 2007; Gregor & Zvolensky, 2008; Anderson & Hope, 2009), partly accompanied by diminished autonomic flexibility and heightened basal arousal (Hoehn- Saric, McLeod, Funderburk, & Kowalski, 2004). This is coincided by a wealth of research that indicates that anxiety disorders are commonly associated with increased self-report of somatic sensations, as well as a subsequent dysfunctional cognitive appraisal of these sensations (Domschke, Stevens, Pfleiderer, & Gerlach, 2010). This often includes a significant bias towards a danger-related and catastrophizing interpretational style, the epitome of which is seen in panic attacks and panic disorder (e.g. Barlow, 1988; Beck, Emery, & Greenberg, 1985; Clark, 1986).

This relates to the second component of interoception: the evaluative component of one's bodily signals. A large body of research highlights two principal information-processing biases characteristic of anxiety including a bias to attend toward threat-related information, and a bias toward negative interpretation of ambiguous stimuli (Mathews & MacLeod, 2005). It is thought that increased cardiac interoceptive sensitivity coupled with these information-processing biases may increase the vulnerability to anxiety disorders by increasing the perceptual base for catastrophic interpretations of bodily symptoms (Chambless, Beck, Gracely, & Grisham, 2000; Clark, 1986; Hibbert, 1984). In this view, as better perception of bodily symptoms increases, both the probability of any given (phasic) physiological change to be perceived and the possibility of catastrophic misinterpretations of somatic cues also increase. As such, heightened interoceptive sensitivity can become a maladaptive component in clinical anxiety disorders. A vicious cycle can be triggered and later perpetuated by the individuals themselves, who often grow to eventually fear their own bodies (see Boettcher, Brake, & Barlow, 2016 for a review).

It is important to note that interoception is not only important in ER, but is also important in its relationship to making effective decisions as briefly mentioned above. The somatic marker hypothesis (Damasio, 1994) has been notably influential in better understanding how somatic markers can be used to impact one's ability to make decisions. To provide context for understanding the implications of this complex model, a brief description is provided below. According to the somatic marker hypothesis, it is argued that when a salient event occurs in a person's life a somatic marker is created and encoded in the experience of the body (i.e., what is referred to as the 'body loop', which is generally speaking, a network that links the mind and body). In the future it is thought that certain internal or external events can trigger a memory of that somatic marker and enact in the body the same somatic state as would have been experienced with the original trigger. This can be the same kind of trigger or something approximate (i.e., the "as-if" body loop). In other words, the brain can stimulate a certain body state "as-if" it were occurring and because one's perception of anybody state is rooted in the body maps of somatosensory regions, individuals commonly perceive the body state as actually occurring even if it is not (Damasio, 1994). Thus, at a basic level the somatic marker hypothesis describes a classically conditioned response of the nervous system that occurs in an automatic, bottom-up fashion, which has been shown to impact decision-making outside of conscious awareness. Therefore, the ability to perceive bodily signals has been found to modulate emotional experience, such that better detection of one's bodily signals has been shown to facilitate the selection and implementation of both antecedent-focused and response-focused ER strategies (Kever, Pollatos, Vermeulen, & Grynberg, 2015). Affective reactions are thought to ordinarily guide and simplify decision making such that, the appraisal of one's affective response to a decision serves as information that guides the evaluation process (Greifeneder, Bless, & Pham, 2011; Winkielman, Knutson, Paulus, & Trujillo, 2007). However, in anxiety disorders, hypervigilant or avoidant processes negatively impact an individual's ability to effectively perceive bodily signals and subsequently use this information to make decisions. For example, research suggests that heightened physiological arousal responses to risk foster behavioral avoidance of risk in favor of safer options (Bechara, Damasio, Tranel, & Damasio, 1997). Further, it is suggested that heightened arousal to risky choice options and/or increased interoceptive awareness of arousal responses may lead anxious individuals to be more risk averse (Kowert & Hermann, 1997; Raghunathan & Pham, 1999; Maner et al., 2007). Given the fact that effective decision making is largely associated with a properly functioning frontal cortex including the PFC and insula, it is unsurprising that effective decision making is commonly hindered in anxiety disorder populations given the fact that frontal EF processes are usually compromised in this context. In normative populations, evidence indicates there is a general predisposition toward risk seeking (Kuhnen & Knutson, 2005; Tobler, O'Doherty, Dolan, & Schultz, 2007), whereas in anxious individuals, altered insular responses tend to shift this prepotent tendency toward the avoidance of risk. The everyday decisions made by individuals suffering from anxiety disorders to avoid perceived threats can have profound cumulative effects on their ability to function adaptively and mark an area that is in need of appropriate intervention and support.

With the above research in mind, it is quite clear that another way to regulate one's own emotions is via a direct modulation of emotion-generative brain regions (e.g., Chambers et al., 2009; Westbrook et al., 2013). This kind of ER strategy has been termed "bottom–up" because it is characterized by a direct reduced reactivity of "lower" emotion-generative brain regions such as the amygdala, without an active recruitment of "higher" brain regions, such as the PFC (e.g. van den Hurk, Janssen, Giommi, Barendregt, & Gielen, 2010; Westbrook et al., 2013). Until recently, bottom-up aspects of the bidirectional communication between body and mind were often overlooked by Western science, even though it has long been central to traditional healing practices. Today, these bottom-up body based approaches are foundational to current understandings of anxiety disorders and recovery, but there are still grey areas left in current research, specifically around what constitutes a "bottom-up" intervention. As such, despite being essential approaches to treatment, there remains to be a lack of consensus around what the term "bottom-up" really means and which techniques satisfy the criteria for such a strategy. For the purpose of the present study, bottom-up approaches can be understood as those interventions actually attempting to monitor and regulate the individual's physiology, and at a meta-level, his or her relationship to bodily sensations.

**Mindfulness.** In the last 2-3 decades there has been a proliferation of research on various forms of mindfulness training in both healthy and clinical populations. These "third wave" treatment approaches include Mindfulness Based Stress Reduction (Kabat-Zinn, 1982), Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999), Mindfulness Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002), Dialectical Behavior Therapy (DBT; Linehan, 1993), and others (Bluett, Homan, Morrison, Levin, & Twohig, 2014; Roemer Williston, Eustis, & Orsillo, 2013). This is also seen more explicitly through mindfulness-based interventions for anxiety disorders, including mindfulness approaches rooted in Eastern contemplative traditions (Davidson, 2010).

Although there has yet to be a consensus around the definition of mindfulness, for the purpose of the present study mindfulness can be understood as a process in which one deliberately pays attention to or becomes aware of all the information in the present moment, without evaluating or judging it, but merely accepting it with an open and curious nature (Kabat-Zinn, 2003). Therefore, mindfulness is different from typical awareness or attention. It involves attending to the present moment in a very deliberate way and learning to regard thoughts and feelings as simply “existing” and realizing that they may or may not be true, instead of simply accepting thoughts and feelings as facts (Baer, 2003; Fjorback et al., 2011). This acknowledgement and acceptance of thoughts, without necessarily changing their content, is in contrast to top-down techniques such as cognitive restructuring that requires active modifications of maladaptive thoughts into an alternative, more adaptive thoughts. Although there are many different forms of mindfulness meditation, at the foundation of most is the idea of deliberate training of attention, either in a focused or open and receptive way. A growing body of research has demonstrated an association between levels of mindfulness, more positive stress appraisals, and coping strategies among anxious and non-anxious individuals (Arch & Craske, 2010; Brewer et al., 2009). This is supported by a recent meta-analysis that indicated mindfulness-based approaches were efficacious in ameliorating symptoms of anxiety (Hofmann et al., 2010). Further, mindfulness training has been shown to have benefits in multiple areas including improved attentional focus (Chiesa, Calati & Serretti, 2011; Lutz et al., 2009), cognitive flexibility (Moore & Malinowski, 2009), reduced affective reactivity, and modification or shifts away from distorted or exaggerated views of oneself (Farb et al., 2007; Goldin, Ramel, & Gross, 2009). This research is also supported by a recent meta-analysis by Sedlmeier and colleagues (2012) who demonstrated positive effects of meditation on regulating negative emotion. Despite the positive findings, it is important to note a growing body of research that draws attention to the possibility of potential adverse effects of mindfulness practice, which are equally important to consider. Adverse effects may include autonomic hyperarousal, perceptual disturbances (Lindahl, Kaplan, Winget, & Britton, 2014), even traumatic memory re-experiencing (Brewin, 2015), and psychosis (Shan, 2000). Furthermore, one of the most well documented possible adverse effects of mindfulness meditation includes the idea of relaxation-induced panic or anxiety (e.g., Heide & Borkovec, 1983; Cohen, Barlow, & Blanchard, 1985; Newman, Lafreniere, & Jacobson, 2016). These ideas are central to the current study, in that mindfulness training was explored within a vulnerable population, including individuals with clinical anxiety. However, the current state of theories on meditation does not allow researchers to draw specific conclusions about precisely who may be at risk for adverse effects, given the heterogeneity and lack of methodological consistency (e.g., see Van Dam et al., 2018), which makes it challenging to examine and prevent these adverse effects from arising.

Interestingly, and relevant to the current study, there has been ongoing debate about whether mindfulness can be understood as using primarily bottom-up versus top-down ER strategies. In fact, recent research has identified several limitations that make addressing this issue particularly challenging (e.g., see Sedlmeier et al., 2012). Although there is research to support both viewpoints, a recent review by Chiesa, Serretti, & Jakobsen (2013) argued that mindfulness training is associated with ‘top-down’ ER in short-term practitioners and with ‘bottom-up’ ER in long-term practitioners. In addition to noting differences in ER depending on the length of practice, there is some research to suggest that neural correlates of mindfulness training may vary as a function of the psychopathological status of persons under investigation. Although this hypothesis has not been thoroughly tested it is suggested that psychopathological status may influence the classification of mindfulness training as “top-down” or “bottom-up” intervention. For instance, Goldin and Gross (2010) showed that neural correlates of mindfulness based intervention approaches in patients with SAD were indicative of a bottom-up rather than top-down ER strategy. In this study participants with SAD completed short-term mindfulness-based stress reduction (MBSR) intervention, and underwent fMRI while completing a self-referential task. Post-MBSR, they found increased activity in brain networks related to attention regulation and reduced activity in brain systems implicated in conceptual-linguistic self-view. The authors argued that enhanced activation of attentional networks during the negative self-processing task in this study was related to greater attentional processes as habitual automatic avoidance (i.e., cognitive/linguistic processes) that had been diminished with mindfulness training (Allen, Chambers, & Knight, 2006). The findings from this study suggest that the bottom-up process was associated with reduced activation of limbic areas, with no (or limited) recruitment of PFC and involves paying attention in a particular way (e.g., purposefully, non-judgmentally, and in the present moment). Of note however, this is not always the case when engaging in mindfulness practices, as the method in which the practice is taught (e.g., top-down vs. bottom-up) can have a significant influence on the outcome.

Developing this idea further, it is important to note that mindfulness is an umbrella term that captures many different approaches and techniques, and has received many different meanings (Lutz et al., 2007). At a very basic level, meditation practices such as mindfulness can be understood as involving the monitoring and regulation of attention and emotion (Lutz et al., 2008; Tang et al., 2015). Unsurprisingly, different types of mindfulness practice involve different components including differences in behaviour, physiology, and brain activity (Tang et al., 2012; Fox et al., 2014; 2016). Understanding and defining categories of meditation has been particularly challenging over the past decade, as research interest in this area has increased significantly. Increasing amounts of empirical evidence have shown that various meditation approaches can lead to significant changes in cognitive and affective processing (Sedlmeier et al., 2012), as well as alterations in the brain at both a functional and structural level brain function structure (Cahn & Polich, 2006; Fox et al., 2014; 2016). Some researchers have conceptualized mindfulness training as consisting of either or both of Focused Attention (FA) versus Open Monitoring (OM; Lutz, Dunne, & Davidson, 2008). FA involves close placement of attention on the breath or some other object (e.g., the body) and letting go of distracting thoughts or mind-wandering. Unsurprisingly, empirical evidence shows that FA is associated with increases in attention and executive control (Brefczynski-Lewis et al., 2007; Carter et al., 2005; Goldin & Gross, 2010). By contrast, OM involves a more diffuse awareness of one’s breath or body and being fully in the present moment with an overall sense of receptivity to stimuli that are arising internally and externally. A greater use of OM seems to be found in more experienced practitioners (Hasenkamp & Barsalou, 2012), and this practice has been associated with greater right hemisphere activation including viscerosomatic areas such as the insula (Brefczynski-Lewis, et al., 2007; Brewer et al., 2011; Pagnoni et al., 2008). A recent review and meta-analysis by Fox and colleagues (2016) demonstrated that different meditation practices including OM and FA show relatively distinct patterns of brain activity on functional neuroimaging. Results from this meta-analysis showed that FA results in activation of the prefrontal cortex (Fox et al., 2016). Specifically results found associations between FA and activations in the premotor cortex, as well as the dorsal anterior cingulate cortex, both of which are regions associated with voluntary regulation of thought and action, reflecting more top-down mechanisms. Results also demonstrated subthreshold activation in the dorsolateral prefrontal cortex and left mid insula, which are regions associated with the top-down focusing of attention. On the other hand, several clusters of activation in the insula (consistent with awareness of ongoing vicero-somatic body signals), left inferior frontal gyrus, pre-supplementary motor area, supplementary motor area, and premotor cortex (regions associated with the voluntary control of action) were associated with OM practice. Smaller but non-significant clusters of activation were also found in brain regions associated with cognitive control and metacognitive awareness. The takeaway message from this recent review is that OM and FA are distinct psychological practices, which are dissociable at the neurophysiological level (Fox et al., 2016). Therefore in the current study OM was chosen as a bottom-up based strategy, to better understand from both a subjective and physiological level the effects of a bottom-up body based technique in a population of adults with anxiety disorders.

***Default mode network.*** In order to appreciate the potential impact of bottom-up intervention approaches such as mindfulness it is useful to consider the implications of the default mode network (DMN). The DMN consists of a network of brain regions that seem to be active when individuals are not actively engaged in a task (i.e., when the brain is at rest). These brain regions include so-called cortical midline structures such as the medial prefrontal cortex (mPFC), posterior cingulate cortex (PCC)/precuneus, and bilateral inferior parietal lobule (IPL) (Fox, Spreng, Ellamil, Andrews-Hanna, & Christoff, 2015). These structures are associated with emotional processing, processing of emotionally salient stimuli, and episodic memory respectively (Drevets & Raichle, 1998; Maddock, Garrett, & Buonocore, 2003).

Mind-wandering has been proposed as the psychological correlate or phenomenological experience associated with the DMN (e.g. Buckner, Andrews-Hanna, & Schacter, 2008; Christoff et al., 2016), which has been conceptualized by some as a failure of executive resources (i.e., off-task behavior) (Mason et al., 2007; Sonuga-Barke & Castellanos, 2007). Mind-wandering is viewed as the shift in contents of thought away from an ongoing task and/or goal at hand to self-generated thoughts and feelings (Smallwood & Schooler, 2015). This is seen when individuals are not focused on a task but rather are engaging in “self-referential narratives”. Although the DMN is observed in both healthy and clinical populations, certain over-activations of the DMN have been linked to various types of psychopathology – including anxiety disorders (Gentili et al., 2009; Zhao et al., 2007). In individuals with anxiety, these narratives are often filled with worry and fear. As one example, in social anxiety disorder, self-referential narratives are thought to involve exaggerated maladaptive cognitions regarding the self (e.g., as socially incompetent) (Goldin, Ramel, & Gross, 2009).

In the practice of mindfulness, practitioners are encouraged to work with mind-wandering in at least one of two ways: by purposefully reorienting their attention away from thoughts and toward an object (i.e., FA), or by taking a non-reactive, non-elaborative stance toward thoughts, simply letting them pass by without judgment (i.e., OM).

Interestingly, expert meditators not only show deactivation of the DMN, but also show activation of an ‘alternate’ DMN that involves the right hemisphere and viscerosomatic awareness (i.e., body awareness) (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Pagnoni, Cekic, & Guo, 2008). This different DMN is suggested to include self-monitoring and cognitive control areas such as the dorsal anterior cingulate (dACC) and DLPFC (Brewer et al., 2011) as well as right hemisphere “viscerosomatic areas” such as insula, secondary somatosensory cortex, and IPL (Farb et al., 2007; Taylor et al., 2012). Thus, it appears that people who practice mindfulness for extended periods of time, presumably with greater engagement with OM practice, show a different DMN in the right hemisphere (“viscerosomatic” network) (Brewer et al., 2011). Given that mindfulness likely increases parasympathetic activation, it could be accomplished through increased body awareness that is then seen on fMRI (e.g., greater brain activation) and increased HRV. Implications of mindfulness as a valuable intervention for anxiety disorders are discussed in detail in the following sections.

**Current anxiety interventions in the context of HRV.** Study 1 illustrated some of the nuanced ways in which HRV plays a role in anxiety disorders. That said, previous research examining the impact of treatment for anxiety on HRV as an outcome variable has shown mixed results. There is currently considerable heterogeneity in treatment studies with respect to treatment type and the specific disorder being treated. For these reasons, it is unsurprising that there is considerable variation in reports on HRV outcomes in response to treatment, and it remains to be seen whether successful treatment of anxiety disorders will be paired with increases in HRV. This is especially true given the increase in research studies indicating that many regulation strategies that are considered adaptive (e.g., cognitive reappraisal, acceptance) have actually been found to decrease parasympathetic activity in individuals struggling with pathological anxiety, a reverse pattern from what is observed in normal, healthy controls (Aldao & Nolen-Hoeksema, 2012; Aldao & Mennin, 2012; Campbell-Sills, Barlow, Brown, & Hofmann, 2006; Cristea et al., 2014; Di Simplicio et al., 2012). By contrast, one experimental study showed that using top-down methods of ER on bottom-up generated emotions actually led to a paradoxical increase in amygdala activity and negative affect (McRae et al., 2011). This research reiterates the point that the way an emotion is generated is related to how it is best regulated. Anxiety, even a particular disorder, is not a homogeneous thing, and some symptoms may be top-down and some bottom-up even within the same individual. Interestingly there is some research that suggests promising effects for mindfulness as a way of increasing HRV (e.g., Tang et al., 2009). A study by Mankus et al. (2013) examined the relationship between HRV and trait mindfulness in individuals with elevated generalized anxiety symptomatology. Results of this study indicated that in the high-generalized anxiety group, self-reported levels of trait mindfulness were positively associated with HRV. This study highlighted the benefits of mindfulness as a way of potentially enhancing parasympathetic influences on the heart rate. However, although mindfulness has been related to several indicators of flexible ER (Goldin & Gross, 2010), there is a scarcity of research examining the relationship between mindfulness and biomarkers of autonomic function. Thus, there is an obvious need for future studies to consider the impact of evidence-based treatments for anxiety disorders on HRV, which would allow for the impact of symptom reduction on HRV to be determined and the downstream effects on health and well-being to be elucidated. At present this remains unclear, as there is a lack of research in this area.

## Overview of Study 2

Treatment approaches such as CBT and even mindfulness-based interventions are often complex and multifaceted, and the different components of these interventions may differentially impact anxiety symptoms in different ways. As such, the aim of Study 2 was to dismantle some of the purported active ingredients of these interventions, exploring effects of brief evidence-based top-down (e.g., cognitive restructuring) versus bottom-up (e.g., mindfulness technique) training in individuals with anxiety disorders. Specifically, the present study examined the implications of top-down and bottom-up short-term intervention strategies on physiological (i.e., HRV) and self-reported indicators of self-regulation (i.e., EF and ER) during stressful ER and EF tasks to help elucidate mixed findings that have been found on the subjective and physiological effects of top-down and bottom-up intervention techniques in individuals diagnosed with an anxiety disorder.

Cognitive restructuring, as the top-down intervention in the present study, focused on modifying dysfunctional beliefs by first identifying negative automatic thoughts, challenging them, and then substituting more adaptive, realistic, and “rational” responses for the automatic thoughts. It is a central technique and active ingredient in CBT that is designed to address negative or faulty thinking (e.g., Beck, 1979; Beck & Beck, 2011). This technique is based on the premise that changing the way a person thinks will change their emotions and behavior (Clark & Beck, 2011). This technique was top-down in the sense that its emphasis was on consciously bringing negative automatic thoughts to one’s attention, and employing verbal/analytical skills, to reinterpret those thoughts. It is important to note that cognitive restructuring is a multi-faceted technique, and in practice, therapists use several mechanisms of cognitive restructuring (e.g., O'Donohue & Fisher, 2012). For example, this approach includes various unique components such as challenging the truthfulness of a thought by looking at evidence for and against the thought, identifying thinking errors the thought represents (e.g., catastrophizing, mind reading, black and white thinking), and developing alternative thoughts that more realistically reflect an individual's experience (Arch & Craske, 2008). For the purpose of the present study, the intention was *not* to use cognitive restructuring as a comprehensive therapeutic intervention for the treatment of anxiety disorders, but instead cognitive restructuring was utilized as a specific top-down cognitive technique and active ingredient of CBT that could be applied across various situations and to examine its impact on individuals' HRV (i.e., examining whether cognitive restructuring impacts autonomic functioning in individuals' with anxiety disorders). The present study focused on one small piece of cognitive restructuring, specifically, the identification and evaluation of negative automatics thoughts, and the subsequent generation of a more balanced thought.

Mindfulness was chosen as the brief bottom-up method in the present study. As noted above, prior research over the past decade has suggested that several broad categories of meditation techniques exist (e.g., FA, OM, compassion or loving kindness practices; e.g., Brewer et al., 2011; Cahn & Polich, 2006, Lippelt et al., 2014; Lutz et al., 2008, Vago & Silbersweig, 2012). The present study chose to focus on the OM technique as the bottom-up body based meditation practice, which is less reliant on frontal structures including the PFC and more reliant on subcortical brain regions involved in more automatic emotion processing such as the amygdala. Furthermore, OM was chosen specifically because it involves all aspects of the present-moment experience in an accepting and non-judgmental manner.

## Hypotheses

Study 2 was guided by the following hypotheses. It was predicted that participants would show differential changes both subjectively (e.g., self-report measures of anxiety) and physiologically (i.e., tonic/phasic HRV) from pre- to post- intervention as indexed by self-reported perceptions of success on an ER task as well as a stressful task of EF that consisted of both cognitive and affective components. The EF task was specifically chosen because the neurovisceral integration model is based on the assumption that EF plays a critical role in ER. Given that research on interventions focused on remediating HRV is scarce, especially in anxiety disorder populations, this aim was primarily exploratory in nature. Furthermore, because the neurovisceral integration model is meant to be a reciprocal bottom-up and top-down system, it was expected that there would be changes in ER and EF performance in both interventions. Therefore, it was expected that greater intervention response would be correlated with increased vagally mediated cardiac variability and better performance on tasks of EF and ER.

# Methods

## Participants

See Study 1 for details.

## Measures

Similar to the first session, participants were asked not to consume caffeine or alcoholic beverages for 12 hours and not to exercise for 24 hours prior to this second study visit. This was also checked on the day of the second visit. Any affirmative answer to these questions resulted in termination of the experimental session. See Study 1 for a description of measures used with the addition the cognitive task used in Study 2 is described below. Of note, several indices of HRV were examined including tonic or 'resting' HRV (5 min pre-any task baseline), phasic HRV for both the ER and EF task (e.g., 5 min pre ER task baseline – 5 min ER task; measure the change from baseline to event/task), and finally, recovery HRV (i.e., post-event HRV) measure for both ER and EF (e.g., 5 min task – 5 min post event rest) (see Figure 4).

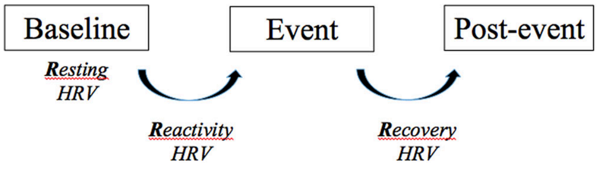

*Figure 4.* Timeline of HRV Recording

From Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart Rate Variability and Cardiac Vagal Tone in Psychophysiological Research-Recommendations for Experiment Planning, Data Analysis, and Data Reporting. Frontiers in Psychology, 8, 213-213.

**ER paradigm.** See Study 1 for details.

**Cognitive test.** Participants completed the N-Back task (Owen, McMillan, Laird, & Bullmore, 2005). This specific version is obtained from the laboratory of Dr. Mauricio Garcia-Barrera, Psychology Faculty at the University of Victoria. Specifically, this task of working memory requires participants to monitor the identity or location of a series of verbal or nonverbal stimuli and to indicate when the currently presented stimulus is the same as the one presented *n* trials previously. There were two conditions: 2-back and 3-back. Thus, in the 2-back condition, participants are to indicate (via a keyboard/button press) whether the stimulus they have just seen is the same as the one they saw 2-back. Likewise a similar instruction is given for the 3-back condition. This task also includes an "emotional interference" condition, where the letter stimuli are flanked by emotional faces (neutral and fearful conditions). The face stimuli are not directly relevant to the task, but included to assess to what extent emotionality may interfere with working memory performance. The performance measure used on this task was Mathews' Correlation Coefficient (MCC) (Matthews, 1975). The MCC was used because it is the best single number assessment for accuracy in classification tasks like in the N-Back task. The MCC was used in this task and represented a proportional accuracy of participants' performance on the N-Back task (i.e., general accuracy) and a gauge of working memory performance. MCC is an efficient measure of the quality of binary classifications, which takes into account true and false positives and negatives (i.e., correctly/incorrectly identifying correct/incorrect targets on the N-Back) (Mathews, 1975). It is computed by calculating the correlation coefficient between the observed and predicted binary classifications, ultimately producing a value between -1 and +1. A coefficient of +1 represents a perfect prediction, whereas 0 represents a prediction no better than random, and -1 indicates a total disagreement between prediction and observation. The MCC was used because it is the best single number assessment for accuracy in classification tasks like in the N-Back task. It ultimately represents a proportional accuracy of participant's performance on the N-Back task (i.e., participants general accuracy) and a gauge of working memory performance.

## Interventions

An equal number of participants were randomly assigned to each group. Specifically, participants were randomly allocated to the top-down vs. bottom-up conditions (ratio 1:1) immediately upon registration and before further information about the study was sent (i.e., before agreeing to participate by singing informed consent). Both groups had a homework component that asked participants to track the frequency and duration of their at-home practice. Participants in both groups were asked to make at least one entry per day in their practise logs. These logs were submitted at the end of the second testing session. Participants in both conditions received daily reminders via CourseSpaces (an online course-based platform through the University of Victoria) to complete their practise logs. Instructions and interventions were standardized and consistent across participants in each group and the same PI (a PhD student in Clinical Psychology) trained all participants in both groups.

