

PERFECTIONISM AS A MODERATOR OF HEART RATE VARIABILITY WHEN  
USING ADULT COLORING BOOKS

by

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## LIST OF ABBREVIATIONS

Abbreviation	Description
ANOVA	Analysis of Variance
ANS	Autonomic Nervous System
APS-R	Almost Perfect Scale-Revised
DMNX	Dorsal Motor Nucleus
ECG	Electrocardiogram
FFT	Fast Fourier Transformation
HF	High-Frequency
HRV	Heart Rate Variability
LF	Low-Frequency
MANCOVA	Multivariate Analysis of Covariance
MANOVA	Multivariate Analysis of Variance
PANAS	Positive Affect Negative Affect Scale
PASAT	Paced Auditory Serial Addition Task
PCI	Perfectionism Cognitions Inventory
PNS	Parasympathetic Nervous System
PSD	Power Spectral Density
RSA	Respiratory Sinus Arrhythmias
SA	Sinoatrial
SAPS	Short Almost Perfect Scale



SDNN	Standard Deviation of R-R Intervals
SNS	Sympathetic Nervous System
S-TAI	State-Trait Anxiety Inventory
SVB	Sympathetic Vagal Balance
VLF	Very Low Frequency

## **I. INTRODUCTION**

Chronic psychological stress can be extremely damaging to the health and well-being of an individual (Taylor 2009). For example, higher rates of chronic stress are related to poor psychological outcomes, such as increased risk of anxiety and depression (Hammen, Kim, Eberhart, & Brennan, 2009; Hammen & Shih, 2008; Young & Dietrich, 2015). Similarly