**Cognitive restructuring.** This top-down intervention technique consisted of 1 brief orientation session of cognitive restructuring with the PI, followed by two weeks of daily practice. First, an overview of the technique and the rationale of cognitive restructuring were explained. It was clarified that feelings are not automatically elicited by situations/events per se, but by negative automatic thoughts that people have about the situation/event. The importance of learning to recognize and to change negative automatic thoughts was stressed, and it was emphasized that it is important to realize that there are several ways of looking at the same situation. This was illustrated by means of a standard example used in previous studies of cognitive restructuring (e.g., De Jongh et al., 1995). After the introductory explanation, participants were instructed on how to identify negative automatic thoughts, evaluate these negative thoughts (e.g., "What is the evidence that supports/against this idea? Is there an alternative explanation or balanced viewpoint?"), and generate alternative more balanced ways of thinking. This approach is consistent with previous research (Beck, 2011) and represents a modified version of cognitive restructuring instructions used in previous research (e.g., Deacon, Fawzy, Lickel, Wolitzky-Taylor, 2011). Using a recent situation in which the participant was distressed by a negative automatic thought, the experimenter assisted the participant in challenging this thought by completing the cognitive restructuring form which consisted of the following sections: (a) situation, (b) negative automatic thought, (c) supporting evidence, (d) disconfirming evidence, and (e) balanced conclusion. The experimenter coached participants through this process in an individualized manner. Participants were instructed to practice this cognitive restructuring technique on a daily basis for the upcoming two weeks, during, or immediately following periods when he/she noticed a shift in his/her mood. Each participant was given a supply of record forms and was asked to make at least one entry per day. If participants did not experience any noticeable mood shifts on a given day, they were instructed to complete an entry using a common negative automatic thought they most often experienced. Instructions for the training of this technique (Appendix B) as well as participant instruction can be found in the manual written for this study (see Appendix C).

**Open monitoring mindfulness.** A brief 1-session OM mindfulness meditation technique was taught to participants in the bottom-up intervention group. This brief mindfulness technique was intended to foster acceptance and non-judgment, and facilitate a greater bottom-up attention. Given that the present study wished to test the effects of a bottom-up approach to ER, the OM technique was employed rather than the FA technique, involving a receptive and open monitoring of arousal, sensations, and emotional responses in the body. In addition, OM was specifically chosen because in OM mindfulness practices, the individual is open to perceive and observe any sensation or thought without focusing on a concept in the mind or a focused item (Colzato, Szapora, & Hommel, 2012). In this way, this technique fosters a bottom-up approach as it induces a relatively distributed attentional state that is primarily characterized by weak top-down biasing of information processing (i.e., not actively trying to cognitively restructure thoughts/feelings) and greater bottom-up control (i.e., openness to present experiences as they continuously arise) (Colzato et al., 2012). The technique provided was a recording of a guided meditation by Dr. Tara Brach, a well-known contemporary mindfulness teacher, which was uploaded as a MP3 file on CourseSpaces for participants to download. Participants were given temporary IDs to access these files over the course of the two weeks. Participants were instructed to keep a daily practice journal to indicate how many times a day they were practicing and the duration of their practice. Participants were instructed to maintain an open and non-judgmental attitude toward emotions, thoughts, feelings, memories, and bodily sensations. Thus, the instructions explicitly asked participants to ‘notice and accept’ their internal experience. This description can be considered consistent with the definition of mindfulness as an open monitoring of the whole field of experience (Lutz, Slagter, Dunne,

& Davidson, 2008). Participants spent approximately 25-30 minutes at minimum each day engaging in the specified technique (i.e., mindfulness technique or cognitive restructuring technique). See Appendix B for instructions of technique.

## Experimental Procedure

Participants returned to the Neuropsychology and Rehabilitation Laboratory at the University of Victoria for session 2, which lasted approximately 60 minutes (see Figure 5 for outline of procedures). During this session participants were trained on the appropriate intervention technique described above (see Appendix B for PI's Manuals). Participants practiced the intervention technique for the following two weeks. Finally, participants returned to the lab for the third and final session, which was two weeks following session 2. The procedure for session 3 is identical to session 1 (see Figure 6 for outline).

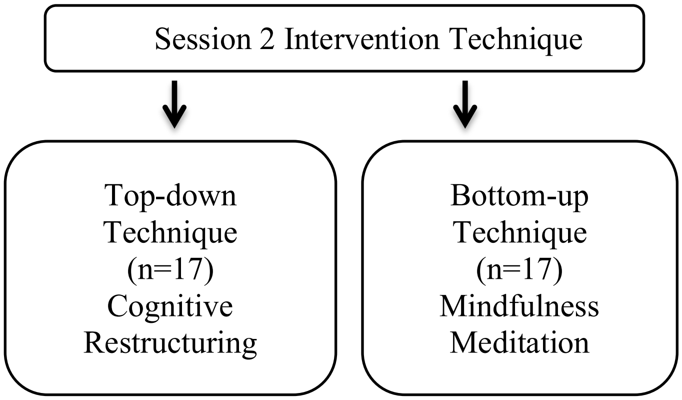

*Figure 5.* Session 2 procedure

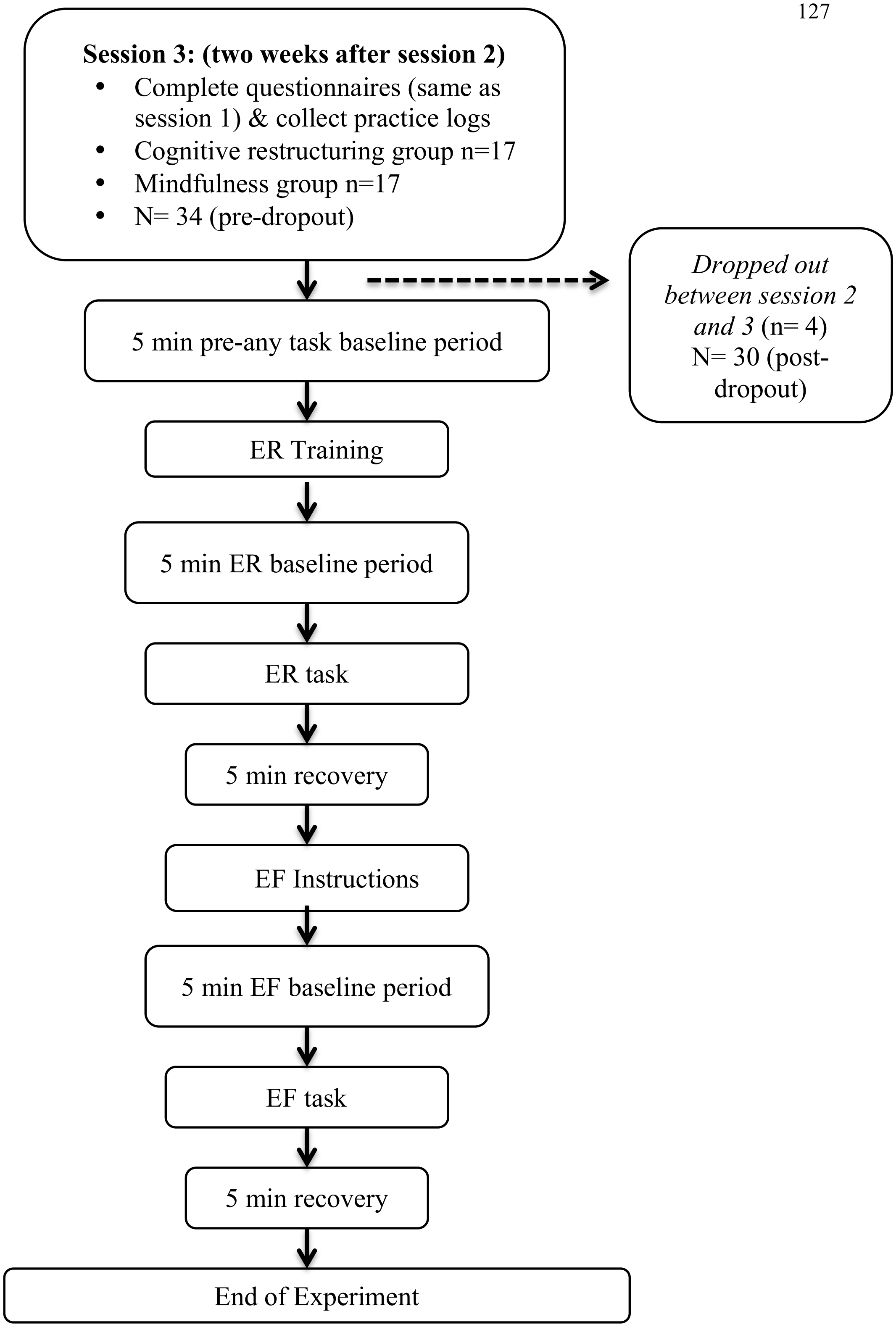

*Figure 6.* Session 3 procedure.

## Statistical Analyses

First, descriptive and inferential statistics were conducted for the entire sample of participants on which complete pre/post intervention data were available (N=30) and are presented in Table 13. To highlight some important areas, the sample exhibited average levels of state anxiety, and high average levels of trait anxiety post-treatment, (previously high end of average range and severely elevated range respectively). Participants endorsed ER difficulties in the high average range; however, this represents a reduction since time 1. Interestingly, participants continued to report the greatest area of concern as being limited access to ER strategies; however, this was significantly reduced since time 1 indicating some self-reported improvement in this area. Participants perceived their overall success on the behavioral ER task to be greater at time 2 compared to time 1. Overall they showed improvements in their interoceptive awareness with highest scores on domains of emotional awareness indicating enhanced awareness of the connection between body sensations and emotional states. Lowest scores were found on a scale measuring the tendency to not worry or experience emotional distress with uncomfortable body sensations indicating that participants in the current sample have most trouble in this area (i.e., show the tendency to worry about uncomfortable sensations in their body). Four subjects data were lost due to attrition. Outlier removal criteria were identical to Study 1.

Two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention) were used to test for intervention effects on each of tonic and phasic HRV. Next, two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention) were used to examine the impact of intervention effects on ER, including overall ER as well as each ER strategy separately (i.e., reappraisal, appraisal, suppression). Two-way repeated measures mixed

ANOVAs (2 Time) x (2 Intervention) were also used to test for intervention effects on each of mean correct-trial RT and response accuracy on the EF N-Back task. Finally, to test for intervention effects on anxiety, two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention) were conducted.

Next, intervention effects on several self-report indices of self-regulation including perceived stress, difficulties with ER, anxiety sensitivity, ER strategy use, trait levels of mindfulness, worry and the ability to control worry, and interoception between the groups was examined. Given the multiple self-report indices used in the current study first correlations between these various self-report variables and the outcome (i.e., intervention) were examined and those variables with significant associations were then tested further using a two-way repeated measures mixed ANOVA (2 Time) x (2 Intervention). Next, stepwise multiple regression analyses were used to determine whether baseline self-report variables predicted response to intervention as measured by the change in participants' scores between time 1 and time 2 for the primary outcome measures including HRV, ER, and EF.

Finally, the present study examined whether the effects of intervention condition on ER was mediated by HRV and/or EF. These variables were chosen as mediators given the relevance to Thayer and Lane's neurovisceral integration model (2000; 2009), which argues that executive control plays an important role in both ER and HRV. In order to test for mediator effects three conditions must initially be met (Barron & Kenny, 1986). First, it needs to be shown that the independent variable (intervention) is related to the dependent variable (ER). Second, the independent variables need to be shown to be related to the mediators (HRV, EF). Third, it needs to be shown that the mediator is related to the dependent variable. Finally, in order to establish the mediator relationship, if the initial three conditions hold in the predicted direction, it needs to be shown that the effect of the independent variable on the dependent variable is either completely (full mediator) or substantially reduced (partial mediator) when controlling for the mediating variables (Barron & Kenny, 1986). Perfect mediation can be shown if the independent variable has no effect when the mediator is controlled.

Table 13

*Descriptive Statistics (Study 2)*

| | *M* | *SD* | *Range (possible range)* |
|---|---|---|---|
| **Self-Report Measures (N=30)** | | | |
| STAI | | | |
| State Percentile | 61.67 | 23.75 | 6-98 (0-100) |
| Trait Percentile | 86.23 | 12.38 | 61-100 (0-100) |
| PSS | 22.47 | 3.19 | 16-30 (0-40) |
| DERS | | | |
| Non-acceptance of Emotional Responses | 14.77 | 5.3 | 6-28 (0-30) |
| Difficulties Engaging in Goal-Directed Behaviour | 16.73 | 4.58 | 9-25 (5-25) |
| Impulse Control Difficulties | 12.7 | 5.23 | 6-24 (6-30) |
| Lack of Emotional Awareness | 13.27 | 3.79 | 7-26 (6-30) |
| Limited Access to Emotion Regulation Strategies | 18.53 | 6.52 | 9-33 (8-40) |
| Lack of Emotional Clarity | 11.17 | 3.77 | 7-24(5-35) |
| Total Score | 87.17 | 23.96 | 51-155 (36-180) |
| ASI | | | |
| Physical | 26.5 | 14.2 | 2-52 (0-24) |
| Cognitive | 5.87 | 5.28 | 0-18 (0-24) |
| Social | 8.47 | 6.48 | 0-22 (0-24) |

| | | | |
|---|---|---|---|
| Total Score | 12.17 | 6.08 | 0-25 (0-72) |
| ERQ | | | |
| Reappraisal | 28.23 | 7.58 | 10-42 (6-42) |
| Suppression | 12.53 | 5.3 | 4-24 (4-28) |
| Total Score | 40.77 | 6.27 | 28-53 (10-70) |
| FFMQ | | | |
| Observe | 28.63 | 6.27 | 14-39 (8-40) |
| Describe | 27.47 | 6.4 | 13-39 (8-40) |
| Awareness | 22.33 | 5.77 | 8-32 (8-40) |
| Nonjudge | 25.31 | 7.22 | 11-37(8-40) |
| Nonreact | 20.5 | 3.83 | 9-28(7-35) |
| PSWQ | 58.83 | 11.47 | 34-80 (16-80) |
| MAIA | | | |
| Noticing | 3.38 | .80 | 1-4.75 (0-5) |
| Non-Distracting | 2.77 | .78 | 1.33-4.67 (0-5) |
| Not Worrying | 2.57 | .75 | .67-4 (0-5) |
| Attention Regulation | 2.76 | .77 | .86-4 (0-5) |
| Emotional Awareness | 3.59 | .76 | 1.2-4.6 (0-5) |
| Self-Regulation | 3.0 | .87 | .75-4.5 (0-5) |
| Body Listening | 2.66 | .95 | .33-4.0 (0-5) |
| Trusting | 3.41 | .92 | .67-5 (0-5) |
| **Behavioural Task Data** | | | |
| Emotion Regulation Task (N=30) | | | (1-5) |
| Sentence Success | 3.84 | 0.64 | 2.93-5 |
| Picture Success | 3.56 | 0.67 | 2.38-4.87 |
| Total Success | 3.7 | 0.64 | 2.66-4.9 |
| Reappraisal Picture | 3.76 | 0.66 | 2.63-4.88 |
| Reappraisal Sentence | 4.09 | 0.59 | 2.8-5 |
| Total Reappraisal | 3.92 | 0.59 | 3.02-4.94 |
| Suppression Pictures | 3.56 | 0.74 | 1.67-4.88 |
| Suppression Sentences | 3.74 | 0.8 | 1.93-5 |
| Total Suppression | 3.65 | 0.74 | 1.8-4.85 |
| Appraisal Picture | 3.45 | 0.78 | 1.94-4.93 |
| Appraisal Sentence | 3.76 | 0.7 | 2.64-5 |
| Total Appraisal | 3.54 | 0.74 | 2.23-4.97 |
| Arousal and Valence Ratings (n=20) | | | (1-5) |
| Sentence Arousal | 2.97 | 0.3 | 2.4-3.67 |

| | | | |
|---|---|---|---|
| Picture Arousal | 3.25 | 0.3 | 2.62-3.91 |
| Sentence Valence | 2.89 | 0.52 | 2.51-4.98 |
| Picture Valence | 2.63 | 0.48 | 1.98-4.33 |
| N-Back (n=29) | | | |
| Accuracy | 0.76 | 0.17 | .32-.98 |
| Reaction Time | 877.27 | 228.06 | 488.43-1522.22 |
| **Physiological Data** | | | |
| HRV (RMSSD; msec) | | | |
| Tonic HRV (n=30) | 36.47 | 25.23 | 6.99-105.4 |
| ER Phasic (n=30) | 1.5 | 8.1 | -14.93-20.59 |
| ER Recovery (n= 29) | -6.06 | -14.95 | -42.59-20.01 |
| N-Back Phasic (n=29) | 0.32 | 14.5 | -65.34-17.11 |
| N-Back Recovery (n=29) | -2.25 | 14.81 | -34.38-55.03 |

*Note:* STAI= State Trait Anxiety Inventory; PSS= Cohen's Perceived Stress Scale; DERS= Difficulties in Regulation Emotion Scale; ASI= Anxiety Sensitivity Index; ERQ= Emotion Regulation Questionnaire; FFMQ= Five Factor Mindfulness Questionnaire; PSWQ= The Penn State Worry Questionnaire; MAIA= Multidimensional Assessment of Interoceptive Awareness; HRV= heart rate variability; RMSSD= root mean square of successive differences

## Results from Inferential Analyses

Firstly, before examining the intervention effects on the outcome variables (i.e., HRV, ER, and EF) the present study evaluated whether there were any differences in adherence between the groups. In general, across both intervention groups, participants engaged in their respective ER technique for an average of 13.77 days and successfully recorded their practice in their practice logs (SD= 2.24; Range 10-20). Examination of differences between the two groups revealed that there were no significant differences in adherence (*t* (28) = -.241, *p* = .812; CR: M = 13.67; SD = 2.41; OM: M = 13.87 SD = 2.13). These results indicate that participants in both groups were compliant and also received the maximal available ‘dose’ of the intervention treatment. Given the number of statistical analyses run in the current study this section outlines only the significant results of Study 2 (see Table 14 for a summary). The interested reader is referred to Appendix E for supplementary materials including a detailed description of all non-significant findings.

Table 14

*Summary of Significant Findings of Study 2*

| HRV | Main Effect | Interaction |
|---|---|---|
| ER Reactivity | | ✓ Time*Intervention |
| N-Back Reactivity | ✓ Age | |
| **Behavioral Tasks** | **Main Effect** | **Interaction** |
| ER: Reappraisal | | ✓ Time * Intervention |
| N-Back Accuracy | ✓Intervention<br>✓Time<br>✓Age | ✓Time * Age |
| N-Back Reaction Time | | ✓Time * Age<br>✓Time * Intervention |
| **Self-Report Measures** | **Main Effect** | **Interaction** |
| Trait Anxiety | ✓Time<br>✓Intervention | ✓Time * Gender |
| Nonjudge | | ✓Time * Intervention |
| Nonreact | ✓Age | ✓Time * Intervention |

*Note:* ✓ = statistical significance; ER= emotion regulation

## Two-Way Repeated Measures Mixed ANOVA Results

**Intervention effects on HRV.** First a two-way repeated measure mixed ANOVA (2 Time) x (2 Intervention) was used to test for intervention effects on each of tonic and phasic HRV, as well as, recovery which is the change in HRV from task/event to post-task/post-event (i.e., recovery = change in HRV from engagement in a stressful task to post-task return to resting state or baseline). Results revealed significant effects for phasic HRV (see Table 15).

***ER reactivity.*** Results showed a significant interaction between time and intervention: $\eta p^2 = .234$, ($F$ (1, 25) = 7.66, $p$ =. 01). Examination of the means indicates that the OM group's HRV significantly increased over time ($t$ (13) = 2.35, $p$ = .04, $d$ = 1.3, $r$ = .55), whereas the CR group's HRV decreased, however did not reach statistical significance ($t$ (14) = -1.43, $p$ = .18, $d$ = -.76, $r$ = .36).

Table 15

*Intervention Effects on ER Reactivity*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>1.5 (6.1) | OM<br>-1.8 (5.8) | CR<br>-2.1 (6.8) | OM<br>5.7 (7.8) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Time | 1 | 139.770 | 2.364 | .137 | .086 |
| Time * Age | 1 | 6.674 | .113 | .740 | .004 |
| Time * Gender | 1 | 77.895 | 1.318 | .262 | .050 |
| Time * Intervention | 1 | 452.559 | 7.655 | .010* | .234 |
| Error (Time) | 25 | 59.118 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Intercept | 1 | 33.823 | 1.150 | .294 | .044 |

| | | | | | |
|---|---|---|---|---|---|
| Age | 1 | 31.262 | 1.063 | .312 | .041 |
| Gender | 1 | 19.115 | .650 | .428 | .025 |
| Intervention | 1 | 76.338 | 2.595 | .120 | .094 |
| Error | 25 | 29.413 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=14); $p < .05$*

***N-Back reactivity.*** Next, the effect of intervention on phasic HRV on the N-Back task was examined (Table 16). One case was identified as an outlier and removed from this analysis. In addition, one observation was lost due to computer acquisition error. Results indicated a significant main effect of age between the groups: $\eta p^2 = .171$, ($F$ (1, 24) = 4.944, $p = .036$). Both groups showed a positive association between age and increased reactivity on the N-Back task.

Table 16

*Intervention Effects on N-Back Reactivity*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR | OM | CR | OM |
| 0.2 (11.2) | 5.0 (10.4) | 2.0 (8.0) | 3.3 (6.8) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | $\eta p^2$ |
|---|---|---|---|---|---|
| Time | 1 | 49.577 | .882 | .357 | .035 |
| Time * Age | 1 | 33.057 | .588 | .451 | .024 |
| Time * Gender | 1 | 13.057 | .232 | .634 | .010 |
| Time * Intervention | 1 | 55.421 | .986 | .331 | .039 |
| Error (Time) | 24 | 56.235 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | $\eta p^2$ |
|---|---|---|---|---|---|
| Intercept | 1 | .000 | .000 | 1.000 | .000 |
| Age | 1 | 509.619 | 4.944 | .036* | .171 |
| Gender | 1 | 113.024 | 1.096 | .305 | .044 |
| Intervention | 1 | 275.280 | 2.671 | .115 | .100 |
| Error | 24 | 103.079 | | | |

*Note:* CR= Cognitive Restructuring (n=13); OM= Open Monitoring (n=15); $p < .05$*

**Effect of Intervention on ER.** Next, two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention) were used to examine the impact of intervention effects on perceived ER success, including overall ER as well as each ER strategy separately (i.e., reappraisal, appraisal, suppression). Significant findings were found for reappraisal of sentences, and total reappraisal. All other ER strategies revealed null results and presented in detail in Appendix E.

***Reappraisal of sentences.*** Results revealed a significant interaction between time and intervention (*F* (1, 26) = 4.157, *p* = .052; $\eta p^2$ = .138). As can been in Table 17, results show that those participants in the CR intervention group showed a greater increase in their perceived ability to successfully reappraise their emotions in response to negative sentences, whereas participants in the OM group showed a decrease in their perceived performance.

Table 17

*Intervention Effects on Reappraisal of Sentences*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.8 (0.4) | OM<br>4.0 (0.6) | CR<br>4.2 (0.5) | OM<br>4.0 (0.7) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | $\eta p^2$ |
|---|---|---|---|---|---|
| *Reappraisal Sentences* | | | | | |
| Time | 1 | .015 | .049 | .826 | .002 |
| Time * Age | 1 | .564 | 1.909 | .179 | .068 |
| Time * Gender | 1 | .810 | 2.743 | .110 | .095 |
| Time * Intervention | 1 | 1.227 | 4.157 | .052* | .138 |
| Error (Time) | 26 | .295 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Reappraisal Sentences* | | | | | |
| Intercept | 1 | 68.496 | 203.616 | .000 | .887 |
| Age | 1 | .036 | .107 | .747 | .004 |
| Gender | 1 | .285 | .846 | .366 | .032 |
| Intervention | 1 | .001 | .003 | .959 | .000 |
| Error | 26 | .336 | | | |

*Note* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15); $p < .05$*

***Total reappraisal.*** There was a significant interaction between time and intervention: $\eta p^2 = .152$; $F(1, 26) = 4.67$, $p = .04$. Results indicate that participants showed different patterns of change from time 1 and time 2 based on the intervention group they belonged to. Examination of group means indicate that for the CR group perceived total reappraisal ability improved, whereas the OM group stayed the same (see Table 18).

Table 18

*Intervention Effects on Total Reappraisal*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.5 (0.4) | OM<br>3.8 (0.5) | CR<br>4.0 (0.5) | OM<br>3.8 (0.6) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Total Reappraisal* | | | | | |
| Time | 1 | .003 | .015 | .904 | .001 |
| Time * Age | 1 | .257 | 1.132 | .297 | .042 |
| Time * Gender | 1 | .617 | 2.712 | .112 | .094 |
| Time * Intervention | 1 | 1.062 | 4.670 | .040* | .152 |
| Error (Time) | 26 | .228 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Reappraisal Sentences* | | | | | |
| Intercept | 1 | 68.496 | 203.616 | .000 | .887 |

| | | | | | |
|---|---|---|---|---|---|
| Age | 1 | .036 | .107 | .747 | .004 |
| Gender | 1 | .285 | .846 | .366 | .032 |
| Intervention | 1 | .001 | .003 | .959 | .000 |
| Error | 26 | .336 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15); $p < .05$*

**Effect of Intervention on Working Memory.** Next, two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention) were used to test for intervention effects on the N-Back working memory task for both response accuracy (measured by Matthew's correlation coefficient) and mean correct-trial reaction time.

Four outliers were identified and removed from this analysis leaving 11 participants in the CR group and 14 participants in the OM group. For response accuracy, results indicated a significant main effect of time ($F$ (1, 21) = 5.015, $p = .036$; $\eta p^2 = .193$) indicating that across both intervention groups, participants' response accuracy improved between time 1 and time 2 (see Table 19). For between-subject effects, results indicated a significant main effect of age ($F$ (1, 21) = 6.939, $p = .016$; $\eta p^2 = .248$), which demonstrates that response accuracy was directly related to differences in age between the groups. Specifically, results showed that for both the CR group (M age= 29.8; Range: 20-60) and OM group (M age= 30.5; Range: 19-63), age was negatively associated accuracy on the N-Back. A significant main effect of intervention ($F$ (1, 21) = 4.958, $p = .037$; $\eta p^2 = .001$) was also found. Examination of group means suggest that overall the OM group had higher accuracy than the CR group on the N-Back task. Results also showed a significant interaction between time and age ($F$ (1, 21) = 5.295, $p = .032$; $\eta p^2 = .201$) suggesting that participants were changing differently between time 1 and time 2 depending on their age. Results revealed a negative association between age and accuracy between time 1 and time

2 (i.e., younger individuals showed greater improvements in accuracy post intervention compared to older individuals).

Table 19

*Intervention Effects on N-Back Accuracy*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>0.73 (0.12) | OM<br>0.79 (0.11) | CR<br>0.73 (0.16) | OM<br>0.84 (0.12) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Accuracy* | | | | | |
| Time | 1 | .037 | 5.015 | .036* | .193 |
| Time * Age | 1 | .039 | 5.295 | .032* | .201 |
| Time * Gender | 1 | .002 | .342 | .565 | .016 |
| Time * Intervention | 1 | .010 | 1.332 | .261 | .060 |
| Error (Time) | 21 | .007 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Accuracy* | | | | | |
| Intercept | 1 | 2.910 | 154.545 | .000 | .880 |
| Age | 1 | .131 | 6.939 | .016* | .248 |
| Gender | 1 | .000 | .017 | .898 | .001 |
| Intervention | 1 | .093 | 4.958 | .037* | .191 |
| Error | 21 | .019 | | | |

*Note:* CR= Cognitive Restructuring (n=11); OM= Open Monitoring (n=14); $p < .05$*

Next, a two-way repeated measure mixed ANOVA (2 Time) x (2 Intervention) was used to test for intervention effects on the mean correct-trial reaction time on the N-Back task (see Table 20 for a summary of results). Results showed a significant interaction between time and age ($F$ (1, 25) = 9.343, $p$ = .005; $\eta p^2 = .27$) suggesting overall, participants were changing differently from pre-intervention to post-intervention depending on their age. Specifically, results demonstrated that younger individuals became faster over time compared to older individuals. Further a significant interaction between time and intervention (*F* (1, 25) = 4.73, *p* = .039 $\eta p^2 = .16$) was found. Examination of sample means indicated that participants in the CR group improved and became faster over time, whereas those in the OM group became slower over time.

Table 20

*Intervention Effects on N-Back Reaction Time*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>933.10 (209.21) | OM<br>879.75 (148.26) | CR<br>858.23 (243.88) | OM<br>895.05 (219.30) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Reaction Time* | | | | | |
| Time | 1 | 12533.779 | 1.020 | .322 | .039 |
| Time * Age | 1 | 114791.117 | 9.343 | .005** | .272 |
| Time * Gender | 1 | 24557.553 | 1.999 | .170 | .074 |
| Time * Intervention | 1 | 58102.427 | 4.729 | .039* | .159 |
| Error (Time) | 25 | 12286.146 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Reaction Time* | | | | | |
| Intercept | 1 | 3549146.84 | 49.568 | .000 | .665 |
| Age | 1 | 91584.465 | 1.279 | .269 | .049 |
| Gender | 1 | 41007.919 | .573 | .456 | .022 |
| Intervention | 1 | 1580.198 | .022 | .883 | .001 |
| Error | 25 | 71601.390 | | | |

*Note:* CR= Cognitive Restructuring (n=14); OM= Open Monitoring (n=15); $p < .05$* $p < .01$**

**Intervention effects on anxiety.** Next we tested for intervention effects on anxiety, utilizing a two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention). This analysis was conducted separately for both state and trait levels of anxiety. One observation was identified as an outlier and removed from this analysis.

***Trait anxiety.*** For trait anxiety, results revealed a significant main effect of time (*F* (1, 26) = 7.104, *p* = .013; ηp$^2$ = .215) indicating that across both interventions, participants reported reductions in their anxiety (see Table 21). The main effect of intervention was significant (*F* (1, 26) = 4.228, *p* = .05; ηp$^2$ = .14), with more significant reductions in anxiety found in the OM group compared to the CR group. There were no significant main effects of age (*F* (1, 26) = .807, *p* = .377; ηp$^2$ = .03) or gender (*F* (1, 26) = .206, *p* = .654; ηp$^2$ = .008). Results also showed a significant interaction between time and gender (*F* (1, 26) = 13.659, *p* = .001; ηp$^2$ = .344). Examination of group means indicated that males showed greater reductions in their anxiety compared to females between time 1 and time 2.

Table 21

*Intervention Effects on Trait Anxiety*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>95.1 (7.3) | OM<br>89.3 (11.4) | CR<br>90.4 (11.9) | OM<br>82.1 (11.7) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Trait Anxiety* | | | | | |
| Time | 1 | 220.589 | 7.104 | .013* | .215 |
| Time * Age | 1 | 14.292 | .460 | .503 | .017 |
| Time * Gender | 1 | 424.134 | 13.659 | .001** | .344 |
| Time * Intervention | 1 | 11.146 | .359 | .554 | .014 |
| Error (Time) | 26 | 31.051 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Trait Anxiety* | | | | | |
| Intercept | 1 | 42860.603 | 228.090 | .000 | .898 |

| | | | | | |
|---|---|---|---|---|---|
| Age | 1 | 151.652 | .807 | .377 | .030 |
| Gender | 1 | 38.643 | .206 | .654 | .008 |
| Intervention | 1 | 794.530 | 4.228 | .050* | .140 |
| Error | 26 | 187.911 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15); $p < .05$* $p < .01$**

**Intervention effects on subjective indices of self-regulation.** Next, the present study examined intervention effects on several self-report indices of self-regulation including perceived stress, difficulties with ER, anxiety sensitivity, ER strategy use, trait levels of mindfulness, worry and the ability to control worry, and interoception between the groups. Means and standard deviations for each of the self-report measures are presented in Table 13. Correlations between the self-report variables and intervention effects were first examined to identify significant relationships that warranted further analyses. The following two variables were the only self-report indices that showed significant associations with intervention effects –the FFMQ Nonjudge ($r = .436$, $p = .018$) and Nonreact subscales ($r = -.447$, $p = .013$). Given the relationships between variables, and the fact that the data included multiple self-report measures pre-intervention and post-intervention, further examinations were conducted on those variables that showed significant associations. Specifically, the present study tested for intervention effects on each of the two self-report indices separately: FFMQ Nonjudge and FFMQ Nonreact utilizing a two-way repeated measures mixed ANOVA (2 Time) x (2 Intervention).

For the FFMQ Nonjudge subscale, results indicated that the interaction between time and intervention was significant ($F$ (1, 25) = 7.765, $p = .01$, $\eta p^2 = .237$). Examination of group means indicated that the CR group showed a decrease in their Nonjudge scores between time 1 and time 2 whereas the OM group showed an increase in their Nonjudge scores (see Table 22 for a summary of results).

Table 22

*Intervention Effects on FFMQ Nonjudge*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>28 (5.7) | OM<br>26.29 (5.9) | CR<br>23.3 (7.0) | OM<br>27.5 (7.1) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *FFMQ Nonjudge* | | | | | |
| Time | 1 | 12.192 | .602 | .445 | .024 |
| Time * Age | 1 | 40.092 | 1.981 | .172 | .073 |
| Time * Gender | 1 | 7.897 | .390 | .538 | .015 |
| Time * Intervention | 1 | 157.151 | 7.765 | .010* | .237 |
| Error (Time) | 1 | 20.239 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *FFMQ Nonjudge* | | | | | |
| Intercept | 1 | 1967.020 | 32.984 | .000 | .569 |
| Age | 1 | 80.916 | 1.357 | .255 | .051 |
| Gender | 1 | 48.490 | .813 | .376 | .031 |
| Intervention | 1 | 32.755 | .549 | .466 | .021 |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=14); FFMQ= Five Factor Mindfulness Questionnaire; $p < .05$*

For the FFMQ Nonreact subscale (see Table 23), results indicated that the main effect of age was significant $F$ (1, 26) = 10.03, $p$ = .004, $\eta p^2$ = .278. Examination of the association between age and FFMQ Nonreact scores indicated that across time and intervention conditions, age was positively and significantly associated with an increase in Nonreact scores over time. The interaction between time and intervention was significant

($F$ (1, 26) = 5.91, $p$ = .022, $\eta p^2$ = .185). Examination of group means revealed that FFMQ Nonreact scores increased in the CR group, whereas they decreased in the OM group.

Table 23

*Intervention Effects on FFMQ Nonreact*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>17.4 (4.27) | OM<br>20.67 (3.6) | CR<br>20.6 (4.21) | OM<br>20.4 (3.56) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *FFMQ Nonreact* | | | | | |
| Time | 1 | 0.279 | .041 | .842 | .002 |
| Time * Age | 1 | 2.711 | .397 | .534 | .015 |
| Time * Gender | 1 | 2.705E-6 | .000 | 1.000 | .000 |
| Time * Intervention | 1 | 40.367 | 5.906 | .022* | .185 |
| Error (Time) | 1 | 6.835 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *FFMQ Nonreact* | | | | | |
| Intercept | 1 | 1324.543 | 70.218 | .000 | .730 |
| Age | 1 | 189.271 | 10.034 | .004** | .278 |
| Gender | 1 | 6.870 | .364 | .551 | .014 |
| Intervention | 1 | 64.703 | 3.430 | .075 | .117 |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15); FFMQ= Five Factor Mindfulness Questionnaire; $p < .05$*, $p < .01$**

Next, the current study examined whether the significant change in subjective correlates of self-regulation listed above (i.e., Nonjudge, Nonreact) predicted objective intervention effects (i.e., outcome variables including HRV, ER, and EF). Results indicated that overall, these self-report variables did not significantly predict the outcome variables including tonic HRV: $F$ (2, 27) = .559, $p$ = .557; $R^2$ = .046; phasic HRV: $F$ (2, 27) = 2.723, $p$ = .085; $R^2$ = .179; performance on the ER task ($F$

(2, 28) = .055, $p$ = .947; $R^2$ = .004), and performance/accuracy on the N-Back task (Accuracy: $F$ (2, 23) = .360, $p$ = .702; $R^2$ = .033; Reaction Time: $F$ (2, 26) = .232, $p$ = .795; $R^2$ = .019).

Stepwise multiple regression analyses were used to determine whether baseline self-report variables predicted response to intervention as measured by the change in participants' scores between time 1 and time 2 for the primary outcome measures including HRV, ER, and EF collapsing across both intervention groups (see Table 24 for a summary of the results). Self-report measures were entered as the independent variables in the regression model. A stepwise procedure was applied for entry and removal of predictors. In this method the predictor that explains the largest part of variance of the dependent variable is the first to enter the model. Subsequently, this predictor is partialed out and the next predictor is selected from the remaining ones according to the same criteria. This procedure is repeated until no significant predictor is left.

First this model with tonic HRV as the dependent variable was examined. Results demonstrated that none of the self-report variables significantly accounted for variance in tonic HRV and consequently no predictors were entered into stepwise linear regression model. Next, the same independent variables were evaluated in predicting phasic HRV (i.e., reactivity) on both the ER and EF tasks. Results provided partial confirmation for specific aspects of self-regulation that were significantly associated with phasic HRV on the ER task. In the first step, the Nonjudge subscale from the FFMQ was entered into the model and best-predicted phasic reactivity on the ER task: ($R$ = .37, $R^2$ = .137; $F$ (1, 28) = 4.27, $p$ = .049). In the second step, the DERS Lack of Emotional Clarity scale was added into the model, and together with the Nonjudge subscale, accounted for the greatest proportion of variance and best-predicted phasic reactivity on the ER task ($R$ = .514, $R^2$ = .264, $\Delta R^2$ = .128; $F$ (1, 28) = 4.67, $p$ = .019). For phasic HRV on the N-Back task, the PSS total score was the only variable entered into the model and best predicted phasic reactivity: ($R$ = .601, $R^2$ = .361; $F$ (1, 27) = 14.68, $p$ = .001). Next, the association between baseline self-report indices of self-regulation and overall perceived ER success as the dependent variable in the model was examined. Findings demonstrated that ASI social concerns subscale was significantly associated with perceptions of overall ER success ($R$ = .47, $R^2$ = .23; $F$ (1, 29) = 8.126, $p$ = .008). The same stepwise regression model was examined with accuracy on the N-Back task as the dependent variable. Results indicated that none of the self-report variables significantly accounted for variance in accuracy on the N-Back task and consequently no predictors were entered into stepwise linear regression model. The last model that was run included N-Back reaction time as the dependent variable, however, results from the stepwise regression analysis indicated that none of the predictor variables were entered into the model, demonstrating that they did not account for a significant amount of variance in participants overall reaction time on this working memory task.

Table 24

*Self-Report Correlates Predicting Response to Intervention*

| | *B* | *SE B* | β | *t* | *p* |
|---|---|---|---|---|---|
| **FFMQ Nonjudge** | -1.057 | 0.375 | -0.51 | -2.821 | **0.009**** |
| **DERS Lack of Emotional Clarity** | -1.196 | 0.563 | -0.384 | -2.123 | **0.043*** |
| **DV: ER Phasic** | | | | | |
| | | | | | |
| **Total PSS** | 1.833 | 0.478 | 0.601 | 3.831 | **0.001**** |
| **DV: N-Back Phasic** | | | | | |
| | | | | | |
| **ASI Social Concerns** | 0.06 | 0.02 | 0.47 | 2.85 | **0.01*** |
| **DV: ER Success** | | | | | |

*Note:* $p < .05$*, < .01**; DV= dependent variable entered in the model; FFMQ= Five Facet Mindfulness Questionnaire; DERS= Difficulties in Emotion Regulation Scale; PSS= Cohen's Perceived Stress Scale; ASI= Anxiety Sensitivity Index; ER= emotion regulation.

**Mediation models.** Finally, regression analyses were used to investigate the hypothesis that HRV and/or EF mediates the relationship between intervention and perceived ER success. Correlations between each of the key variables for the mediation models were examined to ensure that mediation requirements were met. Of note, the three initial conditions, which test for mediator effects, were not met. Specifically, the independent variable (intervention) was not significantly associated with the dependent variable (ratings of perceived success on the ER task). Given that the present study failed to achieve the minimum requirements that need to be met in order to run the full mediation analyses, the models could not be examined any further. Results will be discussed further in the discussion section below.

# Discussion

The aim of Study 2 was to examine whether short-term bottom-up and top-down interventions differentially affected self-regulation in a population of adults with clinically elevated anxiety. The present study examined intervention effects on self-regulation at multiple levels, including physiological (i.e., tonic/phasic HRV), behavioral (i.e., performance on the ER and EF tasks) and subjective (i.e., self-report questionnaires) components. Below is an interpretation of these results.

## Intervention Effects on HRV

**Impact in response to ER task.** The present study did not find significant effects of intervention on either tonic HRV or recovery HRV. This may not be that surprising, given that the intervention used in the present study only spanned over a two-week period. Tonic HRV is generally conceptualized as an individual difference characteristic and is thought to remain relatively stable throughout one's life (Li et al., 2009); as such, it is likely that a two week duration may not have been not long enough to see any significant changes. Another possible explanation is that the current study may have been underpowered to detect a significant effect. Interestingly, however, there was a significant effect of intervention on phasic HRV. Specifically, results demonstrated a significant interaction between time and intervention on phasic HRV (i.e., reactivity) on the ER task such that the CR group showed reduced phasic HRV (i.e., reduced reactivity) whereas the OM group showed significantly increased phasic HRV (i.e., increased reactivity) post-intervention. There has been a growing body of research that suggests that phasic HRV (i.e., reactivity) is associated with the functioning of the vagus nerve; specifically, it is suggested that it is adaptive to show greater vagal withdrawal (i.e., increased reactivity) in the face of a stressor or threat (Thayer & Lane, 2000). This vagal withdrawal is thought to allow for more biologically prepared systems to take hold and allow one's fast acting 'fight or flight' response system to take over (i.e., sympathetic nervous system). This has been seen as evolutionarily adaptive in supporting survival, promoting safety, and generating quick responses when it is appropriate to do so (Schwerdtfeger & Derakshan, 2010; Thayer, Friedman, & Borkovec, 1996). Research suggests that a greater magnitude of change in phasic HRV is a good index of cardiac vagal control, and this is thought to underlie the ability to successfully regulate emotions and respond appropriately (Beauchaine, 2001; Butler, Wilhelm, & Gross, 2006). The results of the current study suggest that the OM and CR intervention resulted in differential changes in phasic HRV post-intervention. It appears that the OM technique facilitated a greater magnitude of change in phasic HRV post-intervention compared to the CR technique. Specifically, individuals in the OM group showed greater vagal withdrawal post-intervention (i.e., enhanced reactivity), whereas the CR showed greater vagal withdrawal pre-intervention (i.e., reduced reactivity).

Of relevance to the current findings, recent research has posed an explanation to account for and understand the meaning of phasic withdrawal particularly seen within the context of mindfulness meditation, including practices directly related to OM techniques. A distinction between arousal and the stress response has been made, which has highlighted the importance of considering context when understanding the interactions between phasic HRV and ER. Specifically, it has been postulated that both of these responses are a result from the activation of the sympathetic system; however, they are not the same phenomenon. Arousal has been described as an energizing function, responsible for harnessing the body's resources, whereas the fight or flight stress response has been described within the context of responding to a perceived harmful event or threat (Canon, 1932). Unlike the mindfulness meditation practices that can foster a relaxation response, OM is unique in that it may generate a different type of response, an arousal response. Arousal is a physiological and psychological state of being awake or responsive to stimuli. OM meditation specifically is grounded in this active state of wakefulness to one's experience. In a recent study by Amihai and Kozhevnikov (2014) the term "phasic alertness" was used to capture these physiological changes. Phasic alertness is described as a significant temporary boost in the capacity to respond to stimuli (Weinbach & Henik, 2011; Sturm et al., 1999; Petersen & Posner, 2012). Much like other meditation practices such as Vajrayana Tantric practices which do not presuppose relaxation (Stutchbury 1998), OM practice has been characterized by an increase in sympathetic activity (Camm et al., 1996; Chess, Tam, & Calaresu, 1975) and results in this state of phasic alertness (i.e., increased reactivity). Although original Buddhist texts (e.g., Pandita, 1995; Gunaratana, 2002; Bodhi, 2012) described meditation practice as aiming to cultivate this state of "relaxed alertness", as Britton and colleagues (2014) suggest, the modern era has artificially imposed this dichotomy between the arousing/wake promoting effects versus relaxing effects of meditation, with much greater emphasis placed on the latter. However, the current study echoes the positions of researchers in the field such as Britton et al. (2014) who acknowledge that mindfulness meditation extends far beyond simple relaxation, but rather involves a continual balance between these two extremes. Thus, in the current study, findings suggest that individuals in the OM intervention group likely developed this state of active wakefulness or “phasic alertness” resulting in greater vagal withdrawal during the emotion paradigm post-intervention. It is likely that during the ER task, these individuals were more attuned to emotional reactions including what was going on for them in their body and as a result experienced increased arousal, not necessarily increased stress; and they were actually better at managing these experiences in an accepting and non-judgmental way.

In contrast, results of the present study suggest that intervention effects on phasic HRV in the CR group actually resulted in reduced vagal withdrawal post-intervention. One explanation for this finding may be that participants in this group were more effective at utilizing CR to regulate their emotional experience, and as a result may not have found the stimuli to be as aversive as they would have had they not received CR intervention. Therefore, that same stress response may not have been activated and as a result did not require vagal withdrawal to stress. It is also possible that these individuals benefited from learning and practicing CR as an antecedent focused ER strategy, whereby the same level of autonomic reaction during the ER task was likely not evoked as a result of efficiently using this strategy. To summarize, with regards to the intervention effects on physiological parameters, results of the current study indicate that post-intervention, the OM group showed greater vagal withdrawal whereas, the CR group showed reduced vagal withdrawal. An important point to consider for interpreting these findings is to understand the context of arousal vs. stress response, and how these two ER techniques function within each.

With regards to physiological reactivity during the N-Back task, the current study revealed a main effect of age on phasic HRV (i.e., reactivity) during the task. Specifically, the study showed that phasic HRV on the N-Back task was directly related to differences in age, independent of intervention, such that increased age was related to increased reactivity (i.e., greater vagal withdrawal and decreased HRV). This finding is consistent with research that shows that HRV tends to decrease both under periods of high workload and as a component of age (Zhang, 2007). As well, it is consistent with the notion that EFs become less efficient with age (e.g., Huizinga, Dolan, van der Molen, 2006; Fjell et al., 2017) and therefore results may have been a function of the cognitively demanding task itself. Reductions in HRV during cognitive tasks are well known and thought to be adaptive (Althaus et al., 1998; Duschek et al., 2008). Generally speaking it is thought that reduced cardiac vagal tone during cognitive engagement in a task helps to establish the most optimal physiological condition that can contribute to optimizing mental functioning (Giuliano et al., 2017). It is widely held that there are individual differences in autonomic regulation, and as seen in the present study, age is one such factor that plays an important role in this association. Vagal withdrawal allows for the establishment of a physiological condition optimal for the mental processes required by the tasks at hand. It is thought that vagal withdrawal reflects an adaptive increase in arousal (i.e., the fight or flight system) to meet cognitive demands, and in the present study that was a challenging working memory task. However, it is important to note that interpretations for the role of phasic HRV remains speculative as this represents a new area of research that is not well understood. Some researchers have suggested that task-related reductions in phasic HRV (i.e., increased reactivity as a result of greater vagal withdrawal) reflect more of a regulated approach to mobilizing energy resources needed to meet the demands of an active cognitive or behavioral task (Porges, 2001; 2007). Consistent with this theory, many studies have found associations between vagal withdrawal and performance on cognitive tasks (e.g., Lenneman & Backs, 2009; Overbeek, van Boxtel, & Westerink, 2014). However, other researchers have found the opposite to be true. That is, a greater increase in phasic HRV (i.e., reduced reactivity) has been found to be associated with better attentional control (e.g., Park, Vasey, Van Bevel, & Thayer, 2014). It has been suggested that the relative value of withdrawal versus increase in vagally mediated HRV may depend on the nature of the task at hand and/or the nature of the sample (Park & Thayer, 2014). For instance, several studies have shown that when the experimental task demands involve regulation of negative affect, better ER is typically associated with increases in HRV (i.e. reduced vagal withdrawal; e.g., Thayer & Brosschot, 2005; Melzig, Weike, Hamm, & Thayer, 2009). This may help to explain that although older individuals in the current study showed greater vagal withdrawal on the EF task, this was not associated with increased accuracy. Therefore, in the context of the working memory task, which included both cognitive and affective components (i.e., aversive faces as distractors), although older individuals showed greater reactivity and in theory may have facilitated optimal resources to perform on the cognitive task, this may not have protected them against the affective distractors and thus resulted in poorer accuracy compared to younger individuals. Thus, it may be in part related to the fact that greater vagal withdrawal did not necessarily infer an optimal state of task engagement for these individuals, but instead may have made these individuals more susceptible to the affective components on this task resulting in reduced accuracy.

Interestingly however, the present study failed to find a significant main effect of intervention and time, or a significant interaction between time and intervention on the N-Back task. This may seem surprising, given that one may expect individuals to show reduced reactivity and improved performance from merely receiving repeated exposure to this challenging working memory task. However, the current study failed to show this change. One consideration that should be made when interpreting these findings includes the fact that the N-Back task was administered at the end of each session. Thus, participants may have been more susceptible to the effects of fatigue, reduced attention and/or reduced effort. On the one hand the absence of expected practice effects may suggest the possibility of insufficient effort, however, on the other hand one prior exposure may not have been enough within this clinical sample of adults with anxiety disorders to detect significant changes. Future work should counter balance the administration of cognitive and/or emotional tasks in order to minimize the impact of these extraneous factors on performance and better account for how the nature of the task may impact HRV. Current research typically examines phasic HRV within the context of cognitive or affective tasks separately, which makes interpreting the lack of significant findings in part challenging. The current study examined emotional reactivity on a complex and stressful task that required *both* cognitive and emotional processing. Given that previous research has suggested that the nature of the task itself (e.g., cognitive and/or affective) may actually moderate the direction of physiological change (Park & Thayer, 2014) future work in this area is needed. Thus findings of the present study highlight the importance of not only considering the magnitude of change in phasic HRV, but also the context in which the change is occurring (e.g., cognitive and/or affective components).

## Intervention Effects on Emotion Regulation

Collapsing across method of emotion generation and regulation, and examining perceived ER as a whole, the current study failed to find any significant differences between the two intervention groups. However, intervention effects on the use of specific ER strategies to regulate negative emotion were examined, a significant association was uncovered for total reappraisal. Specifically, the present study found that the CR group showed increased perceived ER success when utilizing cognitive reappraisal to regulate their emotions, compared to the OM group post-intervention. This finding is consistent with the hypotheses of the study and represents a validity check of the effect of the CR intervention between time 1 and time 2, given that reappraisal would be expected to improve with the application of CR. Overall, the present study demonstrated near-transfer effects of teaching participants in the CR group to utilize cognitive reappraisal as an ER strategy, and over time, these individuals in fact got better at utilizing this strategy, and showed an increase in their perceived ER success. Therefore, in general, teaching individuals with clinically elevated levels of anxiety to use CR as an adaptive ER strategy appears to be helpful, and this is consistent with what has been found in previous research (e.g., Goldin et al., 2017). Interestingly, the current study also found a significant effect of intervention on reappraisal of sentences in particular (i.e., reappraisal of top-down generated emotion). Results demonstrated that the CR group showed increased perceived success, which functions as a validity check on this intervention. By contrast, after the OM group completed their bottom-up focused intervention over the two weeks, they actually showed decreased perceived success in utilizing the top-down ER strategy. Of note, a point that should be taken into consideration when interpreting the findings above includes the level of education of participants' in the present study. The current sample largely consisted of individuals with (or in the process of obtaining) a post-secondary education or a more advanced degree. Thus, it is possible that individuals with higher levels of education and presumably greater verbal cognitive abilities may have utilized CR more successfully given the cognitive demands and abstract reasoning involved in this technique. As such, future replications of this work should examine whether the effects reported here differ within low education samples.

With regards to expressive suppression, the current study did not find significant effects of either intervention on this ER strategy. The lack of any effects for the suppression condition represents another intervention check for the current study given the fact that neither group was taught to suppress their emotions. Instead, each group was taught to actively engage in their emotional experience, albeit in different ways. What is surprising, however, is the fact that the current study also failed to find any significant effect of intervention on perceived ER success when utilizing appraisal as an ER strategy, despite appraisal being an aspect of the OM condition. The lack of significant findings in this case may be a function of the complex nature of appraisal as an ER strategy. For instance, drawing on the field of mindfulness meditation, it is typically the case that with novice meditators, practitioners often have to gain proficiency first in FA practices, which are seen as a stepping stone to engage in OM (Lutz, Slagter, Dunne, & Davidson, 2008). Recall that FA involves close placement of attention on the breath or some other object (e.g., the body) and letting go of everything else that might tend to attract attention such as bodily sensations, environmental noise, or distraction thoughts. Simply speaking, one's attention is actively redirected back to the focus point. On the other hand, in OM the individual is open to perceiving and observing all experiences including any sensation or thought, without the active focusing of attention on any one item. Empirical evidence shows that FA is associated with increases in attention and executive control (Brefczynski-Lewis et al., 2007; Carter et al., 2005; Goldin & Gross, 2010). By contrast, OM involves a more diffuse awareness of one's breath or body and being fully in the present moment with an overall sense of receptivity to stimuli that are arising internally and externally and often is associated with increased arousal and emotional experiences. A greater use of OM seems to be found in more experienced practitioners (Hasenkamp & Barsalou, 2012; Chiesa, Serretti, & Jakobsen, 2013). Therefore, it may be that the complexity of this strategy and the two-week duration was not long enough to see significant changes in this clinical sample, who, by the nature of their psychopathology, often has significant challenges appraising and/or relating to their emotional experiences in an adaptive way. An alternative explanation may be that although efforts were made to teach and practice using OM, it may have functioned more of a FA technique for some given that these individuals were beginners, and perhaps more reliant on the audio recorder to guide their practice as opposed to the natural practice of OM which would typically be self-guided.

It bears mentioning that, despite the absence of self-report findings, in the current study significant effects were found for OM at a physiological level. As mentioned in the preceding section, this group showed greater vagal withdrawal post-intervention on the ER task (i.e., greater reactivity), which is seen as adaptive. However, when it comes to *perceptions* of ER success (i.e., how successful participants thought they were at regulating their emotion), the present study did not find any significant intervention effects on appraisal (i.e., no significant differences between the two groups). Interestingly, these findings demonstrate that there seems to be promising benefits from this type of bottom-up ER strategy at least at a physiological level; however, it may be one's thoughts and/or beliefs that get in the way of practicing and building confidence in utilizing this type of ER strategy. With regards to the CR group, it makes sense that there was no significant change between time 1 and time 2 on appraisal indices, given that CR is the active application of a specific ER strategy, whereas appraisal can be seen as the opposite. As mentioned previously, appraisal has typically been viewed as a control condition in empirical studies on emotion. It has only been recently that researchers are actually considering appraisal to be a distinct strategy for emotional regulation, when in fact it is a core component of many third-wave therapies such as MBSR, MBCT, DBT, and ACT. Although the present study did not find any significant effects on the behavioral ER task, it did show small changes albeit non-significant, in perceived ER success in both groups, which speaks to the potential for appraisal as a strategy to be taught and practiced in the future to help support individuals with clinically elevated levels of anxiety. However, it is clear that more work in this area needs to be conducted in the future.

Another central point to consider from the findings of the current study includes recognizing the utility of multi-method approaches to studying psychological and behavioral phenomenon. As can be seen in the current study, by relying solely on self-report indices the current study would have failed to capture the important nuances and complexity of self-regulation among individuals with clinical anxiety. This idea has been echoed within cognitive rehabilitation literature that often discusses neural and behavioral changes before self-reported change is made, including even basic self-awareness of such changes. In the present study, it is striking that with regards to perceived ER success, the only intervention effects that were found were for cognitive reappraisal ability. However, when this association was explored at a deeper level, significant findings were revealed at a physiological level indicating that changes were occurring even within the OM group who had not been exposed to CR training but rather engaged in training more closely aligned with an appraisal approach to regulating emotion. Thus, the main message is this: relying solely on self-report measures may underestimate significant intervention effects. Future studies should work to harmonize subjective, behavioral, and physiological parameters when assessing and treating individuals with various psychopathological disorders including anxiety. By doing so researchers can begin to capture a more comprehensive picture of self-regulation within the context of various presenting illnesses and in turn maximize the quality of care and treatment these individuals are receiving.

## Intervention Effects on Working Memory

The current study showed significant intervention effects on working memory including both accuracy and reaction time parameters. With regards to accuracy, the present study found a main effect of time indicating that across both intervention groups participants performed more accurately on the working memory task between time 1 and time 2. The present study also showed a main effect of age, such that age was negatively associated with accuracy on the working memory task (i.e., younger individuals were more accurate). A significant interaction between time and age revealed that younger participants showed greater improvements in their accuracy over time compared to older participants. This result is consistent with well-known age-related changes in working memory within the literature; increases in age are often associated with decreases in working memory (e.g., McEvoy, Pellouchoud, Smith, & Gevins, 2001; Wang et al., 2011). Interestingly, as discussed in the preceding section, older age was not only associated with reduced accuracy on the working memory task, but also with increased reactivity (i.e., reduced phasic HRV) as discussed in detail above. Findings of the present study also showed a main effect of intervention. Overall, the OM group showed higher accuracy than the CR group. With regards to the effect of intervention on participants' reaction times, a significant time by intervention interaction was found. Specifically, over time the CR group became faster, whereas the OM group became slower. A significant interaction between time and age revealed that younger participants overall became faster over time.

Taking the accuracy and reaction time results together, findings suggest that the CR group became more efficient in their performance on the working memory task post-intervention. They performed faster and maintained their overall level of accuracy. These results are in line with the hypotheses and represent another intervention check, given the fact that the CR is a top-down technique, which resulted in improvements in working memory. These results are consistent with literature that suggests an important link between CR and executive functions including working memory (Andreotti et al., 2013). Working memory was explicitly chosen as the index of executive functions in the current study given its central importance across ER strategies. For instance, CR requires reappraising or reframing a stressful situation by thinking about it in ways that are less distressing and requires working memory abilities (e.g., Campbell et al., 2009; Ochsner & Gross, 2007; Schmeichel et al., 2008). Thus, by practicing CR over a two-week period it appears that participants in this group were able to improve both their CR abilities but also their working memory abilities (i.e., increased efficiency). This makes conceptual sense given that working memory is thought to play a critical role in the reappraisal process, thus showing an important association between these processes (Schmeichel et al., 2008). Further, research suggests that regions involved in CR show a significant overlap with prefrontal areas in the brain that underlie working memory abilities, and appear to become activated on brain scans during tasks of cognitive reappraisal (Ochsner & Gross, 2008). Therefore, it is likely that as a result of the intervention, participants were able to more efficiently utilize their working memory abilities as a result of having practiced a technique heavily reliant on these higher order cognitive abilities. On the other hand, for the OM group, the present study showed that although participants in this group took more time to react, they were more accurate. Again this highlights the relevance of working memory as an executive component underlying the ER technique. This finding is consistent with the mindfulness maxim of learning, which is based on the idea to "respond, not react". For example, a recent study by Smart and Segalowitz (2017) highlighted this idea of responding and not reacting, and showed that mindfulness training was associated with improved performance monitoring (and reduced anxiety) in older adults. These findings are also consistent with a recent systematic review by Chiesa and colleagues (2011), which demonstrated improvements in working memory as a result of mindfulness meditation practice. To summarize, the findings of the current study illustrate the positive impact of the CR intervention condition on participants' working memory abilities, as measured by performance on the N-Back task. These findings shed light on the importance of speed-accuracy tradeoffs, and within both groups although to a different degree, the current study found improvements resulting either in increased speed or increased accuracy. These findings drill down into the nuances of cognitive efficiency and the speed-accuracy tradeoff. The CR group seemed to favor faster responses but not necessarily more accurate, whereas the converse is true for OM.

## Intervention Effects on Anxiety

With regards to intervention effects on anxiety, the present study showed a main effect of time suggesting that participants showed a significant reduction in their self-reported anxiety post-intervention, regardless of the particular intervention condition. Results also demonstrated a main effect of intervention, indicating that the two intervention groups were different overall. Overall, the OM group had lower anxiety compared to the CR group. Finally, a significant interaction of time and gender on anxiety was found. Specifically, males showed a greater decrease in their reported levels of anxiety compared to females. Of note however, the current sample was predominantly female and should be replicated with a better gender representation. Findings of the present study are in line with previous research supporting the beneficial effects of both mindfulness (Goyal et al., 2014; Smits, Berry, Tart, & Powers, 2008) and CR (Olatunji, Cisler, & Deacon, 2010) on anxiety symptoms. Further, results highlight the beneficial effects of using these short-term ecologically valid intervention strategies in supporting individuals with clinically elevated levels of anxiety regulate their emotions more effectively. This finding is consistent with what was hypothesized in the present study and shows beneficial impacts of both CR and OM for this clinical population. The important observation, then, is that it seems short-term interventions including CR and OM could positively impact an individual's psychological state, but interestingly, OM mindfulness meditation led to greater enhancements on subjective measures of anxiety.

## Intervention Effects on Self-Reported Self-Regulation

In addition to physiological and behavioural changes in self-regulation, the current study also sought to examine whether there were intervention effects on subjective indices of self-regulation as measured by responses on various self-report questionnaires. Overall, the results demonstrated a significant effect of intervention on two subscales of specific self-report measures. Firstly, the present study found a significant interaction between time and intervention on the Nonjudge subscale of the FFMQ. This mindfulness subscale is thought to represent the non-judging of inner experience, and involves adopting a less critical and non-evaluative viewpoint towards thoughts and feelings. Higher scores on this scale indicate greater levels of mindfulness. Results demonstrated that the CR group's score on this subscale decreased, whereas OM group's score increased post-intervention. This is consistent with what was hypothesized based on the nature of the intervention techniques employed in this study. CR involves taking more of an evaluative lens for instance, being able to evaluate evidence for and against a negative thought and generating an alternative, more balanced thought. Within this technique individuals are learning how to evaluate their thoughts as a way of decreasing their negative emotions. Thus, decreased scores on this subscale (i.e., indicative of greater judgment and evaluation of emotional experience) are consistent with what was hypothesized because in essence, they are doing the exact opposite within this ER approach. On the other hand, OM as an ER technique involves adopting more of a non-judgmental perspective and instead of actively applying a strategy to explicitly evaluate their emotional experience, they instead learn to become more mindful and accepting of their emotional response in that moment. Interestingly, research has demonstrated that higher non-judging is associated with lower anxiety (Cash

& Whittingham, 2010), which highlights positive effects of OM as an intervention for anxiety disorders. Post-hoc analyses revealed that the non-judging of emotional experience was negatively and significantly associated with anxiety. Thus, adopting a non-judgmental and less critical approach to emotional experiences is associated with lower levels of anxiety. Interestingly these findings are consistent with what the current study showed within the physiological domain, specifically the trending association that was discussed earlier, whereby the Nonjudge subscale was trending towards significantly predicting phasic HRV. Recall that in the preceding sections the present study showed that phasic HRV decreased in the CR group (i.e., reduced reactivity) whereas the OM group showed increased phasic HRV (i.e., increased reactivity) post-intervention, and here the OM group was also associated with non-judgment toward their inner experiences, which taken these findings together conceptually makes sense.

Secondly, the present study also found intervention effects on the Nonreact subscale on the FFMQ. The current study specifically showed a significant main effect of age whereby age was positively associated with scores on the Nonreact subscale. Thus, older individuals were associated with a better ability at adopting a non-reactive response toward their inner experience. Results also revealed a significant interaction between time and intervention whereby Nonreact scores increased in the CR group, however decreased in the OM group. The Nonreact subscale represents non-reactivity of inner experience, which refers to the tendency to allow thoughts and feelings to come and go, without getting caught up in or carried away by these. This finding was surprising given that the CR group showed increased scores on this subscale whereas the OM showed decreased scores on this subscale. This finding may be indicative of the level of difficulty that is inherent within the

OM intervention technique for meditation-naïve practitioners. It makes conceptual sense that by engaging in such a challenging technique which works to increase one's awareness of multiple aspects of their emotional experience including physiological responses, participants in turn may have felt more reactive toward these experiences. This may especially be true within this clinical sample. For instance, research has long suggested that individuals with anxiety disorders often disconnect from their bodies and are not always accepting of, or aware of physiological body-based symptoms (e.g., see Domschke, Stevens, Pfleiderer, & Gerlach, 2010 for a review on these topics). There is often avoidance of or hypervigilance towards these physiological reactions. Thus, it makes sense that by becoming more aware, there would likely be an increase in the level of reactivity, at least initially, especially if this is something new for an individual who has longstanding clinically elevated levels of anxiety who perhaps may have habitually suppressed such emotional responses throughout their lives. It also speaks to the fact that certain techniques including OM, can lead to heightened awareness or attention to internal cues of anxiety (Baer et al., 2008; Craig, 2003). Thus, observing at such a heightened level, as was the case in the OM group, may have contributed to increased interoceptive awareness and thereby to an increase in anxious arousal in these individuals, ultimately accounting for why the present study found decreased scores on the Nonreact subscale in this group.

Another potential explanation for this finding includes the idea of potential adverse effects of mindfulness. There has been research to suggest that in some individuals, a paradoxical anxiety reaction can be triggered in response to relaxation (Heide & Borkovec, 1983). This may have had some influence in the current study, given that qualitatively, several participants stated to the PI during the experimental paradigm how challenging it was to sit and “do-nothing”. Another possible explanation for this finding includes the fact that the duration of 2 weeks may not have been long enough of an exposure to the OM technique to see a significant decrease in self-reported reactivity. This makes conceptual sense if we think about the typical window of time for treatment such as systematic desensitization for example. In essence, OM could be considered a form of interoceptive exposure, and like all exposure activities, there may have been a temporary increase in aversive experience before this aversive response is extinguished. Longer time-periods with this intervention may reveal an eventual increase in non-reactivity as the exposure becomes less aversive. On the other hand, it is likely that within the CR group, individuals may have taken more of a cognitive approach (i.e., utilizing cognitive restructuring more frequently) to regulating their emotion. Utilizing this ER technique effectively allows an individual to by-pass increased arousal and emotional reaction, by way of regulating or restructuring the way they are thinking about the negative stimuli before their full emotional response is elicited. Thus, no wonder participants in the CR group showed the ability to not-react to their emotional experiences post-intervention.

The present study also examined whether any of the baseline subjective self-report measures predicted response to intervention, defined as the change in the outcome measures between time 1 and time 2. Firstly, results from the stepwise regression revealed that the FFMQ Nonjudge subscale and Lack of Emotional Clarity subscale of the DERS, significantly predicted phasic reactivity on the ER task. Specifically, the FFMQ Nonjudge subscale was found to be negatively and significantly associated with phasic HRV. As discussed in the preceding section, this mindfulness subscale is thought to represent the non-judging of inner experience, and involves adopting a less critical and non-evaluative viewpoint towards thoughts and feelings. Phasic HRV as an outcome in this model represents the change in phasic HRV between time 1 and time 2. Thus, this negative association indicates that those participants with greater non-judgment toward their inner experience at baseline showed reduced vagal withdrawal (i.e., reduced emotional reactivity) post-intervention. This makes conceptual sense, given that in order to be able to effectively self-regulate, one has to be non-judgmental of what one is experiencing. This suggests that for individuals with clinically elevated levels of anxiety, mindfulness including being accepting and less critical of one’s emotional experience may decrease physiological reactivity resulting in more effective and flexible responding.

Interestingly, the Lack of Emotional Clarity subscale on the DERS was also negatively and significantly associated with phasic reactivity on the ER task. Higher scores on this ER subscale are thought to represent a lack of emotional identification or clarity. This finding indicates that those participants who showed a greater lack of clarity about the nature of their emotions at baseline predicted reduced emotional reactivity post-intervention. These results may not be surprising, given that a lack of clarity around emotional experiences are common in anxiety disorders, which often lead to uncertainty and fear of emotional experiences (Chalmers et al., 2014). Thus, it makes sense that a greater lack of clarity of one’s emotional experience would be associated with greater emotional reactivity and reduced HRV given that these individuals would likely be functioning in a hyper-vigilant manner which is common among anxiety disorders. The present study showed that individuals’ with poor emotional clarity were associated with reduced HRV (i.e., greater emotional reactivity). These findings are consistent with previous research that has shown low HRV is associated with poor self-regulatory capacity and hyper-vigilant responses (Friedman, 2007; Thayer et al., 2009; Thayer & Lane, 2000). Given that those participants who reported greater difficulty understanding their emotions at baseline were associated with reduced emotional reactivity (i.e., reduced vagal withdrawal) post-intervention, future work may want to consider this component of ER when determining avenues for treatment within anxiety disorder populations. Results also revealed that higher levels of perceived stress were associated with greater emotional reactivity on the N-Back task (i.e., phasic HRV). These results demonstrate that participants with higher stress levels showed greater emotional reactivity on the N-Back task, a stressful working memory task. These results indicate the potential for high levels of stress was associated with greater emotional reactivity on the working memory task. There is a wealth of research to support the idea that an optimal amount of stress may be ideal for supporting effortful cognitive engagement, however, when those levels become too high, it can be maladaptive. Thus, it is unsurprising that individuals who reported higher levels of perceived stress showed greater emotional reactivity (i.e., greater vagal withdrawal and lower HRV) on the N-Back task. Results also demonstrated that anxiety related to social concerns, (i.e., scores on the ASI social concerns scale) significantly predicted total perceived success on the behavioural ER paradigm. That is, individuals who reported higher levels of social anxiety (e.g., fear of publicly observable anxiety reactions) reported higher levels of perceived ER success on the ER paradigm. This finding is interesting and indicates that perhaps participants were performing in a more desirable way as a function of the anxiety they may have experienced in participating in the experiment. Although this task was executed individually, in a room free of distractions, individuals did interact with the primary investigator at the beginning of the session to go through the task instructions and practice phase. This may have increased levels of anxiety in that moment and perhaps to more effort or engagement on the ER task. Overall, these findings shed light on the importance of examining diverse facets of self-regulation in anxiety disorders. These findings also highlight the potential utility of targeting these specific components of self-regulation within interventions for anxiety disorders.

## Meditation Model

Results of the current study sought to investigate whether HRV and/or EF mediated the relationship between intervention and ER. However, the initial meditation conditions that are required to be met before testing the full model did not hold. Specifically, intervention was not significantly and directly associated with perceived ER success on the behavioral paradigm. These non-significant findings are actually consistent with the above discussion. Specifically, the present study indicates that it may not be a direct or simplistic 1:1 relationship between intervention and perceptions of ER ability and success. Instead, it appears that there are several layers and dynamic interactions that exist between the multiple facets of self-regulation including behavioral, physiological, and subjective parameters. It is within these complex interactions that the present study has begun to unfold better understanding self-regulation within the context of adults living with clinically elevated levels of anxiety.

These non-significant findings also shed light on a far greater and more crucial point to consider. The dissociation between objective behavior, self-report, and psychophysiological measurements in the current study is remarkable. The research findings in the present study bring up important questions including the utility of self-report alone, given that this is typically the approach to measuring response to treatment in current standard clinical practice. Findings from the current study suggest that other markers may be more sensitive to change (e.g., behavioral, physiological change), and thus deserve greater acknowledgement. Navigating the unique associations and dissociations between multiple methods of assessing and treating self-regulation deficits including objective behavior, subjective report, and psychophysiological appear to be more representative of the complexities underlying the pathogenesis of clinical anxiety. This study shows support for the efficacy of multi-method approaches to assessment and intervention, and identifies the need for future studies to consider this approach to studying psychological disorders. Specifically, future clinical studies should not rely merely on self-report and assessments by clinicians (which often primarily rely on clients' self-report), but also incorporate biological and behavioral efficacy measures.

## Limitations and Future Directions

The present study outlines the impact of two short-term intervention techniques on multi-modal aspects of self-regulation in a sample of adults with clinically elevated levels of anxiety. Despite these contributions, there are some limitations of the current study that should be addressed in future research. First, the sample was fairly homogenous in terms of gender, with the majority being female. Although the effects of gender on self-regulation are most consistently reported in children prior to the onset of puberty, there are mixed results in adults (Hosseini-Kamkar & Morton, 2014), and this may place constraints on the generalizability of this study. Future studies should apply this approach to examining self-regulatory ability amongst clinical anxiety by recruiting a sample with a better representation of genders.

Second, it was an intentional choice to examine persons with clinically elevated anxiety as a whole as this is more representative of typical presentations of this diagnostic group (i.e., because of high comorbidity among anxiety disorders). That said, it may be useful to examine this integration of behavior, physiology, and subjective experience as it pertains to self-regulation within specific diagnostic categories. Although across anxiety disorders, a core underlying element includes an exaggerated appraisal of threat (Beck & Haigh, 2014), differences exist in the content and triggers of anxiety across each disorders (Cisler, Olatunji, Feldner, & Forsyth, 2010; Rosellini, Boettcher, Brown, & Barlow, 2015). Moreover, results of the present study demonstrate the complexity of the experience of anxiety including subjective, behavioral, and physiological parameters, and it is possible that the interaction of these factors may evolve differently within specific anxiety disorders. Due to a lack of research in this area, definitive conclusions cannot yet be made. However, prior research has demonstrated that HRV is reduced across anxiety disorders, yet it remains unclear whether specific symptoms characteristic to the anxiety disorders or the disorder itself are characterized by the most robust associations, and thus future research is warranted (Chalmers et al., 2014; Chalmers, Heathers, Abbott, Kemp, & Quintana, 2016). Therefore, the multi-methodological design used in the current study should be explored and replicated within specific anxiety disorder categories in order to allow for a greater understanding of how the relationships among these factors may change depending on the specific diagnosis. Future researchers may also wish to replicate the present study with a non-anxious control group in order to determine whether the effects found in the present study are unique to anxiety disorder populations or can be applied more broadly. Similar to the treatment specific protocols that exist for various anxiety disorders (e.g., treatment for phobias vs. generalized anxiety), this research can help to elucidate how subjective, physiological, and behavioral symptoms of self-dysregulation present and how they are maintained within pathological anxiety.

Finally, the choice to utilize CR and OM for the purpose of isolating top-down and bottom-up intervention techniques was deliberate. That said, it is recognized that there may be limitations in choosing such an advanced bottom-up technique within a group of novice meditation practitioners. It has been argued that most meditative techniques lie on a continuum and involve some combination of FA and OM (Lutz et al., 2008), and the impact of mindfulness practices can vary depending on the expertise of the practitioner (e.g., novices compared to expert meditators; e.g., Chiesa, Serretti, & Jakobsen, 2013). It has been suggested that expert practitioners garner the ability to flexibly shift between these mindful and concentrative types, and at various points use both top-down and to a greater extent, bottom-up processing (Chambers et al., 2009; Chiesa & Malinowski, 2011; Chiesa, Serretti, & Jakobsen, 2013). Therefore, at some level the complexity of these bottom-up practices make it challenging to isolate and study within a research context.

## Summary and Implications of Study 2

The major strength of Study 2 is that it is the first to examine how short-term bottom-up and top-down interventions differentially affected physiological (i.e., both tonic and phasic HRV), behavioral (i.e., performance on a stressful EF and ER task) and subjective (i.e., self-report questionnaires) indices of self-regulation within the same study of adults with clinically elevated anxiety. Given that emotions are multi-faceted processes (Bradley & Lang, 2000), we have the opportunity to assess their regulation through multiple channels including self-report, behavioral observation and performance, and physiological responses. The current study showed that HRV is one tool that is especially useful within the context of anxiety disorders, and has several clinical implications including the ability to inform early intervention, prognosis, and treatment. This is significant for several reasons. Anxiety disorders are the most prevalent psychiatric disorders (Kessler & Greenberg, 2002; Kessler et al., 2005), and one of the most costly (Kessler & Greenberg, 2002). Anxiety disorders also increase the risk of cardiovascular disease three- to fourfold, whereas risk of cardiac mortality is increased twofold (Janszky, Ahnve, Lundberg, & Hemmingsson, 2010; Roest, Martens, de Jong, & Denollet, 2010; Shibeshi, Young-Xu, & Blatt, 2007). Considering that reductions in HRV predict adverse future events (Thayer, Yamamoto, & Brosschot, 2010), findings of this study have important implications for facilitating future health of individuals with a diagnosis of anxiety. Accordingly, by showing that short-term brief intervention techniques have the potential to impact self-regulation deficits in anxiety disorders at multiple levels, including subjective experiences of anxiety, physiological changes, and perceived success at ER, the present study has begun to bridge this gap between theory and practice, and have hopefully taken an important first step toward addressing these ongoing difficulties. Finally, given that there is often a substantial lag between onset of symptoms and treatment in individuals suffering with an anxiety disorder, the need to find ecological short-term intervention strategies is crucial. Thus, the present study demonstrated that active ingredients of well-known treatments for these disorders have a strong potential to ameliorate decreases in phasic HRV. This is especially important given that interventions leading to increased HRV (e.g., cardiovascular risk reduction strategies including physical exercise, smoking cessation, and dietary changes) and the alleviation of psychiatric symptoms appear to lower the risk of future morbidity and mortality (Chalmers et al., 2014). Despite this, short-term interventions targeting HRV for individuals with anxiety disorders remains quite limited despite the longstanding traditions in viewing somatic and psychological states as being deeply interconnected (Thayer & Lane, 2009), and thus worthwhile targets of treatment.

Existing mainstream psychological interventions often focus more on top-down management of anxiety through methods like cognitive restructuring (i.e., as used in CBT), which would be commensurate with lack of prefrontal activity in anxiety, and Thayer and Lane's (2000; 2009) emphasis on the role of the PFC for modulating effective autonomic arousal. This largely echoes traditional treatments that have addressed only psychological as opposed to physiological or somatic symptoms (Odgen, Minton, & Paine, 2006; van der Kolk, 1994). Another approach could be to examine the impact of interventions that work on autonomic response from the bottom-up in changing affect and cognition. This underscores a gap in the field's knowledge and therefore, represents a critical point for further inquiry, although the emergence of interoceptive exposure (Boettcher, Brake, & Barlow, 2016) as a specific technique within CBT, as well as somatically-focused psychotherapies (e.g., Somatic Experiencing, Hakomi therapy) may herald further advancements in this area.

This study showed support for both bottom-up and top-down approaches to supporting self-regulatory deficits in anxiety disorder populations, in unique and distinctive ways. Future research is required in order to continue to translate research to practice and support individuals in utilizing these self-regulatory skills. A recent meta-analysis conducted by Goessl, Curtiss, and Hofmann (2017) showed that HRV biofeedback training is one such avenue, and has been shown to reduce self-reported stress and anxiety. Other researchers have found evidence for neurofeedback and HRV training for individuals with symptoms of anxiety and depression (White et al., 2017). In conclusion, the integration of behavior, physiology, and subjective experience is central to self-regulation. The present study is one of the first to integrate these components in understanding ER within clinical anxiety and continue to support the notion that HRV is a promising psychophysiological indicator that may continue to assist in gaining a deeper understanding of self-regulation.

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## Appendix A
## Eligibility Requirements

Inclusion criteria: Individuals between 19 and 80 years of age, have normal or corrected-to-normal vision, can speak and understand English, with a mix of gender and race/ethnic backgrounds reflective of the local population.

Exclusion criteria: Currently receiving psychotherapy treatment (past history of psychotherapy is acceptable), concurrent heavy drug or alcohol use, and specific use of beta-blocker drugs such as Propranolol or Atenolol or anticholinergic drugs (e.g., benedryl, tricyclic antidepressants). Participants with a history of cardiac pathology (e.g., prior heart attacks, arrhythmias) will also be excluded. These exclusion criteria pertain to factors that could affect the EKG recording.

Screening Questions:

How old are you? _________
How frequently do you drink alcohol? __________________________________________
How much alcohol do you typically have in one sitting? ____________________________
How often do you drink caffeine? ______________________________________________
How much caffeine do you have each day? _____________________________________
Are you currently taking prescription medication? ________________________________
If so, what medications are you taking? ________________________________________
Which of these medications do you take each day? _______________________________

- *Note*: we will exclude participants taking beta-blockers and anticholinergic drugs.
  Provide list of beta-blockers if participant is unsure: commonly prescribed beta-blockers include Acebutolol (Sectral), Atenolol (Tenormin), Betaxolol (Kerlone), Bisoprolol/hydrochlorothiazide (Ziac), Bisoprolol (Zebeta), Metoprolol (Lopressor, Toprol XL), Nadolol (Corgard), Propranolol (Inderal) and Sotalol (Betapace).
  Anticholinergic drugs (e.g., benedryl, tricyclic antidepressants)

Do you smoke cigarettes? ____________________________________________________
If so, how many cigarettes do you smoke each day? _______________________________
Have you ever been told you have an arrhythmia or any other heart abnormality? _______
*Note:* we will exclude participants with a history of cardiac pathology (e.g., prior heart attacks, arrhythmias)

If so, what is your condition? ________________________________________________
Do you have any respiratory conditions (i.e., problems with your breathing) such as asthma or bronchitis? If so, what conditions? _____________________________________
Do you have any history of cardiac, pulmonary, metabolic and other diseases that would cause autonomic nervous system dysfunction? ____________________________________
Have you been previously diagnosed with an anxiety disorder? ______________________
If yes, which diagnosis did you receive? ________________________________________
Do you experience high levels of anxiety? _______________________________________
If yes, use State Trait Anxiety Inventory.

Are you currently receiving psychotherapy or any other treatment? ___________________
Have you received psychotherapy and/or any other treatments in the past? _____________
If yes, when and for how long? (i.e.,. how many sessions) ________________________

# Appendix B

## Primary Investigator's Manuals

## Cognitive Restructuring

Session Outline:
I. Overview of The Session
II. Orienting the Participant to the Brief Top-Down Technique
III. Characteristics of Negative Thoughts
IV. Identifying Negative Thoughts
V. Challenging and Counteracting Negative Thoughts
VI. Practice Exercise: Challenging Negative Thoughts and Generating Alternative Balanced Thoughts
VII. Review and Practice Using Cognitive Restructuring Log

### I. Overview of the Session

We will now take some time to orient ourselves to a brief technique called "cognitive restructuring". First, I will give you a brief introduction to what cognitive restructuring is and how it can be used. Then we will work together to practice this technique. Finally, we will review what is called a "Cognitive Restructuring Log" that you will be asked to use over the next two weeks before we meet at our third and final session. Do you have any questions before we begin?

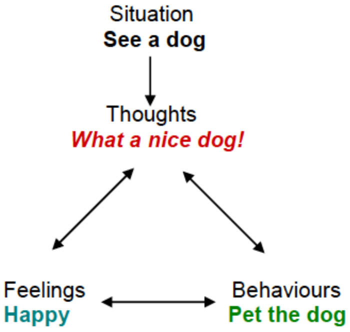
### II. Orienting the Participant to the Brief Top-Down Technique

Our emotions, thoughts, and behavior are intricately linked. When any one of these things is altered, it affects all the others in the system. Oftentimes these thoughts are not explicit, but are running in the background like a tape-recorder, all the while still impacting how we feel and how we act. Cognitive restructuring is a technique designed to help people recognize and alter thought patterns that may be causing us to experience negative emotion. Cognitive restructuring is a useful tool for understanding and reacting differently to the thinking patterns that negatively influence our mood and behavior.

*(Walk participant through the dog example below and then prompt each participant to come up with his or her own example. Aid in helping the participant to draw awareness to this process. Illustrate how negative thoughts can create negative emotions that then interfere with our behavior, and ultimately can get in the way of us achieving our goals.)*

As an example, imagine that you are terrified of dogs. Every time you see one, you run the other way, because you are convinced that all dogs are vicious beasts that will bite you. You may find out that a dog bit you when you were a child, which is no doubt the reason you fear dogs. Now imagine a situation where you are walking down the street and you see a dog. You might expect to feel afraid, to think that the dog will bite, and to run way or avoid the dog in some way (e.g., by turning and walking the opposite direction, or crossing the street). In our triangle, it would look like this:

However, if we imagine that you have a friend who is not afraid of dogs and actually likes them very much, your friend's thoughts, feelings, and actions might be very different:



Remember: One thing to notice in these two examples is that the situation did not change: but if you change your thoughts, then your feelings and actions change as well.

*(Work with participant to explore a personal example creating it on their handout).*

There are numerous methods to changing what we refer to as dysfunctional thought patterns. Generally, they all begin with first identifying automatic thoughts, (e.g., those thoughts which provide a running commentary to your experience) and then challenging how realistic or accurate they are. Instead of accepting all of these thoughts as accurate reflections of reality, I want you to think of these thoughts not as facts, but merely interpretations, which may or may not be true. We will work together to evaluate these thoughts and consider alternate points of view that may be more realistic. In this way, you will practice developing a more balanced way of thinking.

As an example to illustrate this technique, I want you to imagine someone is laying in bed and suddenly hears a sound. This person may think: "There is a burglar in the house!". How would this individual feel and how would he/she react? [PAUSE for participant response] Imagine now that the same person hears the noise and thinks: "It was a vase, which was accidentally knocked over by the cat". How would he/she then feel? [PAUSE for participant response] You can start to get a sense, then of how we think affects how we feel and also how we might act in a given situation.

Before we explore the characteristics of negative thoughts, I want to make one point clear: *everyone* has negative thoughts. It is a normal and commonly occurring human experience. However, people who struggle with anxiety might experience these thoughts more frequently or more intensely, which can lead to impairment in day-to-day functioning.

## III. Characteristics of Negative Thoughts

The interesting thing about negative thoughts is that they differ from positive thoughts in a number of ways. I am going to read a list of the characteristics of negative thoughts. You don't have to tell me explicitly, but see how many of these apply to your own negative thinking.

1. Negative thoughts can often sound true, especially when they occur so fast and so frequently, but when you stop and take a close look at them, they generally are not 100% accurate.

2. Negative thoughts often occur very quickly, so quickly we may not be aware of them right away and may not link them to how we are feeling (e.g., they just pop into your head without any effort on your part).

3. Negative thoughts often occur in telegraphic or short form. For example we may think "oh no!" and this can set off a chain reaction of other negative thoughts ("Bad things always happen to me"; "I am a failure".)

4. Negative thoughts can increase and maintain your distressing feelings (e.g., anxiety, depression).

5. Negative thoughts are often distorted or flawed in some way (e.g., they do not fit all of the facts). For example black-and-white thinking is an unhelpful thinking style commonly experienced by people with negative thoughts (e.g., "If I am not perfect, then I have failed").

6. Negative thoughts are unbalanced, in that they often do not consider all the information in a situation, including both the positive and negative sides.

## IV. Identifying Negative Thoughts

We are constantly thinking and most of the time we are unaware of it because thinking is a habit. One of the tricky things with negative thoughts is that they may have been operating for a long time, and so the negative thoughts have become automatic and part of our thinking habit. We want to get better at catching the negative thoughts that are related to the negative emotions and then we can learn to change them to more balanced thoughts which will help us feel better.

Increasing awareness of negative thoughts can help in two ways. First, when we become more aware of negative thoughts, we disrupt their flow. Second, when we catch a negative thought we can use our critical mind to evaluate the negative thoughts, and change the way we are thinking about a certain situation/event to reduce negative emotion.

A good way to become aware of your negative thoughts, is when you notice a shift in your mood stop and ask yourself: “What is going through my mind right now?”

But sometimes, simple awareness isn’t enough. You may have to challenge and evaluate your negative thoughts more actively.

## V. Challenging and Counteracting Negative Thoughts

Now that we know a bit more about the effect of negative thoughts have on us, you may be asking yourself how you can change these thoughts to more positive or rational ones.

One of the best ways to weaken the impact of negative thoughts is to test or challenge them. You can weaken the hold of negative thoughts by challenging them with the following questions:

[The following questions have been selected from Beck, J. S. (2011). *Cognitive Behavior Therapy: Basics and Beyond*. Guilford Press.]

1. This thought that I’m having right now – what is the evidence that supports this idea? What is the evidence against this idea?
2. What is an alternative explanation or balanced viewpoint?

*Of note, while the number of questions that could be employed to challenge negative automatic thoughts are practically limitless, the questions chosen for the purpose of this study reflect main question categories as originally proposed by Beck et al. (1985). Further, recent studies have employed similar approaches to cognitive restructuring and our methods closely resemble this work (e.g., Deacon, Fawzy, Lickel, Wolitzky-Taylor, 2011). Of note, components in this manual have been previously used in a manual for Cognitive Behavior Therapy treatment (i.e., Townsend, L. (2014). RAD Group for Youth: Reducing Anxiety and Depression Manual. Saanich Child and Youth Mental Health, Ministry of Children and Family Development) and has been refined for the purpose of this study.*

## VI. Practice Exercise: Challenging Negative Thoughts and Generating Alternative Balanced Thoughts

*Identify*

During the next week, when your notice your mood change ask yourself "What is running through my mind right now?" and try your best to identify your negative automatic thought in that situation and then follow the steps below:

*Examine the Thought*

What is the evidence that supports this idea? What is the evidence against this idea? Is there an alternative explanation or balanced viewpoint?

Though we may believe something to be true, this does not necessarily mean that it is. It is often valuable to see if the facts of the situation back up what you are thinking, or whether they contradict what you are thinking. Using the thought challenging questions evaluate your negative automatic thought.

*Generate Alternative*

Once you identify the negative automatic thought running through your mind, and you have examined it using the evaluative questions, try to generate an alternative more balanced thought.

*Note: These instructions are adaptations of cognitive restructuring and have been modified from a previous study (Larson, Hooper, Osborne, Bennett, & McHugh, 2016). These instructions are made to be easily accessible as brief instructions. As such, this is not an exhaustive example of cognitive restructuring (see O'Donohue & Fisher, 2012 for more examples).*

## VII. Review and Practice Using Cognitive Restructuring Log

This log will help you practice this cognitive restructuring technique. It will aid you in identifying and challenging negative automatic thoughts that come up throughout your day.

Let's do the first one together. In the past week, was there a time where you noticed your mood change? (Further prompting if needed may include "Was there a time in the past week where you became distressed about something?" What was going through your mind? Let's use this negative automatic thought.")

Just as you did with me, please complete the log when you notice your mood changing over the next two weeks. When you notice a change in your mood, use this as an indicator to check in with yourself and ask, "What is going through my mind right now?"

This will aid you in first identifying your negative automatic thoughts. Next you will use the evaluative questions to examine your thought and generate an alternative more balanced thought.

This technique takes practice and you may not feel/notice a difference immediately, but we encourage you to practice as often as possible before we meet next. Just as any other skill, at first this task may seem difficult, frustrating, and even effortful. This is normal. However, over time you will likely start to notice shifts in your thoughts and feelings when completing the log. It may become less effortful the more times you do it, and you may even start to experience more immediate changes in your emotions after completing the log. We acknowledge that this can be difficult work, and want to encourage you to be kind to yourself over the next two weeks.

To help support you in your practice, we encourage you to schedule a “Logging Time”. This is a specific time in your day that can be devoted to completing your daily practice log. For instance, designating 7:00 pm as your “Logging Time” and setting aside 15-20 minutes to complete your log. Again, we are requiring a minimum of 1 entry per day. However, just like with most skills, the more practice the better. Please be sure to fill out your log appropriately for the number of times you practice each day.

Any questions/concerns? *(Problem solve with the participants on an as-needed basis to reduce any foreseeable barriers as a way of increasing homework compliance).*

# Mindfulness Technique

Session Outline:

- I. Overview of the Session
- II. Orienting the Participant to the Brief Bottom-Up Technique
- III. Overview of the Bottom-Up Technique
- IV. Experiential Mindfulness Exercise: Script of Guided Session
- V. Review Practice Journal

## I. Overview of the Session

We will now take some time to orient ourselves to a brief technique called "mindfulness". First, I will give you a brief introduction to what mindfulness is and how it can be used. Then we will work together to practice this technique. Finally, we will review what is called a "Daily Journal" that you will be asked to use over the next two weeks before we meet at our second, and final session. Do you have any questions before we begin?

## II. Orienting the Participant to the Brief Bottom-Up Technique

Mindfulness is a technique that focuses on awareness of thoughts and feelings without attachment or judgment, which helps us to disentangle ourselves from our distorted thought patterns and connect to the actual situation. One mindfulness technique, what is referred to as open monitoring, requires you to pay attention to all aspects of the present-moment experience in an accepting and non-judgmental manner. It encourages you to experience what's happening in the present moment fully without avoiding it.

When we have anxiety, we are not often engaging in the present-moment with such an accepting manner. Instead, we are often judging our experience, worrying about the past or the future, and even rejecting our experience of being activated by ideas about things that may or may not occur. Open monitoring can be helpful in the sense that you become open to anything that may enter your awareness, at any given time, and throughout the moment-to-moment aspects of your daily life. You become aware of thoughts and feelings without the need to establish an attachment or a judgment to them. In this way, open-monitoring meditation involves maintaining an open and non-judgmental attitude toward emotions, thoughts, feelings, memories, and bodily sensations.

## III. Overview of the Bottom-Up Technique

*(The instructions for the mindfulness intervention technique, adapted from Keng, Smoski, & Robins, (2016), included an open monitoring experiential exercise.)*

Now I am going to train you on how to use a strategy for dealing with negative emotions. We call this technique mindfulness.

What this technique involves is to acknowledge thoughts and emotions (both negative and positive), but allowing them to be there more openly and with acceptance. It is opening to or receiving the present moment, pleasant or unpleasant, just as it is, without either clinging to it or rejecting it.

Typically, our natural tendency when experiencing difficult thoughts and emotions is that we tend to think about them over and over again, judge them as good or bad, or try to push them away and not want to deal with them. The technique of mindfulness is to avoid these two opposites. So, instead of engaging with our thoughts and emotions or pushing them away, we practice accepting and being aware of them as simply thoughts and emotions and watching them come and go.

One good way of understanding mindfulness is by doing an experiential exercise. We will go through this exercise now together. Get in a comfortable position. I will start the recording when you are ready. Any questions before we begin?

## IV. Experiential Mindfulness Exercise

Embodied Awareness Meditation Script of Guided Session [22:18]

“In the stillness let your senses be wide-awake…. Aware of the sounds around you… aware of the sensations and aliveness in the body… to deepen that wakefulness in the body, letting the awareness scan through the body…. Begin the area of the eyes…the region of the eyes… you might soften the eyes… and then let yourself become aware of and receive the sensations that are there… you might also be aware of flickering light in darkness… vibration… you might also sense the space that the vibration is floating in, that is happening in… bringing the attention to the mouth you might let there be a slight smile of the mouth, the inside of the mouth is smiling. Let the tongue fill the lower jaw. See if you can relax right down to the root of the tongue. And feeling the sensations, receiving the sensations, of aliveness through the mouth. Bringing the awareness to the area of the throat, you may imagine the throat filling the whole neck, and then receiving the aliveness, the vibrating or tingling, the sensations that are there. Sensing that you can bring the awareness inside the shoulders, you can feel the shoulders from the inside out. As a way of softening there you may imaging a kind of dissolving from ice to water, a melting sensation. Then even further, water to gas. Receiving the play of sensations in the shoulders, see if you can also imagine and feel even the interior space that they are arising out of. If you imagine a nucleus of an atom, all the particles are really appearing out emptiness and disappearing. Huge amounts of space between them. Sensing the length and volume of the arms. Let the hands rest in a very easy, effortless way. Then softening the hands. Softening a little more, and feeling them from the inside out. Receiving the aliveness, the movements of sensations. You might notice tingling and vibrating. Perhaps places of warmth… pressure… feeling the hands from the inside out. And also can you imagine the space, this aliveness the hands are floating in. The interior space it is arising out of. Letting there be openness in the chest area. Feeling the heart, the region of the heart from the inside out. Receiving the dance of sensations that’s there. Might be pressure, tightness, squeezing, vibrating, tingling. Very intimate attention. Feeling the aliveness and imagining the space it is happening in. Feeling the sensations throughout the whole chest area. And the space that fills the chest. Relaxing through the abdominal area, and letting this next breath to be received in a softening belly. This breath…. And now this one… and again…loosening the belly, feeling the awareness from the inside out… feeling the life that is there. The movement of sensation, places of heat, tenderness, vibration, pressure. Sensing the space it's floating in. Interior space this aliveness arises from. Scanning now through the pelvic region, relaxing and feeling from the inside out, the sensations there. Receptive, open. Aware of the energetic aliveness, and the space its happening in. Aware of the length and volume of your legs. Placing the awareness inside the feet, feeling the feet from the inside out. Aware of the tingling vibrating aliveness that is there. Sensing your feet and your body extending downward, outward, really to really feel the earth body, sensing the aliveness and energy of this earth body flowing into you and filling you. You can feel your whole body as a field of sensation.

Letting this dance of aliveness be just as it is, not opposing anything not controlling. Sensing this elemental dynamism of light. Of points of light in the night sky. All received and happening in, vast awareness. Just rest in this wakeful, openness, letting life be just as it is. Receiving this changing play of sensations, sounds, aliveness… Moment to moment…

The moments when there is awareness of thinking are really an invitation to relax back home again. To re-awaken the senses… You will notice when your lost in thought you are not aware of the sounds appearing and disappearing right here. And when we are lost with thought we lose contact with the physical aliveness, the felt sense. So come back. Come back with some ease and without any judgment. Just listen again to the sounds right here. Re-relax a little through the body as you feel the aliveness and space. Right here. Again just letting life be as it is, moment to moment. Resting in that wakeful openness. That receives the changing flow. And if it helps to stabilize the mind sound, by having the sensations of the breath in the foreground, that's a fine way to help support your practice.

[Longer pause…]

Every time there is that noticing of that drift into virtual reality, into thoughts, there is a coming back you are really strengthening the muscle of remembrance. You can start fresh in any moment, arriving right here, these sounds, these sensations, the in flow and out flow of the breath… all received in a wakeful openness, received by awareness.

As a way of closing the meditation, let this wakeful openness be filled in the domain of the heart. Just sense the heart space that is here. And from that space of tenderness of warmth, sense whatever prayer or blessing you would like to offer to yourself right now. A mental whisper of a prayer to your own being. For your own heart. Feel the sincerity and care… that fills this heart space now… extending in all directions. And sense how this heart space really includes all beings everywhere. Closing by offering your prayer to all beings."

To summarize, the purpose of this technique is to engage in what we refer to as open monitoring, that is, to allow your attention to be open, within the present experience, rather than engaging in thinking about specific thoughts and/or feelings you may be having (or what they might mean) or turning your attention away from them. The idea is to notice and allow your present experience, including your thoughts and emotions, in a non-judgmental manner.

Note. The above excerpt is from Brach, T. (2016, March 9). *Embodied Awareness Meditation* [Audio podcast]. Retrieved from itpc://www.tarabrach.com/feed/podcast/

### V. Review Practice Homework

*Participants in this group were asked to complete a homework practice component. Specifically, they were asked to track the frequency and duration of their home practice. The requirement was to make at least one entry per day in their practice logs. These logs were submitted at the end of the second testing session. Participants received daily reminders via SONA to complete their practice. The mindfulness technique listed above was recorded and uploaded as a MP3 file on Course Spaces for participants to download. Participants were given temporary ID's to access these files over the course of the two weeks. Ensure participants know how to access and download file. Answer questions as needed.*

This Daily Journal will help you practice this mindfulness technique. It will aid you in tracking your practice throughout the next two weeks. Let's do the first entry together. Just as you did with me, please complete your Daily Journal after your practice each day before we meet next, final session.

Any questions/concerns? *(Problem solve with the participants on an as-needed basis to reduce any foreseeable barriers to increase the likelihood of homework completion).*

I also want to take a moment now to acknowledge that this may feel effortful and challenging at times. Just as with learning any new skill, I want to encourage you to be kind to yourself. The more you practice the more likely you will see and/or feel a change in your practice and remember - this takes time. For homework the minimum requirement is practicing once a day and recording it in your Daily Journal. However, we encourage you to practice as much as possible.

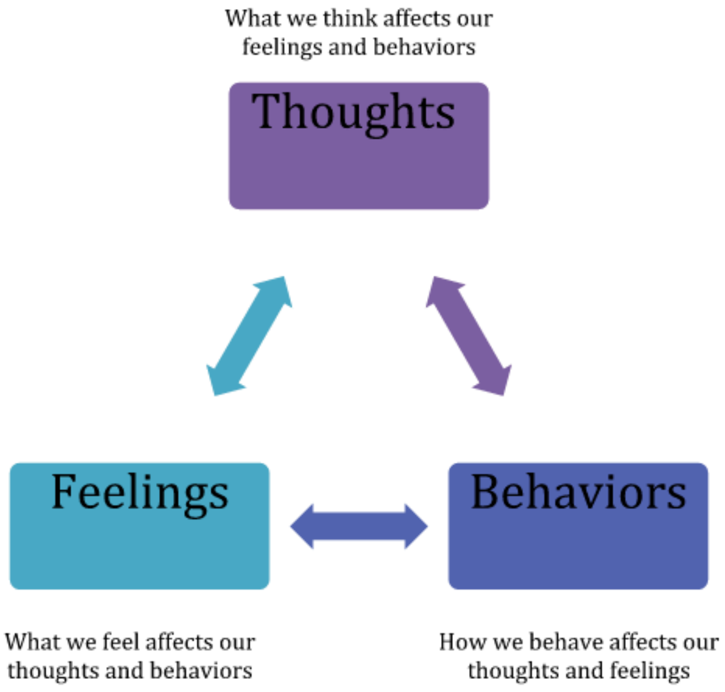
# Appendix C

## Participant Manuals

## Cognitive Restructuring

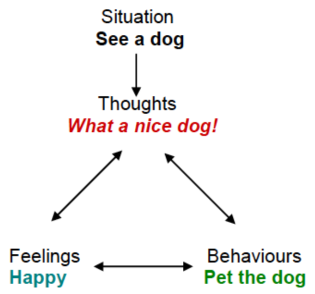
### Introduction to Brief Top-Down Technique

Our emotions, thoughts, and behavior are intricately linked. When any one of these things is altered, it affects all the others in the system. Oftentimes these thoughts are not explicit, but are running in the background like a tape-recorder, all the while still impacting how we feel and how we act.



As an example, imagine that you are terrified of dogs. Every time you see one, you run the other way, because you are convinced that all dogs are vicious beasts that will bite you. You may find out that a dog bit you when you were a child, which is no doubt the reason you fear dogs. Now imagine a situation where you are walking down the street and you see a dog. You might expect to feel afraid, to think that the dog will bite, and to run way or avoid the dog in some way (e.g., by turning and walking the opposite direction, or crossing the street). In our triangle, it would look like this:

However, if we imagine that you have a friend who is not afraid of dogs and actually likes them very much, your friend’s thoughts, feelings, and actions might be very different:



Remember: One thing to notice in these two examples is that the situation did not change: but if you change your thoughts, then your feelings and actions change as well.

Practice: Now try and generate your own example. Let’s work together to try and create a triangle together.

# Cognitive Restructuring: What is it?

Cognitive restructuring is a technique designed to help people recognize and alter thought patterns that may be causing us to experience negative emotion. Cognitive restructuring is a useful tool for understanding and reacting differently to the thinking patterns that negatively influence our mood and behavior.

There are numerous methods to changing what we refer to as dysfunctional thought patterns. Generally, they all begin with first identifying automatic thoughts, (e.g., those thoughts which provide a running commentary to your experience) and then challenging how realistic or accurate they are. Instead of accepting all of these thoughts as accurate reflections of reality, I want you to think of these thoughts not as facts, but merely interpretations, which may or may not be true. And remember, everyone has negative thoughts!

# Characteristics of Negative Thoughts

- Negative thoughts can often sound true, but they generally are not 100% accurate.
- Negative thoughts often occur very quickly, so quickly we may not be aware of them right away and may not link them to how we are feeling (e.g., they just pop into your head without any effort on your part).
- Negative thoughts often occur in telegraphic or short form. For example we may think "oh no!" and this can set off a chain reaction of other negative thoughts ("Bad things always happen to me"; "I am a failure".)
- Negative thoughts can increase and maintain your distressing feelings (e.g., anxiety, depression).
- Negative thoughts are often distorted or flawed in some way (e.g., they do not fit all of the facts). Black-and-white thinking is one example of an unhelpful thinking style that is commonly experienced by people with negative thoughts (e.g., "If I am not perfect, then I have failed").
- Negative thoughts are unbalanced, in that they often do not consider all the information in a situation, including both the positive and negative sides.

# Cognitive Restructuring Steps

*Step 1: Identify*

When I noticed my mood change ask myself: “What is running through my mind right now?”.

*Step 2: Examine the Thought*

1. This thought that I’m having right now – what is the evidence that supports this idea? What is the evidence against this idea?
2. What is an alternative explanation or balanced viewpoint?

*Step 3: Generate Alternative*

Once I have examined the thought. Ask myself, “What is a more balanced way of thinking about this situation?”

# Practice Using Cognitive Restructuring Log

This log will help you practice this cognitive restructuring technique. Please complete the log when you notice your mood changing over the next two weeks. When you notice a change in your mood, use this as an indicator to check in with yourself and ask, "What is going through my mind right now?"

This will aid you in first identifying your negative automatic thoughts. Next you will use the evaluative questions to examine your thought and generate an alternative more balanced thought.

*Points to Remember Over the Next Two Weeks:*

1. Be kind to yourself!
2. Make at minimum 1 entry in your log per day. The more practice you are able to do the better!
3. Schedule a designated "Logging Time".

# Cognitive Restructuring Log

| Date | A Situation: describe the event that triggered your distress | B Negative thoughts: record what you said to yourself about the event | C Supporting Evidence: What is the evidence that supports this idea? | D Disconfirming Evidence: What is the evidence against this idea? | E Generate an alternative, more “balanced” thought |
|---|---|---|---|---|---|
| | | | | | |

# Mindfulness Technique

## Introduction to Brief Bottom-Up Technique

*What is Mindfulness?*

Mindfulness is about being aware of what is happening the present moment, moment-by-moment, without making judgments about what we notice.

*What Does Mindfulness Involve?*

This technique involves acknowledging thoughts and emotions (both negative and positive), but allowing them to be there more openly and with acceptance. It is opening to or receiving the present moment, pleasant or unpleasant, just as it is, without either clinging to it or rejecting it.

Typically, our natural tendency when experiencing difficult thoughts and emotions is that we tend to think about them over and over again, judge them as good or bad, or try to push them away and not want to deal with them. The technique of mindfulness is to avoid these two opposites; so instead of engaging with our thoughts and emotions or pushing them away, we practice accepting and being aware of them as simply thoughts and emotions and watching them come and go.

*Why Practice Mindfulness?*

Our minds can be focused on things in the past, present, or future. We often find ourselves ruminating about events that have already happened, or worrying about things that could happen. These habits of thought are often distressing, not only in our minds, but also in our bodies.

Mindfulness is a practice, which encourages us to attend to the present moment. There is good evidence that mindfulness practice can help people cope more effectively with a wide variety of feeling-states such as anxiety.

# Experiential Mindfulness Exercise

Please listen to this recording and practice this mindfulness technique at least once a day and record your practice in your journal.

Embodied Awareness Meditation Guided Session [22:18]

You can access this session by uploading it as a MP3 file on Course Spaces. Link: [insert here]

*Purpose:*

The purpose of this technique is to engage in what we refer to as open monitoring, that is, to allow your attention to be open, within the present experience, rather than engaging in thinking about specific thoughts and/or feelings you may be having (or what they might mean) or turning your attention away from them. The idea is to notice and allow your present experience, including your thoughts and emotions, in a non-judgmental manner.

*Be Kind to Yourself:*

It is important to mindful of the fact that this technique can be challenging and at times, can feel frustrating. Be kind to yourself as you practice this technique over the next two weeks. It is normal and common to feel frustrated and/or overwhelmed when beginning mindfulness practice. Just notice when you have thoughts/feelings related to this practice over the next two weeks, and try just noticing your experience without reacting to- or providing judgment towards it.

*Points to Remember Over the Next Two Weeks:*

1. Be kind to yourself!
2. Make at minimum 1 entry in your log per day. The more practice you are able to do the better.
3. Schedule a designated “Mindfulness Time”.

# **Daily Practice: Mindfulness Technique**

*Daily Journal*

| Date | Practice Session Completed? | Number of Practice Sessions |
|---|---|---|
| | | |

# Appendix D

## Supplementary Materials: Study 1 Results

### Specific ER Strategies

The following analyses pertain to the role of tonic and phasic HRV in predicting perceived ER success when utilizing the specific ER strategies of cognitive reappraisal, expressive suppression, and appraisal.

**Reappraisal.** A hierarchical regression analysis was used to examine whether tonic HRV predicted total reappraisal success on the ER task, over and beyond the other predictor variables (see Table D1). This model produced non-significant findings ($R^2$ = .299, $F$ (6, 15) = 1.064, $p$ = .425). Tonic HRV did not predict total reappraisal success over and beyond the other variables in the model ($t$ (15) = 1.158, $p$ = .265, $d$ = .60, $r$ = .29).

Table D1

*Tonic HRV and Total Reappraisal (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Total Reappraisal (DV) | 3.55 | 0.53 | |
| Trait Anxiety | 93.36 | 8.64 | -.27 |
| Age | 37.64 | 16.2 | -.24 |
| Gender | | | .12 |
| Arousal | 6.34 | 0.65 | -.32 |
| Valence | 5.07 | 0.57 | .37 |
| Tonic HRV | 29.28 | 16.01 | .33 |

Hierarchical Regression Analysis: Tonic HRV and Total Reappraisal Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 4.487 | 3.497 | |
| Trait Anxiety | -0.012 | 0.015 | -0.188 |

| | | | |
|---|---|---|---|
| Age | -0.007 | 0.007 | -0.212 |
| Gender | 0.142 | 0.261 | 0.122 |
| Arousal | -0.119 | 0.248 | -0.146 |
| Valence | 0.191 | 0.301 | 0.204 |
| | | | |
| Step 2 | | | |
| Constant | 4.533 | 3.46 | |
| Trait Anxiety | -0.012 | 0.015 | -0.197 |
| Age | -0.005 | 0.007 | -0.153 |
| Gender | 0.192 | 0.262 | 0.165 |
| Arousal | -0.133 | 0.246 | -0.164 |
| Valence | 0.132 | 0.302 | 0.141 |
| **Tonic HRV** | **0.009** | **0.008** | **0.264** |

*Note:* $R^2$ *= .236 for Step 1,* $\Delta R^2$ *= .063 for Step 2.*

A hierarchical regression analysis was also used to examine whether phasic HRV predicted total reappraisal success on the ER task (Table D2), over and beyond the other variables in the model (same as above). Anxiety was negatively and significantly associated with total reappraisal success. These results demonstrate that high anxiety was associated with poorer reappraisal ability (i.e., lower perceived success). However, results showed that the overall regression model with all 6 predictors was non-significant and produced an $R^2$ = .368, $F$ (6, 16) = 1.552, $p$ = .225. Phasic HRV did not significantly or uniquely predict total reappraisal success over and beyond the other variables in the model ($t$ (16) = -.734, $p$ = .474, $d$ = -0.37, $r$ = 0.18).

Table D2

*Phasic HRV and Total Reappraisal Success (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Total Reappraisal Success (DV) | 3.55 | 0.52 | |
| Age | 36.83 | 16.29 | -.24 |

| | | | |
|---|---|---|---|
| Gender | | | .12 |
| State Anxiety | 68.13 | 20.39 | -.38* |
| Arousal | 6.36 | 0.65 | -.31 |
| Valence | 5.05 | 0.56 | .36* |
| Phasic HRV | 0.51 | 6.04 | -.23 |

** p <.05*

Hierarchical Regression: Phasic HRV and Total Reappraisal Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 1.692 | 2.514 | |
| State Anxiety | -0.011 | 0.006 | -0.443 |
| Age | -0.002 | 0.007 | -0.075 |
| Gender | 0.137 | 0.23 | 0.119 |
| Arousal | 0.054 | 0.227 | 0.067 |
| Valence | 0.435 | 0.263 | 0.468 |
| | | | |
| Step 2 | | | |
| Constant | 1.635 | 2.55 | |
| State Anxiety | -0.011 | 0.006 | -0.422 |
| Age | -0.001 | 0.006 | -0.422 |
| Gender | 0.21 | 0.253 | 0.181 |
| Arousal | 0.054 | 0.23 | 0.067 |
| Valence | 0.414 | 0.268 | 0.445 |
| **Phasic HRV** | **-0.014** | **0.02** | **-0.168** |

*Note: $R^2$ = .347 for Step 1, $\Delta R^2$ = .021 for Step 2.*

**Total suppression.** A regression analysis was used to examine whether tonic HRV predicted overall expressive suppression success on the ER task (see Table D3). Valence was significantly and positively associated with overall perceived suppression ability (*r* = .64, *p* = .001) suggesting that positive valence was associated with better perceived ER ability, whereas arousal was negatively and significantly related (*r* = - .60, *p* = .002) suggesting that greater arousal was associated with lower perceived ER success. The multiple regression model with all 6 predictors (same as analyses described above) produced an $R^2$ = .541, *F* (6, 15) = 2.950, *p* = .042. These results indicated that together, all

6 predictors (i.e., anxiety, age, gender, arousal, valence and tonic HRV) predicted participants' perceived ability to successfully regulate their emotions using expressive suppression. Tonic HRV did not uniquely predict overall suppression ability over and beyond the other predictors in the model (*t* (15) = 1.59, *p* = .133, *d* = .82, *r* = .38).

Table D3

*Tonic HRV and Total Suppression (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Suppression (DV) | 3.35 | 0.66 | |
| Trait Anxiety | 93.36 | 8.64 | -.14 |
| Age | 37.64 | 16.2 | -.01 |
| Gender | | | .14 |
| Arousal | 6.3418 | 0.65262 | -.60* |
| Valence | 5.0705 | 0.56575 | .65** |
| Tonic HRV | 29.28 | 16.01 | .35 |

**p < .01 ** p<.001*

Hierarchical Regression: Tonic HRV and Total Suppression

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 2.532 | 3.639 | |
| Trait Anxiety | 0 | 0.015 | 0 |
| Age | 0 | 0.008 | -0.001 |
| Gender | 0.092 | 0.272 | 0.064 |
| Arousal | -0.297 | 0.258 | -0.294 |
| Valence | 0.51 | 0.313 | 0.437 |
| | | | |
| Step 2 | | | |
| Constant | 2.596 | 3.477 | |
| Trait Anxiety | -0.001 | 0.015 | -0.01 |
| Age | 0.003 | 0.007 | 0.065 |
| Gender | 0.161 | 0.263 | 0.111 |
| Arousal | -0.317 | 0.247 | -0.313 |
| Valence | 0.429 | 0.303 | 0.368 |
| **Tonic HRV** | **0.012** | **0.008** | **0.294** |

*Note:* $R^2$ *= .464 for Step 1,* $\Delta R^2$ *= .077 for Step 2.*

Next we examined whether phasic HRV predicted overall suppression success on the ER task (see Table D4). Arousal was negatively and significantly (*r* = -.61, *p* = .001) and valence was positively and significantly (*r* = .65, *p* = < .001) related to overall suppression ability. However, the multiple regression model with all 6 predictors (same as above) produced an $R^2$ = .494, *F* (6, 16) = 2.599, *p* = .059. Thus, results indicated that together, anxiety, age, gender, arousal, valence and phasic HRV did not significantly predict overall suppression success. Phasic HRV did not uniquely predict total suppression success (*t* (16) = .426, *p* = .676, *d* = .21, *r* = .11).

Table D4

*Phasic HRV and Total Suppression Success (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Total Suppression Success (DV) | 3.33 | 0.66 | |
| Age | 36.83 | 16.29 | .04 |
| Gender | | | .16 |
| State Anxiety | 68.13 | 20.39 | -.03 |
| Arousal | 6.36 | 0.65 | -.61*** |
| Valence | 5.05 | 0.56 | .65*** |
| Phasic HRV | 0.51 | 6.04 | .04 |

** p <.05 ** p < .01 *** p<.001*

Hierarchical Regression: Phasic HRV and Total Suppression Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 2.179 | 2.814 | |
| State Anxiety | -0.004 | 0.007 | -0.112 |
| Age | 0.002 | 0.008 | 0.061 |
| Gender | 0.113 | 0.258 | 0.077 |
| Arousal | -0.265 | 0.254 | -0.261 |
| Valence | 0.563 | 0.294 | 0.48 |

| | | | |
|---|---|---|---|
| Step 2 | | | |
| Constant | 2.217 | 2.886 | |
| State Anxiety | -0.004 | 0.007 | -0.123 |
| Age | 0.002 | 0.008 | 0.042 |
| Gender | 0.066 | 0.287 | 0.045 |
| Arousal | -0.265 | 0.261 | -0.261 |
| Valence | 0.577 | 0.303 | 0.491 |
| **Phasic HRV** | **0.009** | **0.022** | **0.087** |

*Note:* $R^2$ *= .488 for Step 1,* $\Delta R^2$ *= .006 for Step 2.*

**Total appraisal.** Lastly, a hierarchical regression analysis was used to examine whether tonic HRV predicted total appraisal success on the ER task, over and beyond the other predictor variables (same as above). Significant correlations were found for tonic HRV ($r = .61$, $p = .001$), arousal ($r = -.43$, $p = .02$) and valence ($r = .45$, $p = .02$). The multiple regression model with all 6 predictors produced an $R^2 = .574$, $F(6, 15) = 3.363$, $p = .026$. As can be seen in Table D5, tonic HRV had a positive and significant regression weight, demonstrating that those participants with higher tonic HRV perceived themselves to be more successful at regulating their emotional responses using appraisal as the ER strategy during the computerized task. Tonic HRV significantly predicted overall appraisal success over and beyond the other predictor variables ($t(15) = 3.226$, $p = .006$, $d = 1.67$, $r = .64$).

Table D5

*Tonic HRV and Total Appraisal (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Total Appraisal (DV) | 3.29 | 0.67 | |
| Trait Anxiety | 93.36 | 8.64 | -.21 |
| Age | 37.64 | 16.2 | -.18 |
| Gender | | | .11 |
| Arousal | 6.3418 | 0.65262 | -.43* |

| | | | |
|---|---|---|---|
| Valence | 5.0705 | 0.56575 | .45* |
| Tonic HRV | 29.28 | 16.01 | .61** |

**p <.05 ** p<.001*

Hierarchical Regression Analysis: Tonic HRV and Total Appraisal

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 4.174 | 4.274 | |
| Trait Anxiety | -0.008 | 0.018 | -0.109 |
| Age | -0.007 | 0.009 | -0.162 |
| Gender | 0.121 | 0.319 | 0.082 |
| Arousal | -0.241 | 0.304 | -0.236 |
| Valence | 0.301 | 0.368 | 0.255 |
| Step 2 | | | |
| Constant | 4.301 | 3.392 | |
| Trait Anxiety | -0.01 | 0.014 | -0.128 |
| Age | -0.001 | 0.007 | -0.034 |
| Gender | 0.256 | 0.257 | 0.175 |
| Arousal | -0.28 | 0.241 | -0.273 |
| Valence | 0.14 | 0.296 | 0.118 |
| **Tonic HRV** | **0.024** | **0.007** | **0.574*** |

*Note:* $R^2$ *= .278 for Step 1,* $\Delta R^2$ *= .296 for Step 2 (p* < .01). **p* <.01.

A hierarchical regression analysis was used to examine whether phasic HRV predicted total appraisal success on the ER task, over and beyond the other predictor variables. As can be seen in Table D6, arousal was negatively ($r$ = -.45, $p$ = .015) and valence was positively ($r$ = .47, $p$ = .013) associated with overall appraisal performance. Results indicated that the multiple regression with all 6 predictors was not significant ($R^2$ = .426, $F$ (6, 16) = 1.977, $p$ = .129). Phasic HRV did not uniquely predict appraisal success on the ER task ($t$ (16) = 1.634, $p$ = .122, $d$ = .82, $r$ = .38).

Table D6

*Phasic HRV and Total Appraisal Success (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Total Appraisal Success (DV) | 3.26 | 0.66 | |
| Age | 36.83 | 16.29 | -.13 |
| Gender | | | .13 |
| State Anxiety | 68.13 | 20.39 | -.23 |
| Arousal | 6.36 | 0.65 | -.45* |
| Valence | 5.05 | 0.56 | .47* |
| Phasic HRV | 0.51 | 6.04 | .20 |

* $p < .05$

Hierarchical Regression: Phasic HRV and Total Appraisal Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 2.051 | 3.254 | |
| State Anxiety | -0.009 | 0.008 | -0.276 |
| Age | -0.001 | 0.009 | -0.034 |
| Gender | 0.141 | 0.298 | 0.096 |
| Arousal | -0.128 | 0.294 | -0.125 |
| Valence | 0.497 | 0.34 | 0.418 |
| | | | |
| Step 2 | | | |
| Constant | 2.207 | 3.107 | |
| State Anxiety | -0.01 | 0.007 | -0.321 |
| Age | -0.005 | 0.009 | -0.113 |
| Gender | -0.055 | 0.309 | -0.037 |
| Arousal | -0.127 | 0.281 | -0.124 |
| Valence | 0.553 | 0.327 | 0.466 |
| **Phasic HRV** | **0.039** | **0.024** | **0.356** |

*Note:* $R^2 = .330$ *for Step 1,* $\Delta R^2 = .096$ *for Step 2.*

### Interaction between Emotion Generation and Regulation

The following analyses are focused on examining the match between emotion generation (i.e., bottom-up vs. top-down) and regulation strategies (cognitive reappraisal, expressive suppression, appraisal).

**Reappraisal sentences.** The hierarchical analysis was run with reappraisal of sentences as the dependent variable (see Table D7 for results). Anxiety was significantly and negatively associated with reappraisal success ($r$ = - .40, $p$ = .03) suggesting that those participants with greater levels of anxiety were associated with poorer performance on these trials. Overall, results indicated non-significant findings, $R^2$ = .404, $F$ (6, 15) = 1.698, $p$ = .190 which demonstrated that the regression model with all 6 predictor variables (i.e., age, gender, anxiety, arousal, valence, and tonic HRV) did not adequately account for, or explain participants' perceived ability to successfully use reappraisal to regulate their emotions on the sentence trials of the ER task. Tonic HRV did not significantly predict reappraisal performance on the sentence trials above and beyond the other variables ($t$ (15) = 1.355, $p$ = .196, $d$ = .70, $r$ = .33).

Table D7

*Tonic HRV and Reappraisal Sentences (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Reappraisal Sentences (DV) | 3.8 | 0.61 | |
| Trait Anxiety | 93.36 | 8.64 | -.40* |
| Age | 37.64 | 16.2 | -.18 |
| Gender | | | .02 |
| Sentence Arousal | 3.01 | 0.36 | -.36 |
| Sentence Valence | 2.74 | 0.33 | .02 |
| Tonic HRV | 29.28 | 16.01 | .34 |

* $p < .05$

Hierarchical Regression Analysis: Tonic HRV and Reappraisal of Sentences

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 10.25 | 2.711* | |
| Trait Anxiety | -0.031 | 0.015 | -0.446 |
| Age | 0 | 0.008 | 0.009 |
| Gender | -0.001 | 0.289 | -0.001 |
| Sentence Arousal | -0.762 | 0.413 | -0.445 |
| Sentence Valence | -0.446 | 0.441 | -0.242 |
| | | | |
| Step 2 | | | |
| Constant | 9.711 | 2.673* | |
| Trait Anxiety | -0.031 | 0.015 | -0.439 |
| Age | 0.002 | 0.008 | 0.058 |
| Gender | 0.05 | 0.285 | 0.037 |
| Sentence Arousal | -0.706 | 0.405 | -0.412 |
| Sentence Valence | -0.494 | 0.431 | -0.268 |
| **Tonic HRV** | **0.011** | **0.008** | **0.284** |

*Note:* $R^2$ *= .332 for Step 1,* $\Delta R^2$ *= .073 for Step 2.* *$p$ <.01.

The hierarchical analysis described above was run again with reappraisal of sentences as the dependent variable, this time focused on phasic rather than tonic HRV (see Table D8 for results). Results indicated that when all 6 predictors were entered in the model, the overall regression was not significant and produced an $R^2$ = .208, *F* (6, 16) = .698, *p* = .655. Similarly, results showed that phasic HRV did not uniquely predict participants' ability to use reappraisal to successfully regulate their negative emotions evoked by the negative sentences in the ER task (*t* (16) = - .786, *p* = .443, *d* = -0.39, *r* = 0.19).

Table D8

*Phasic HRV and Reappraisal Sentences (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Sentence Success (DV) | 3.81 | 0.60 | |
| Age | 36.83 | 16.29 | -.18 |
| Gender | | | .02 |
| State Anxiety | 68.13 | 20.39 | -.31 |
| Sentence Arousal | 3.02 | 0.35 | -.35 |
| Sentence Valence | 2.74 | 0.32 | .02 |
| Phasic HRV | 0.51 | 6.04 | -.20 |

Hierarchical Regression: Phasic HRV and Reappraisal of Sentences

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 6.237 | 2.415* | |
| State Anxiety | -0.006 | 0.008 | -0.206 |
| Age | -6.29E-05 | 0.009 | -0.002 |
| Gender | -0.018 | 0.315 | -0.014 |
| Sentence Arousal | -0.554 | 0.475 | -0.323 |
| Sentence Valence | -0.118 | 0.508 | -0.064 |
| | | | |
| Step 2 | | | |
| Constant | 6.223 | 2.443* | |
| State Anxiety | -0.005 | 0.008 | -0.175 |
| Age | 0.002 | 0.009 | 0.045 |
| Gender | 0.068 | 0.337 | 0.051 |
| Sentence Arousal | -0.59 | 0.483 | -0.344 |
| Sentence Valence | -0.155 | 0.516 | -0.084 |
| **Phasic HRV** | **-0.02** | **0.025** | **-0.2** |

*Note:* $R^2 = .177$ *for Step 1,* $\Delta R^2 = .031$ *for Step 2*. $^*p < .05$.

**Reappraisal pictures.** A hierarchical regression analysis was conducted in order to examine whether tonic HRV predicted participants' success at utilizing cognitive reappraisal as an ER strategy to reduce their negative emotion evoked by picture stimuli on ER task. Valence ratings were significantly and positively correlated with reappraisal success on these trials ($r = .615$, $p = .001$) suggesting that greater positive valence ratings were associated with better performance. For reappraisal of pictures, the regression model with all 6 predictors was non-significant and produced an $R^2 = .506$, $F(6, 15) = 2.557$, $p = .066$ which is trending toward statistical significance. As can be seen in Table D9, valence had a significant positive regression weight, indicating that participants who found the pictures to be more positive and less negative, perceived themselves to be better at reappraising their emotions elicited by the picture stimuli ($t(15) = 3.066$, $p = .008$, $d = 1.58$, $r = .41$). Tonic HRV did not uniquely predict reappraisal success on the picture trials ($t(15) = .594$, $p = .561$, $d = .31$, $r = .15$).

Table D9

*Tonic HRV and Reappraisal Pictures (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Reappraisal Pictures (DV) | 3.29 | 0.58 | |
| Trait Anxiety | 93.36 | 8.64 | -.06 |
| Age | 37.64 | 16.2 | -.24 |
| Gender | | | .20 |
| Picture Arousal | 3.33 | 0.42 | -.19 |
| Picture Valence | 2.33 | 0.35 | .62* |
| Tonic HRV | 29.28 | 16.01 | .24 |

** p < .01*

Hierarchical Regression Analysis: Tonic HRV and Reappraisal of Pictures

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | -1.166 | 2.212 | |
| Trait Anxiety | 0.015 | 0.013 | 0.224 |
| Age | -0.01 | 0.007 | -0.277 |
| Gender | -0.107 | 0.254 | -0.084 |
| Picture Arousal | 0.157 | 0.288 | 0.113 |
| Picture Valence | 1.305 | 0.394 | 0.777* |
| | | | |
| Step 2 | | | |
| Constant | -1.173 | 2.258 | |
| Trait Anxiety | 0.015 | 0.014 | 0.219 |

| | | | |
|---|---|---|---|
| Age | -0.009 | 0.007 | -0.253 |
| Gender | -0.074 | 0.265 | -0.058 |
| Picture Arousal | 0.143 | 0.295 | 0.103 |
| Picture Valence | 1.258 | 0.41 | 0.749* |
| **Tonic HRV** | **0.004** | **0.007** | **0.114** |

*Note:* $R^2 = .494$ *for Step 1,* $\Delta R^2 = .012$ *for Step 2.* $^*p < .01$.

A hierarchical regression analysis was conducted in order to examine whether phasic HRV predicted participants' success at utilizing reappraisal as an ER strategy to reduce their negative emotion during the ER task. Results showed that anxiety ($r = -.37$, $p = .04$) and valence ($r = .61$, $p = .001$) were related to reappraisal success on the picture trials. The regression model with all 6 predictors produced an $R^2 = .563$, $F(6, 16) = 3.442$, $p = .022$. As can be seen in Table D10, valence had a significant positive regression weight, indicating that participants who found the pictures to be more positive and less negative, were better at reappraising their emotions elicited by the picture stimuli ($t(16) = 3.256$, $p = .005$, $d = 1.6$, $r = .63$). Phasic HRV did not uniquely predict reappraisal success on the picture trials ($t(17) = -.669$, $p = .513$, $d = -.324$, $r = .16$).

Table D10

*Phasic HRV and Reappraisal Pictures (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Reappraisal Pictures Success (DV) | 3.29 | 0.57 | |
| Age | 36.83 | 16.29 | -.24 |
| Gender | | | .20 |
| State Anxiety | 68.13 | 20.39 | -.37* |
| Picture Arousal | 3.35 | 0.42 | -.19 |
| Picture Valence | 2.32 | 0.34 | .61** |
| Phasic HRV | 0.51 | 6.04 | -.22 |

$^*p < .05$ $^{**}p < .001$

Hierarchical Regression: Phasic HRV and Reappraisal of Pictures

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 0.973 | 1.441 | |
| State Anxiety | -0.01 | 0.005 | -0.35 |
| Age | -0.004 | 0.006 | -0.109 |
| Gender | 0.003 | 0.22 | 0.003 |
| Picture Arousal | 0.146 | 0.26 | 0.108 |
| Picture Valence | 1.133 | 0.331 | 0.683* |
| | | | |
| Step 2 | | | |
| Constant | 0.818 | 1.484 | |
| State Anxiety | -0.009 | 0.005 | -0.337 |
| Age | -0.003 | 0.007 | -0.076 |
| Gender | 0.073 | 0.247 | 0.058 |
| Picture Arousal | 0.168 | 0.266 | 0.124 |
| Picture Valence | 1.104 | 0.339 | 0.666* |
| **Phasic HRV** | **-0.012** | **0.018** | **-0.13** |

*Note:* $R^2$ *= .551 for Step 1,* $\Delta R^2$ *= .012 for Step 2. ** $p$ <.01.

**Suppression sentences.** The multiple regression model with all 6 predictors (same as above) produced an $R^2$ = .775, $F$ (6, 15) = 8.606, $p$ = <. 001. Tonic HRV and valence were positively and significantly correlated with performance on the suppression sentence trials of the ER task ($r$ = .42, $p$ = .03 and $r$ = .43, $p$ = .02 respectively), whereas arousal was negatively and significantly correlated ($r$ = - .82, $p$ = < .001). As can be seen in Table D11 tonic HRV had a positive and significant weight over and beyond the other variables in predicting participants' success at using expressive suppression as an ER strategy in response to negative sentences ($t$ (15) = 2.297, $p$ = .036, $d$ = 1.19, $r$ = .51). Arousal was negatively and significantly associated with performance on the suppression sentence trials indicating that the more stimulated participants were the poorer they perceived themselves at being able to regulate their emotional response using suppression (*t* (15) = -5.387, *p* = <. 001, *d* = -2.78, *r* = .81).

Table D11

*Tonic HRV and Suppression Sentences (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Suppression Sentences (DV) | 3.53 | 0.71 | |
| Trait Anxiety | 93.36 | 8.64 | -.04 |
| Age | 37.64 | 16.2 | -.10 |
| Gender | | | .03 |
| Sentence Arousal | 3.01 | 0.36 | -.82** |
| Sentence Valence | 2.74 | 0.33 | .43* |
| Tonic HRV | 29.28 | 16.01 | .42* |

** p <.05 ** p<.001*

Hierarchical Regression Analysis: Tonic HRV and Suppression Sentences

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 7.839 | 2.117** | |
| Trait Anxiety | -.002 | .012 | -.023 |
| Age | .006 | .006 | .134 |
| Gender | -.043 | .226 | -.028 |
| Sentence Arousal | -1.622 | .323 | -.817** |
| Sentence Valence | .214 | .344 | .100 |
| | | | |
| Step 2 | | | |
| Constant | 7.188 | 1.902** | |
| Trait Anxiety | -.001 | .010 | -.015 |
| Age | .008 | .006 | .186 |
| Gender | .018 | .203 | .012 |
| Sentence Arousal | -1.553 | .288 | -.783** |
| Sentence Valence | .156 | .307 | .073 |
| **Tonic HRV** | **.013** | **.006** | **.296*** |

*Note:* $R^2 = .696$ *for Step 1,* $\Delta R^2 = .079$ *for Step 2 (p < .05).* **p* < .05, ***p* <.01.

Results indicated that valence was positively and significantly related (*r* = .44, *p* = .018) and arousal was negatively and significantly (*r* = -.81, *p* = < .001) associated with sentence success. For phasic HRV, the multiple regression model with all 6 predictors (same as above) produced an $R^2$ = .703, *F* (6, 16) = 6.298, *p* =. 001. As can be seen in Table D12 arousal had a negative and significant weight over and beyond the other variables in predicting participants' success at using expressive suppression as an ER strategy in response to negative pictures (*t* (16) = -4.883, *p* = < .001, *d* = -2.44, *r* = .77). Phasic HRV did not uniquely predict suppression success on the sentence trials (*t* (16) = .330, *p* = .745, *d* = .17, *r* = .08).

Table D12

*Phasic HRV and Suppression of Sentences (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Suppression Sentence Success (DV) | 3.50 | 0.70 | |
| Age | 36.83 | 16.29 | -.06 |
| Gender | | | .05 |
| State Anxiety | 68.13 | 20.39 | -.05 |
| Sentence Arousal | 3.02 | 0.35 | -.81** |
| Sentence Valence | 2.74 | 0.32 | .44* |
| Phasic HRV | 0.51 | 6.04 | .08 |

** p <.05 ** p<.001*

Hierarchical Regression: Phasic HRV and Suppression of Sentences

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 7.862 | 1.713<br>* | |
| State Anxiety | 0.004 | 0.006 | 0.11 |
| Age | 0.005 | 0.006 | 0.125 |
| Gender | -0.055 | 0.223 | -0.035 |
| Sentence Arousal | -1.71 | 0.337 | -0.848* |
| Sentence Valence | 0.15 | 0.361 | 0.069 |

| | | | |
|---|---|---|---|
| Step 2 | | | |
| Constant | 7.867 | 1.759 * | |
| State Anxiety | 0.004 | 0.006 | 0.102 |
| Age | 0.005 | 0.007 | 0.113 |
| Gender | -0.081 | 0.243 | -0.052 |
| Sentence Arousal | -1.699 | 0.348 | -0.842* |
| Sentence Valence | 0.161 | 0.372 | 0.074 |
| **Phasic HRV** | **0.006** | **0.018** | **0.052** |

*Note:* $R^2$ *= .701 for Step 1,* $\Delta R^2$ *= .002 for Step 2*. **p* <.01.

**Suppression pictures.** A hierarchical regression analysis was used to examine whether tonic HRV predicted participants’ ability to use suppression to regulate their emotions elicited by negative pictures. Valence was positively and significantly associated with suppression of picture success ($r$ = .763, $p$ = < .001). The multiple regression model with all 6 predictors produced an $R^2$ = .619, $F$ (6, 15) = 4.061, $p$ = .013. As can be seen in Table D13, valence was the only predictor variable with a positive and significant weight, indicating that picture stimuli that were rated less negative and more positive, were more easily regulated with expressive suppression ($t$ (15) = 3.471, $p$ = .003, $d$ = 1.79, $r$ = .67). Tonic HRV did not uniquely predict suppression of pictures perceived success ($t$ (15) = 1.113, $p$ = .283, $d$ = .58, $r$ = 0.28).

Table D13

*Tonic HRV and Suppression Pictures (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Suppression Pictures (DV) | 3.18 | 0.69 | |
| Trait Anxiety | 93.36 | 8.64 | -.22 |
| Age | 37.64 | 16.2 | .09 |
| Gender | | | .23 |

| | | | |
|---|---|---|---|
| Picture Arousal | 3.33 | 0.42 | -.37 |
| Picture Valence | 2.33 | 0.35 | .76* |
| Tonic HRV | 29.28 | 16.01 | .24 |

* *p<.001*

Hierarchical Regression Analysis: Tonic HRV and Suppression Pictures

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | -0.789 | 2.382 | |
| Trait Anxiety | 0.002 | 0.014 | 0.02 |
| Age | 0.003 | 0.007 | 0.065 |
| Gender | -0.066 | 0.274 | -0.043 |
| Picture Arousal | 0.033 | 0.311 | 0.02 |
| Picture Valence | 1.584 | 0.425 | 0.791* |
| | | | |
| Step 2 | | | |
| Constant | -0.803 | 2.365 | |
| Trait Anxiety | 0.001 | 0.014 | 0.012 |
| Age | 0.004 | 0.007 | 0.104 |
| Gender | -0.001 | 0.278 | -0.001 |
| Picture Arousal | 0.006 | 0.309 | 0.003 |
| Picture Valence | 1.491 | 0.43 | 0.745* |
| **Tonic HRV** | **0.008** | **0.007** | **0.187** |

*Note:* $R^2$ *= .588 for Step 1,* $\Delta R^2$ *= .031 for Step 2. *p* <.01.

A hierarchical regression analysis was conducted in order to examine whether phasic HRV predicted how successfully participants were able to suppress their emotions in response to negative pictures on the ER task. As can be seen in Table D14, valence was positively and significantly ($r = .77$, $p = < .001$) and arousal was negatively and significantly ($r = -.39$, $p = .032$) related to suppression success on the picture trials. The multiple regression model with all 6 predictors produced an $R^2 = .604$, $F(6, 16) = 4.06$, $p = .012$. Valence was the only predictor variable with a positive and significant weight ($t(16) = 4.031$, $p = .001$, $d = 2.02$, $r = .71$), indicating that picture stimuli that were rated less negative and more positive, were perceived as being more easily regulated using expressive suppression, over and beyond the other predictor variables. Phasic HRV did not uniquely predict suppression success on the picture trials (*t* (16) = .155, *p* = .879, *d* = .08, *r* = .04).

Table D14

*Phasic HRV and Suppression of Pictures (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Suppression Pictures Success (DV) | 3.15 | 0.69 | |
| Age | 36.83 | 16.29 | .128 |
| Gender | | | .246 |
| State Anxiety | 68.13 | 20.39 | .006 |
| Picture Arousal | 3.35 | 0.42 | -.392* |
| Picture Valence | 2.32 | 0.34 | .769** |
| Phasic HRV | 0.51 | 6.04 | .005 |

** p <.05 ** p<.001*

Hierarchical Regression: Phasic HRV and Suppression of Pictures

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | -0.497 | 1.643 | |
| State Anxiety | -0.003 | 0.006 | -0.077 |
| Age | 0.005 | 0.007 | 0.112 |
| Gender | -0.044 | 0.251 | -0.029 |
| Picture Arousal | 0.02 | 0.296 | 0.012 |
| Picture Valence | 1.57 | 0.377 | 0.781* |
| | | | |
| Step 2 | | | |
| Constant | -0.455 | 1.714 | |
| State Anxiety | -0.003 | 0.006 | -0.08 |
| Age | 0.004 | 0.008 | 0.105 |
| Gender | -0.063 | 0.285 | -0.041 |
| Picture Arousal | 0.015 | 0.308 | 0.009 |
| Picture Valence | 1.578 | 3.91 | 0.785* |
| **Phasic HRV** | **0.003** | **0.021** | **0.029** |

*Note:* $R^2$ *= .603 for Step 1,* $\Delta R^2$ *= .001 for Step 2.* * *p* <.01.

**Appraisal sentences.** A hierarchical regression analysis was conducted in order to examine whether tonic HRV predicted how successful participants' perceived themselves to be at utilizing appraisal as an ER strategy in response to the negative sentences. Results suggested that tonic HRV (*r* = .654, *p* = <. 001) was positively and significantly correlated with participants' appraisal success on the sentence trials, suggesting that those with higher tonic HRV perceived themselves at being better at regulating their emotions in this condition. Arousal was negatively and significantly correlated with appraisal success on the sentence trials (*r* = -.629, *p* = .001) suggesting that participants that were over stimulated perceived themselves to be poorer at regulating their emotions using appraisal on sentence trials. The multiple regression model with all 6 predictors produced an $R^2$ = .705, *F* (6, 15) = 5.985, *p* = .002. As can be seen in Table D15, tonic HRV had a significant positive regression weight, indicating that participants with higher tonic HRV perceived themselves to be better at using appraisal to regulate their negative emotion as elicited by sentence stimuli, after controlling for the other variables in the model. Anxiety, age, gender, and valence ratings did not significantly predict participants' appraisal success on the picture trials of the ER task. For this model, tonic HRV (*t* (15) = 3.84, *p* = .002, *d* = 2.0, *r* = .70) and sentence arousal (*t* (15) = -3.190, *p* = .006, *d* = -1.65, *r* = .64) predicted participants' appraisal success on sentence trials.

Table D15

*Tonic HRV and Appraisal Sentences (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Appraisal Sentences (DV) | 3.56 | 0.74 | |
| Trait Anxiety | 93.36 | 8.64 | -.138 |
| Age | 37.64 | 16.2 | -.249 |

| | | | |
|---|---|---|---|
| Gender | | | .03 |
| Sentence Arousal | 3.01 | 0.36 | -.629* |
| Sentence Valence | 2.74 | 0.33 | .288 |
| Tonic HRV | 29.28 | 16.01 | .654* |

** p <.001*

Hierarchical Regression Analysis: Tonic HRV and Appraisal Sentences

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 8.155 | 3.092* | |
| Trait Anxiety | -0.01 | 0.017 | -0.114 |
| Age | -0.003 | 0.009 | -0.064 |
| Gender | -0.002 | 0.33 | -0.001 |
| Sentence Arousal | -1.247 | 0.472 | -0.596* |
| Sentence Valence | 0.071 | 0.503 | 0.032 |
| | | | |
| Step 2 | | | |
| Constant | 6.843 | 2.294** | |
| Trait Anxiety | -0.009 | 0.013 | -0.099 |
| Age | 0.002 | 0.007 | 0.035 |
| Gender | 0.121 | 0.244 | 0.074 |
| Sentence Arousal | -1.109 | 0.348 | -0.53** |
| Sentence Valence | -0.046 | 0.37 | -0.02 |
| **Tonic HRV** | **0.026** | **0.007** | **0.566**** |

*Note:* $R^2$ *= .416 for Step 1,* $\Delta R^2$ *= .290 for Step 2 (*$p$ < .01). *$p$ < .05, **$p$ <.01.

A hierarchical regression analysis was conducted in order to examine whether phasic HRV predicted how successful participants' perceived themselves to be at utilizing appraisal in response to the negative sentences in the ER task (Table D16). Results indicated that arousal was negatively and significantly correlated with appraisal success on the sentence trials ($r$ = -.63, $p$= .001). The multiple regression model with all 6 predictors was non-significant and produced an $R^2$ = .426, $F$ (6, 16) = 1.978, $p$ = .129. Phasic HRV did not uniquely predict appraisal success on the sentence trials (*t* (16) = .884, *p* = .39, *d* = .44, *r* = .22).

Table D16

*Phasic HRV and Appraisal Sentences (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Appraisal Sentence Success (DV) | 3.54 | 0.74 | |
| Age | 36.83 | 16.29 | -.201 |
| Gender | | | .05 |
| State Anxiety | 68.13 | 20.39 | -.192 |
| Sentence Arousal | 3.02 | 0.35 | -.626* |
| Sentence Valence | 2.74 | 0.32 | .297 |
| Phasic HRV | 0.51 | 6.04 | .123 |

** p <.001*

Hierarchical Regression: Phasic HRV and Appraisal of Sentences

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 6.75 | 2.55 | |
| State Anxiety | -0.002 | 0.008 | -0.046 |
| Age | -0.001 | 0.01 | -0.03 |
| Gender | 0.024 | 0.333 | 0.015 |
| Sentence Arousal | -1.205 | 0.502 | -0.569 |
| Sentence Valence | 0.201 | 0.537 | 0.088 |
| | | | |
| Step 2 | | | |
| Constant | 6.77 | 2.57 | |
| State Anxiety | -0.003 | 0.009 | -0.075 |
| Age | -0.003 | 0.01 | -0.075 |
| Gender | -0.078 | 0.354 | -0.048 |
| Sentence Arousal | -1.162 | 0.507 | -0.549 |
| Sentence Valence | 0.244 | 0.543 | 0.108 |
| **Phasic HRV** | **0.023** | **0.026** | **0.192** |

*Note: $R^2$ = .398 for Step 1, $\Delta R^2$ = .028 for Step 2.*

**Appraisal pictures.** A hierarchical regression analysis was conducted in order to examine whether tonic HRV predicted how successful participants' perceived themselves to be at utilizing appraisal and an ER strategy in response to the negative pictures on the ER task. As can be seen in Table D17, tonic HRV (*r* = .512, p= <. 01), and valence (*r* = .536, p= <. 01) were positively and significantly correlated with participants' perceived success on these trials, suggesting that higher tonic HRV was associated with better perceived ER ability on these trials. The multiple regression model with all 6 predictors produced an $R^2$ = .524, *F* (6, 15) = 2.753, *p* = .052. Tonic HRV had a significant positive regression weight, indicating that participants with higher tonic HRV perceived themselves to be better at using appraisal to regulate their emotions elicited by negative images, after controlling for the other variables in the model. Anxiety, age, gender, arousal and valence ratings did not significantly predict participants' appraisal success on the picture trials of the ER task. For this model, tonic HRV (*t* (15) = 2.6, *p* = .02, *d* = 1.34, *r* = .56) significantly and uniquely predicted participants' perceived appraisal success on the picture trials.

Table D17

*Tonic HRV and Appraisal Pictures (n=22)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Appraisal Pictures (DV) | 3.01 | 0.64 | |
| Trait Anxiety | 93.36 | 8.64 | -.269 |
| Age | 37.64 | 16.2 | -.089 |
| Gender | | | .191 |
| Picture Arousal | 3.33 | 0.42 | -.251 |
| Picture Valence | 2.33 | 0.35 | .536* |
| Tonic HRV | 29.28 | 16.01 | .512* |

** p < .01*

Hierarchical Regression Analysis: Tonic HRV and Appraisal Pictures

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 1.892 | 2.859 | |
| Trait Anxiety | -0.009 | 0.017 | -0.115 |
| Age | -0.004 | 0.008 | -0.095 |
| Gender | 0.068 | 0.329 | 0.048 |
| Picture Arousal | -0.029 | 0.373 | -0.019 |
| Picture Valence | 0.888 | 0.51 | 0.478 |
| | | | |
| Step 2 | | | |
| Constant | 1.859 | 2.452 | |
| Trait Anxiety | -0.01 | 0.015 | -0.136 |
| Age | 0 | 0.007 | 0.007 |
| Gender | 0.224 | 0.288 | 0.159 |
| Picture Arousal | -0.095 | 0.321 | -0.062 |
| Picture Valence | 0.663 | 0.445 | 0.357 |
| **Tonic HRV** | **0.02** | **0.008** | **0.489*** |

*Note:* $R^2 = .310$ *for Step 1,* $\Delta R^2 = .214$ *for Step 2* ($p < .05$). *$p < .05$

Lastly, a hierarchical regression analysis was conducted in order to examine whether phasic HRV predicted how successful participants' perceived themselves to be at utilizing appraisal and an ER strategy in response to the negative pictures on the ER task. As can be seen in Table D18, valence was positively and significantly correlated with participants' perceived success on these trials ($r = .55$, $p = .003$), suggesting that those participants that rated the pictures less negatively and more positively were associated with greater perceived appraisal success on the picture trials. The multiple regression model with all 6 predictors produced an $R^2 = .529$, $F(6, 16) = 2.99$, $p = .037$. Phasic HRV had a significant positive regression weight, indicating that participants with higher phasic HRV perceived themselves to be better at regulating their emotions elicited by negative images using appraisal as the ER strategy. Results showed that phasic HRV uniquely predicted perceived appraisal success on the picture trials after controlling for the other variables in the model (*t* (16) = 2.234, *p* = .04, *d* = 1.12, *r* = .49). Table D18 also shows a positive and significant weight for valence, indicating that those that rated the images more positively and less negatively also perceived themselves to be better at appraising their emotional response, after controlling for the other predictors in the model (*t* (16) = 2.807, *p* = .013, *d* = 1.4, *r* = .57). Anxiety, age, gender, and arousal ratings did not significantly predict participants' perceived appraisal success on the picture trials of the ER task.

Table D18

*Phasic HRV and Appraisal Pictures (n=23)*

| Variable | *M* | *SD* | *r* |
|---|---|---|---|
| Appraisal Pictures Success (DV) | 2.99 | 0.64 | |
| Age | 36.83 | 16.29 | -.037 |
| Gender | | | .211 |
| State Anxiety | 68.13 | 20.39 | -.246 |
| Picture Arousal | 3.35 | 0.42 | -.284 |
| Picture Valence | 2.32 | 0.34 | .55* |
| Phasic HRV | 0.51 | 6.04 | .272 |

** p < .01*

Hierarchical Regression: Phasic HRV and Appraisal of Picture Success

| Step 1 | *B* | *SE B* | β |
|---|---|---|---|
| Constant | 1.278 | 1.911 | |
| State Anxiety | -0.009 | 0.007 | -0.299 |
| Age | 0.002 | 0.009 | 0.052 |
| Gender | 0.057 | 0.292 | 0.04 |
| Picture Arousal | -0.036 | 0.345 | -0.023 |
| Picture Valence | 1.002 | 0.438 | 0.535 |
| | | | |
| Step 2 | | | |
| Constant | 1.887 | 1.741 | |
| State Anxiety | -0.011 | 0.006 | -0.344 |
| Age | -0.003 | 0.008 | -0.064 |

| | | | |
|---|---|---|---|
| Gender | -0.216 | 0.29 | -0.152 |
| Picture Arousal | -0.123 | 0.313 | -0.08 |
| Picture Valence | 1.116 | 0.398 | 0.596* |
| **Phasic HRV** | **0.048** | **0.021** | **0.45*** |

*Note:* $R^2$ *= .381 for Step 1,* $\Delta R^2$ *= .147 for Step 2 (*$p < .05$). *$p < .05$

# Appendix E

## Supplementary Materials: Study 2 Results

### Two-Way Repeated Measures Mixed ANOVA Results

**Tonic HRV.** One observation was identified as an outlier on the tonic HRV variable and was removed from this analysis. Table E1 illustrates the non-significant main effects and interactions for tonic HRV.

Table E1

*Intervention Effects on Tonic HRV*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>28.9 (16.3) | OM<br>40.7 (24.7) | CR<br>29.4 (22.5) | OM<br>41.4 (26) |

*Tests of Within-Subjects Effects*

| | *Df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Time | 1 | .653 | .006 | .937 | .000 |
| Time * Age | 1 | 17.925 | .177 | .677 | .007 |
| Time * Gender | 1 | 7.949 | .079 | .782 | .003 |
| Time * Intervention | 1 | .095 | .001 | .976 | .000 |
| Error (Time) | 25 | 101.175 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Intercept | 1 | 13681.743 | 14.935 | .001 | .374 |
| Age | 1 | 918.760 | 1.003 | .326 | .039 |
| Gender | 1 | 628.118 | .686 | .415 | .027 |
| Intervention | 1 | 1930.361 | 2.107 | .159 | .078 |

| | | | | | |
|---|---|---|---|---|---|
| Error | 25 | 916.061 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=14)

**ER reactivity.** Next, phasic HRV on the ER task was examined. One observation was identified as an outlier and removed from this analysis. Non-significant main effects and interactions are presented in Table E2.

Table E2

*Intervention Effects on ER Reactivity*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>1.5 (6.1) | OM<br>-1.8 (5.8) | CR<br>-2.1 (6.8) | OM<br>5.7 (7.8) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Time | 1 | 139.770 | 2.364 | .137 | .086 |
| Time * Age | 1 | 6.674 | .113 | .740 | .004 |
| Time * Gender | 1 | 77.895 | 1.318 | .262 | .050 |
| Time * Intervention | 1 | 452.559 | 7.655 | .010* | .234 |
| Error (Time) | 25 | 59.118 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Intercept | 1 | 33.823 | 1.150 | .294 | .044 |
| Age | 1 | 31.262 | 1.063 | .312 | .041 |
| Gender | 1 | 19.115 | .650 | .428 | .025 |
| Intervention | 1 | 76.338 | 2.595 | .120 | .094 |
| Error | 25 | 29.413 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=14); $p < .05$*

**N-Back reactivity.** Next, the effect of intervention on phasic HRV on the N-Back task was examined (see Table E3). One case was identified as an outlier and removed from this analysis. In addition, one observation was lost due to computer acquisition error.

Table E3

*Intervention Effects on N-Back Reactivity*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>0.2 (11.2) | OM<br>5.0 (10.4) | CR<br>2.0 (8.0) | OM<br>3.3 (6.8) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Time | 1 | 49.577 | .882 | .357 | .035 |
| Time * Age | 1 | 33.057 | .588 | .451 | .024 |
| Time * Gender | 1 | 13.057 | .232 | .634 | .010 |
| Time * Intervention | 1 | 55.421 | .986 | .331 | .039 |
| Error (Time) | 24 | 56.235 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Intercept | 1 | .000 | .000 | 1.000 | .000 |
| Age | 1 | 509.619 | 4.944 | .036* | .171 |
| Gender | 1 | 113.024 | 1.096 | .305 | .044 |
| Intervention | 1 | 275.280 | 2.671 | .115 | .100 |
| Error | 24 | 103.079 | | | |

*Note:* CR= Cognitive Restructuring (n=13); OM= Open Monitoring (n=15); *p* < .05*

**Recovery HRV.** Lastly, two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention) were used to examine the impact of intervention effects on recovery which is the change in HRV from task/event to post-task/post-event (i.e., recovery = change in HRV from engagement in a stressful task to post-task return to resting state or baseline), following both the ER and N-Back task (see Table E4). For recovery on the ER task, four observations were lost due to attrition, and an additional 3 observations were lost due to a computer programming error during HRV acquisition. A total of 27 observations were available; specifically, 13 observations for the CR group and 14 observations for the OM group.

Table E4

*Intervention Effects on ER Recovery*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>-2.6 (9.4) | OM<br>-8.6 (9.2) | CR<br>-3.2 (9.9) | OM<br>-8.6 (16.7) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Time | 1 | 8.414 | .079 | .781 | .003 |
| Time * Age | 1 | .018 | .000 | .990 | .000 |
| Time * Gender | 1 | 6.963 | .066 | .800 | .003 |
| Time * Intervention | 1 | 1.212 | .011 | .916 | .000 |
| Error (Time) | 23 | 105.953 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Intercept | 1 | 430.736 | 2.312 | .142 | .091 |
| Age | 1 | 200.355 | 1.075 | .311 | .045 |
| Gender | 1 | 1.279 | .007 | .935 | .000 |
| Intervention | 1 | 382.667 | 2.054 | .165 | .082 |
| Error | 23 | 186.313 | | | |

*Note:* CR= Cognitive Restructuring (n=13); OM= Open Monitoring (n=14)

For recovery on the N-Back task, two observations were lost due to HRV acquisition error and one case was identified as an outlier and removed (total of 3 observations were lost; see Table E5 for a summary of the results).

Table E5

*Intervention Effects on N-Back Recovery*

| Pre-Intervention | | Post-Intervention | |
|---|---|---|---|
| CR<br>1.6 (6.6) | OM<br>-3.7 (17.1) | CR<br>-3.3 (11.9) | OM<br>-5.2 (8.2) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Time | 1 | 176.672 | 1.239 | .277 | .051 |
| Time * Age | 1 | 26.660 | .187 | .670 | .008 |
| Time * Gender | 1 | 48.253 | .338 | .566 | .014 |
| Time * Intervention | 1 | 45.504 | .319 | .578 | .014 |
| Error (Time) | 23 | 142.649 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| Intercept | 1 | 2.670 | .018 | .894 | .001 |
| Age | 1 | 320.693 | 2.193 | .152 | .087 |
| Gender | 1 | 86.697 | .593 | .449 | .025 |
| Intervention | 1 | 258.881 | 1.770 | .196 | .071 |
| Error | 23 | 146.263 | | | |

*Note:* CR= Cognitive Restructuring (n=12); OM= Open Monitoring (n=15)

**Effect of Intervention on ER.** Next, two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention) were used to examine the impact of intervention effects on perceived ER success, including overall ER as well as each ER strategy separately (i.e., reappraisal, appraisal, suppression). Findings for each ER strategy are presented in Tables E6- E15 below.

Table E6

*Intervention Effects on Sentence Success*

| Pre-Intervention | | Post-Intervention | |
|---|---|---|---|
| CR<br>3.6 (0.5) | OM<br>3.7 (0.7) | CR<br>3.9 (0.6) | OM<br>3.8 (0.7) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Sentence Success* | | | | | |
| Time | 1 | .011 | .040 | .842 | .002 |

| | | | | | |
|---|---|---|---|---|---|
| Time * Age | 1 | .163 | .591 | .449 | .022 |
| Time * Gender | 1 | .336 | 1.221 | .279 | .045 |
| Time * Intervention | 1 | .188 | .684 | .416 | .026 |
| Error (Time) | 26 | .275 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Sentence Success* | | | | | |
| Intercept | 1 | 64.926 | 117.776 | .000 | .819 |
| Age | 1 | .013 | .023 | .880 | .001 |
| Gender | 1 | .000 | .001 | .979 | .000 |
| Intervention | 1 | .008 | .014 | .906 | .001 |
| Error | 26 | .551 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E7

*Intervention Effects on Picture Success*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.1 (0.5) | OM<br>3.3 (0.7) | CR<br>3.6 (0.5) | OM<br>3.5 (0.8) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Picture Success* | | | | | |
| Time | 1 | .022 | .099 | .756 | .004 |
| Time * Age | 1 | .267 | 1.220 | .279 | .045 |
| Time * Gender | 1 | .398 | 1.822 | .189 | .065 |
| Time * Intervention | 1 | .518 | 2.369 | .136 | .083 |
| Error (Time) | 26 | .219 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Picture Success* | | | | | |
| Intercept | 1 | 44.209 | 71.499 | .000 | .733 |
| Age | 1 | .171 | .276 | .604 | .011 |
| Gender | 1 | .204 | .329 | .571 | .013 |
| Intervention | 1 | .023 | .037 | .850 | .001 |
| Error | 26 | .618 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E8

*Intervention Effects on Total ER Success*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.4 (0.4) | OM<br>3.5 (0.7) | CR<br>3.8 (0.5) | OM<br>3.7 (0.7) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Total Success* | | | | | |
| Time | 1 | .000 | .002 | .968 | .000 |
| Time * Age | 1 | .211 | .908 | .349 | .034 |
| Time * Gender | 1 | .367 | 1.580 | .220 | .057 |
| Time * Intervention | 1 | .332 | 1.431 | .242 | .052 |
| Error (Time) | 26 | .232 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Total Success* | | | | | |
| Intercept | 1 | 54.063 | 99.217 | .000 | .792 |
| Age | 1 | .069 | .127 | .724 | .005 |
| Gender | 1 | .056 | .102 | .752 | .004 |
| Intervention | 1 | .014 | .026 | .873 | .001 |
| Error | 26 | .545 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15); ER= Emotion regulation

Table E9

*Intervention Effects on Reappraisal of Pictures*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.2 (0.5) | OM<br>3.5 (0.6) | CR<br>3.8 (0.6) | OM<br>3.7 (0.7) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Reappraisal Pictures* | | | | | |
| Time | 1 | .000 | .000 | .985 | .000 |
| Time * Age | 1 | .071 | .255 | .618 | .010 |

| | | | | | |
|---|---|---|---|---|---|
| Time * Gender | 1 | .446 | 1.605 | .216 | .058 |
| Time * Intervention | 1 | .919 | 3.308 | .080 | .113 |
| Error (Time) | 26 | .278 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Reappraisal Pictures* | | | | | |
| Intercept | 1 | 47.948 | 99.802 | .000 | .793 |
| Age | 1 | .000 | .000 | .986 | .000 |
| Gender | 1 | .725 | 1.510 | .230 | .055 |
| Intervention | 1 | .019 | .040 | .844 | .002 |
| Error | 26 | .480 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E10

*Intervention Effects on Suppression of Pictures*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.2 (0.7) | OM<br>3.3 (0.9) | CR<br>3.6 (0.6) | OM<br>3.5 (0.9) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Suppression Pictures* | | | | | |
| Time | 1 | .048 | .168 | .685 | .006 |
| Time * Age | 1 | .342 | 1.195 | .284 | .044 |
| Time * Gender | 1 | .284 | .991 | .329 | .037 |
| Time * Intervention | 1 | .335 | 1.171 | .289 | .043 |
| Error (Time) | 26 | .286 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Suppression Pictures* | | | | | |
| Intercept | 1 | 40.979 | 45.874 | .000 | .638 |
| Age | 1 | .411 | .460 | .504 | .017 |
| Gender | 1 | .385 | .431 | .517 | .016 |
| Intervention | 1 | .000 | .000 | .987 | .000 |
| Error | 26 | .893 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E11

*Intervention Effects on Suppression of Sentences*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.6 (0.6) | OM<br>3.5 (0.9) | CR<br>3.8 (0.7) | OM<br>3.7 (0.9) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Suppression Sentences* | | | | | |
| Time | 1 | .175 | .514 | .480 | .019 |
| Time * Age | 1 | .163 | .479 | .495 | .018 |
| Time * Gender | 1 | .908 | 2.670 | .114 | .093 |
| Time * Intervention | 1 | .030 | .088 | .769 | .003 |
| Error (Time) | 26 | .340 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Suppression Sentences* | | | | | |
| Intercept | 1 | 57.499 | 58.791 | .000 | .693 |
| Age | 1 | .054 | .055 | .816 | .002 |
| Gender | 1 | .038 | .038 | .846 | .001 |
| Intervention | 1 | .437 | .447 | .510 | .017 |
| Error | 26 | .978 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E 12

*Intervention Effects on Total Suppression*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.4 (0.6) | OM<br>3.4 (0.9) | CR<br>3.7 (0.6) | OM<br>3.6 (0.9) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Total Suppression* | | | | | |
| Time | 1 | .009 | .034 | .855 | .001 |
| Time * Age | 1 | .251 | .913 | .348 | .034 |

| | | | | | |
|---|---|---|---|---|---|
| Time * Gender | 1 | .555 | 2.016 | .168 | .072 |
| Time * Intervention | 1 | .146 | .531 | .473 | .020 |
| Error (Time) | 26 | .275 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Total Suppression* | | | | | |
| Intercept | 1 | 48.963 | 55.899 | .000 | .683 |
| Age | 1 | .190 | .217 | .645 | .008 |
| Gender | 1 | .162 | .185 | .670 | .007 |
| Intervention | 1 | .113 | .129 | .723 | .005 |
| Error | 26 | .876 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E13

*Intervention Effects on Appraisal of Pictures*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.0 (0.6) | OM<br>3.1 (0.8) | CR<br>3.5 (0.7) | OM<br>3.4 (0.9) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Appraisal Pictures* | | | | | |
| Time | 1 | .254 | .729 | .401 | .027 |
| Time * Age | 1 | .623 | 1.789 | .193 | .064 |
| Time * Gender | 1 | .278 | .799 | .380 | .030 |
| Time * Intervention | 1 | .165 | .474 | .497 | .018 |
| Error (Time) | 26 | .348 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Appraisal Pictures* | | | | | |
| Intercept | 1 | 41.535 | 51.570 | .000 | .665 |
| Age | 1 | .017 | .021 | .885 | .001 |
| Gender | 1 | .259 | .322 | .575 | .012 |
| Intervention | 1 | .023 | .028 | .868 | .001 |
| Error | 26 | .805 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E 14

*Intervention Effects on Appraisal of Sentences*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.5 (0.6) | OM<br>3.7 (0.7) | CR<br>3.8 (0.6) | OM<br>3.8 (0.8) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Appraisal Sentences* | | | | | |
| Time | 1 | .037 | .112 | .740 | .004 |
| Time * Age | 1 | .161 | .493 | .489 | .019 |
| Time * Gender | 1 | .448 | 1.370 | .253 | .050 |
| Time * Intervention | 1 | .153 | .468 | .500 | .018 |
| Error (Time) | 26 | .327 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Appraisal Sentences* | | | | | |
| Intercept | 1 | 64.651 | 95.297 | .000 | .786 |
| Age | 1 | 7.446E-05 | .000 | .992 | .000 |
| Gender | 1 | .005 | .007 | .934 | .000 |
| Intervention | 1 | .109 | .161 | .691 | .006 |
| Error | 26 | .678 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

Table E 15

*Intervention Effects on Total Appraisal*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>3.2 (0.6) | OM<br>3.4 (0.7) | CR<br>3.5 (0.7) | OM<br>3.6 (0.8) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Total Appraisal* | | | | | |
| Time | 1 | .009 | .023 | .880 | .001 |
| Time * Age | 1 | .123 | .320 | .576 | .012 |
| Time * Gender | 1 | .386 | 1.002 | .326 | .037 |
| Time * Intervention | 1 | .012 | .031 | .861 | .001 |

| | | | | | |
|---|---|---|---|---|---|
| Error (Time) | 26 | .385 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *Total Appraisal* | | | | | |
| Intercept | 1 | 48.778 | 73.580 | .000 | .739 |
| Age | 1 | .101 | .152 | .700 | .006 |
| Gender | 1 | .061 | .092 | .764 | .004 |
| Intervention | 1 | .283 | .427 | .519 | .016 |
| Error | 26 | .663 | | | |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=15)

**Intervention effects on anxiety.** Next we tested for intervention effects on anxiety, utilizing a two-way repeated measures mixed ANOVAs (2 Time) x (2 Intervention). This analysis was conducted separately for both state and trait levels of anxiety. One observation was identified as an outlier and removed from this analysis.

***State anxiety.*** For state anxiety, results indicated that the main effect of time failed to reach statistical significance *F* (1, 25) = .058, *p* = .812; ηp$^2$ = .002 (see Table E16). The interaction between time and age (*F* (1, 25) = .096, *p* = .759; ηp$^2$ = .004), time and gender (*F* (1, 25) = .780, *p* = .386; .03) and between time and intervention (*F* (1, 25) = .016, *p* = .90; ηp$^2$ = .001) were similarly non-significant.

Table E16

*Intervention Effects on State Anxiety*

| **Pre-Intervention** | | **Post-Intervention** | |
|---|---|---|---|
| CR<br>71.6 (20.9) | OM<br>67.6 (18.2) | CR<br>66.5 (15.2) | OM<br>60.4 (27.2) |

*Tests of Within-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *State Anxiety* | | | | | |
| Time | 1 | 19.205 | .058 | .812 | .002 |

| | | | | | |
|---|---|---|---|---|---|
| Time * Age | 1 | 31.910 | .096 | .759 | .004 |
| Time * Gender | 1 | 258.517 | .780 | .386 | .030 |
| Time * Intervention | 1 | 5.337 | .016 | .900 | .001 |
| Error (Time) | 25 | 331.383 | | | |

*Tests of Between-Subjects Effects*

| | *df* | *MS* | *F* | *p* | *ηp²* |
|---|---|---|---|---|---|
| *State Anxiety* | | | | | |
| Intercept | 1 | 18935.949 | 32.484 | .000 | .565 |
| Age | 1 | 20.935 | .036 | .851 | .001 |
| Gender | 1 | 173.527 | .298 | .590 | .012 |
| Intervention | 1 | 306.337 | .526 | .475 | .021 |

*Note:* CR= Cognitive Restructuring (n=15); OM= Open Monitoring (n=14)

# Appendix E

## Questionnaires

This appendix contains the following questionnaires, each of which is associated with published, peer-reviewed articles (source articles available on request):

1. Demographic and Life Stress Questionnaire (unpublished measure)
2. Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004)
3. Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007)
4. The Emotion Regulation Questionnaire (ERQ; Gross & John, 2003)
5. Perceived Stress Scale (Cohen et al., 1983)
6. Multidimensional Assessment of Interoceptive Awareness (Mehling et al., 2012)
7. Five Factor Mindfulness Questionnaire (Baer et al., 2008)
8. State Trait Anxiety Inventory (STAI) form Y (Spielberger, 1983; 2010)
9. The Penn State Worry Questionnaire (PSWQ) (Meyer et al., 1990)

# Demographic and Life-Stress Questionnaire

ID #:

Age:

Gender:

Race/Ethnicity:

Highest Level of Education:

Marital Status:

Current Living Situation:

Work Status:

Country Where You Were Born:

How many times in your life have you moved to a different city or town?

How many times in your life have you moved to a different country?

Would you say, in your life, that you have had an average level of stress, a less-than-average level of stress, or an above-average level of stress?

________________________

What are the three most stressful events that have ever happened in your life, and when did those occur?

________________________

Would you say that *within the last week*, you have an average level of stress, a less-than-average level of stress, or an above-average level of stress?

________________________

In a typical week, would you say that you feel stressed (please circle your answer):

Never
Rarely (1-2 times a week)
Often (3-5 times a week)

Very Often (6-7 times a week)
Always (Everyday)

Has anyone in your family ever been diagnosed with a psychological condition? Y N

(If yes) Does anyone in your family suffer from depression, anxiety, or any other psychological condition? Y N

Was this person a first-degree relative (such as parent, sibling, or child)? Y N

How do you generally cope with your negative emotions? (e.g., exercise, hang out with friends, listen to music)

______________________

# DERS

**Please indicate how often the following statements apply to you by writing the appropriate number from the scale below on the line beside each item:**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| almost never | sometimes | about half the time | most of the time | almost always |
| (0-10%) | (11-35%) | (36-65%) | (66-90%) | (91-100%) |

______ 1) I am clear about my feelings.

______ 2) I pay attention to how I feel.

______ 3) I experience my emotions as overwhelming and out of control.

______ 4) I have no idea how I am feeling.

______ 5) I have difficulty making sense out of my feelings.

______ 6) I am attentive to my feelings.

______ 7) I know exactly how I am feeling.

______ 8) I care about what I am feeling.

______ 9) I am confused about how I feel.

______ 10) When I'm upset, I acknowledge my emotions.

______ 11) When I'm upset, I become angry with myself for feeling that way.

______ 12) When I'm upset, I become embarrassed for feeling that way.

______ 13) When I'm upset, I have difficulty getting work done.

______ 14) When I'm upset, I become out of control.

______ 15) When I'm upset, I believe that I will remain that way for a long time.

______ 16) When I'm upset, I believe that I'll end up feeling very depressed.

______ 17) When I'm upset, I believe that my feelings are valid and important.

______ 18) When I’m upset, I have difficulty focusing on other things.

______ 19) When I’m upset, I feel out of control.

______ 20) When I’m upset, I can still get things done.

______ 21) When I’m upset, I feel ashamed with myself for feeling that way.

______ 22) When I’m upset, I know that I can find a way to eventually feel better.

______ 23) When I’m upset, I feel like I am weak.

______ 24) When I’m upset, I feel like I can remain in control of my behaviors.

______ 25) When I’m upset, I feel guilty for feeling that way.

______ 26) When I’m upset, I have difficulty concentrating.

______ 27) When I’m upset, I have difficulty controlling my behaviors.

______ 28) When I’m upset, I believe that there is nothing I can do to make myself feel better.

______ 29) When I’m upset, I become irritated with myself for feeling that way.

______ 30) When I’m upset, I start to feel very bad about myself.

______ 31) When I’m upset, I believe that wallowing in it is all I can do.

______ 32) When I’m upset, I lose control over my behaviors.

______ 33) When I’m upset, I have difficulty thinking about anything else.

______ 34) When I’m upset, I take time to figure out what I’m really feeling.

______ 35) When I’m upset, it takes me a long time to feel better.

______ 36) When I’m upset, my emotions feel overwhelming.

# ASI-3

Enter the number from the scale below that best describes how typical or characteristic each of the 16 items is of ***you***, putting the number next to the item. You should make your ratings in terms of how much you agree or disagree with the statement as a ***general*** description of yourself.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| very little | a little | some | much | very much |

1. It is important for me not to appear nervous.
2. When I cannot keep my mind on a task, I worry that I might be going crazy.
3. It scares me when my heart beats rapidly.
4. When my stomach is upset, I worry that I might be seriously ill.
5. It scares me when I am unable to keep my mind on a task.
6. When I tremble in the presence of others, I fear what people might think of me.
7. When my chest feels tight, I get scared that I won't be able to breathe properly.
8. When I feel pain in my chest, I worry that I'm going to have a heart attack.
9. I worry that other people will notice my anxiety.
10. When I feel "spacey" or spaced out I worry that I may be mentally ill.
11. It scares me when I blush in front of people.
12. When I notice my heart skipping a beat, I worry that there is something seriously wrong with me.
13. When I begin to sweat in a social situation, I fear people will think negatively of me.
14. When my thoughts seem to speed up, I worry that I might be going crazy.
15. When my throat feels tight, I worry that I could choke to death.
16. When I have trouble thinking clearly, I worry that there is something wrong with me.
17. I think it would be horrible for me to faint in public.
18. When my mind goes blank, I worry there is something terribly wrong with me.

# Emotion Regulation Questionnaire (ERQ)

**Instructions:**
We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is you emotional experience, or what you feel like inside. The other is your emotional expression, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the follow scale:

**1---------------2----------------3----------------4----------------5----------------6----------------7**
**strongly neutral strongly**
**disagree agree**

1. ______ When I want to feel more *positive* emotion (such as joy or amusement), I *change what I'm thinking about.*
2. ______ I keep my emotions to myself.
3. ______When I want to feel less *negative* emotion (such as sadness or anger), I *change what I'm thinking about.*
4. ______When I am feeling *positive* emotions, I am careful not to express them.
5. ______When I'm faced with a stressful situation, I make myself *think about it* in a way that helps me stay calm.
6. ______I control my emotions by *not expressing them.*
7. ______When I want to feel more *positive* emotion, I *change the way I'm thinking* about the situation.
8. ______I control my emotions by *changing the way I think* about the situation I'm in.
9. ______When I am feeling *negative* emotions, I make sure not to express them.
10. ______When I want to feel less *negative* emotion, I *change the way I'm thinking* about the situation.

# Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts **during the last month**. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

**0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often**

1. In the last month, how often have you been upset because of something that happened unexpectedly?.................................... **0 1 2 3 4**
2. In the last month, how often have you felt that you were unable to control the important things in your life?...................................................... **0 1 2 3 4**
3. In the last month, how often have you felt nervous and "stressed"? .............. **0 1 2 3 4**
4. In the last month, how often have you felt confident about your ability to handle your personal problems?.................................................................. **0 1 2 3 4**
5. In the last month, how often have you felt that things were going your way?........................................................................................ **0 1 2 3 4**
6. In the last month, how often have you found that you could not cope with all the things that you had to do? .............................................................. **0 1 2 3 4**
7. In the last month, how often have you been able to control irritations in your life?......................................................................... **0 1 2 3 4**
8. In the last month, how often have you felt that you were on top of things?..... **0 1 2 3 4**
9. In the last month, how often have you been angered because of things that were outside of your control? ..................................... **0 1 2 3 4**
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?............................ **0 1 2 3 4**

# Multidimensional Assessment of Interoceptive Awareness (MAIA)

**Below you will find a list of statements. Please indicate how often each statement applies to you generally in daily life.**

| | **Circle one number on each line** | | | | | |
|---|---|---|---|---|---|---|
| . | **Never** | | | | | **Always** |
| 1. When I am tense I notice where the tension is located in my body. | 0 | 1 | 2 | 3 | 4 | 5 |
| 2. I notice when I am uncomfortable in my body. | 0 | 1 | 2 | 3 | 4 | 5 |
| 3. I notice where in my body I am comfortable. | 0 | 1 | 2 | 3 | 4 | 5 |
| 4. I notice changes in my breathing, such as whether it slows down or speeds up. | 0 | 1 | 2 | 3 | 4 | 5 |
| 5. I do not notice (I ignore) physical tension or discomfort until they become more severe. | 0 | 1 | 2 | 3 | 4 | 5 |
| 6. I distract myself from sensations of discomfort. | 0 | 1 | 2 | 3 | 4 | 5 |
| 7. When I feel pain or discomfort, I try to power through it. | 0 | 1 | 2 | 3 | 4 | 5 |
| 8. When I feel physical pain, I become upset. | 0 | 1 | 2 | 3 | 4 | 5 |
| 9. I start to worry that something is wrong if I feel any discomfort. | 0 | 1 | 2 | 3 | 4 | 5 |
| 10. I can notice an unpleasant body sensation without worrying about it. | 0 | 1 | 2 | 3 | 4 | 5 |
| 11. I can pay attention to my breath without being distracted by things happening around me. | 0 | 1 | 2 | 3 | 4 | 5 |
| 12. I can maintain awareness of my inner bodily sensations even when there is a lot going on around me. | 0 | 1 | 2 | 3 | 4 | 5 |
| 13. When I am in conversation with someone, I can pay attention to my posture. | 0 | 1 | 2 | 3 | 4 | 5 |
| 14. I can return awareness to my body if I am distracted. | 0 | 1 | 2 | 3 | 4 | 5 |
| 15. I can refocus my attention from thinking to sensing my body. | 0 | 1 | 2 | 3 | 4 | 5 |
| 16. I can maintain awareness of my whole body even when a part of me is in pain or discomfort. | 0 | 1 | 2 | 3 | 4 | 5 |

**Please indicate how often each statement applies to you generally in daily life.**

| | **Circle one number on each line** | | | | | |
|---|---|---|---|---|---|---|
| | **Never** | | | | | **Alw** |
| 17. I am able to consciously focus on my body as a whole. | 0 | 1 | 2 | 3 | 4 | |
| 18. I notice how my body changes when I am angry. | 0 | 1 | 2 | 3 | 4 | |
| 19. When something is wrong in my life I can feel it in my body. | 0 | 1 | 2 | 3 | 4 | |
| 20. I notice that my body feels different after a peaceful experience. | 0 | 1 | 2 | 3 | 4 | |
| 21. I notice that my breathing becomes free and easy when I feel comfortable. | 0 | 1 | 2 | 3 | 4 | |
| 22. I notice how my body changes when I feel happy / joyful. | 0 | 1 | 2 | 3 | 4 | |
| 23. When I feel overwhelmed I can find a calm place inside. | 0 | 1 | 2 | 3 | 4 | |
| 24. When I bring awareness to my body I feel a sense of calm. | 0 | 1 | 2 | 3 | 4 | |
| 25. I can use my breath to reduce tension. | 0 | 1 | 2 | 3 | 4 | |
| 26. When I am caught up in thoughts, I can calm my mind by focusing on my body/breathing. | 0 | 1 | 2 | 3 | 4 | |
| 27. I listen for information from my body about my emotional state. | 0 | 1 | 2 | 3 | 4 | |
| 28. When I am upset, I take time to explore how my body feels. | 0 | 1 | 2 | 3 | 4 | |
| 29. I listen to my body to inform me about what to do. | 0 | 1 | 2 | 3 | 4 | |
| 30. I am at home in my body. | 0 | 1 | 2 | 3 | 4 | |
| 31. I feel my body is a safe place. | 0 | 1 | 2 | 3 | 4 | |
| 32. I trust my body sensations. | 0 | 1 | 2 | 3 | 4 | |

# Five Factor Mindfulness Questionnaire (FFMQ)

**Please rate each of the following statements using the scale provided. Write the number in the blank that best describes <u>your own opinion</u> of what is <u>generally true for you</u>.**

| **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|
| **never or very rarely true** | **rarely true** | **sometimes true** | **often true** | **very often or always true** |

_____ 1. When I'm walking, I deliberately notice the sensations of my body moving.
_____ 2. I'm good at finding words to describe my feelings.
_____ 3. I criticize myself for having irrational or inappropriate emotions.
_____ 4. I perceive my feelings and emotions without having to react to them.
_____ 5. When I do things, my mind wanders off and I'm easily distracted.
_____ 6. When I take a shower or bath, I stay alert to the sensations of water on my body.
_____ 7. I can easily put my beliefs, opinions, and expectations into words.
_____ 8. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.
_____ 9. I watch my feelings without getting lost in them.
_____ 10. I tell myself I shouldn't be feeling the way I'm feeling.
_____ 11. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.
_____ 12. It's hard for me to find the words to describe what I'm thinking.
_____ 13. I am easily distracted.
_____ 14. I believe some of my thoughts are abnormal or bad and I shouldn't think that way.
_____ 15. I pay attention to sensations, such as the wind in my hair or sun on my face.
_____ 16. I have trouble thinking of the right words to express how I feel about things
_____ 17. I make judgments about whether my thoughts are good or bad.
_____ 18. I find it difficult to stay focused on what's happening in the present.
_____ 19. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.
_____ 20. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.
_____ 21. In difficult situations, I can pause without immediately reacting.

_____ 22. When I have a sensation in my body, it's difficult for me to describe it because I can't find the right words.

_____ 23. It seems I am "running on automatic" without much awareness of what I'm doing.

_____24. When I have distressing thoughts or images, I feel calm soon after.

_____ 25. I tell myself that I shouldn't be thinking the way I'm thinking.

_____ 26. I notice the smells and aromas of things.

_____ 27. Even when I'm feeling terribly upset, I can find a way to put it into words.

_____ 28. I rush through activities without being really attentive to them.

_____ 29. When I have distressing thoughts or images I am able just to notice them without reacting.

_____ 30. I think some of my emotions are bad or inappropriate and I shouldn't feel them.

_____ 31. I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.

_____ 32. My natural tendency is to put my experiences into words.

_____ 33. When I have distressing thoughts or images, I just notice them and let them go.

_____ 34. I do jobs or tasks automatically without being aware of what I'm doing.

_____ 35. When I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about.

_____ 36. I pay attention to how my emotions affect my thoughts and behavior.

_____ 37. I can usually describe how I feel at the moment in considerable detail.

_____ 38. I find myself doing things without paying attention.

_____ 39. I disapprove of myself when I have irrational ideas.

## The Penn State Worry Questionnaire (PSWQ)

Instructions: Rate each of the following statements on a scale of 1 ("not at all typical of me") to 5 ("very typical of me"). Please do not leave any items blank.

| | Not at all typical of me | | | | Very typical of me |
|---|---|---|---|---|---|
| 1. If I do not have enough time to do everything, I do not worry about it. | 1 | 2 | 3 | 4 | 5 |
| 2. My worries overwhelm me. | 1 | 2 | 3 | 4 | 5 |
| 3. I do not tend to worry about things. | 1 | 2 | 3 | 4 | 5 |
| 4. Many situations make me worry. | 1 | 2 | 3 | 4 | 5 |
| 5. I know I should not worry about things, but I just cannot help it. | 1 | 2 | 3 | 4 | 5 |
| 6. When I am under pressure I worry a lot. | 1 | 2 | 3 | 4 | 5 |
| 7. I am always worrying about something. | 1 | 2 | 3 | 4 | 5 |
| 8. I find it easy to dismiss worrisome thoughts. | 1 | 2 | 3 | 4 | 5 |
| 9. As soon as I finish one task, I start to worry about everything else I have to do. | 1 | 2 | 3 | 4 | 5 |
| 10. I never worry about anything. | 1 | 2 | 3 | 4 | 5 |
| 11. When there is nothing more I can do about a concern, I do not worry about it any more. | 1 | 2 | 3 | 4 | 5 |
| 12. I have been a worrier all my life. | 1 | 2 | 3 | 4 | 5 |
| 13. I notice that I have been worrying about things. | 1 | 2 | 3 | 4 | 5 |
| 14. Once I start worrying, I cannot stop. | 1 | 2 | 3 | 4 | 5 |
| 15. I worry all the time. | 1 | 2 | 3 | 4 | 5 |
| 16. I worry about projects until they are all done. | 1 | 2 | 3 | 4 | 5 |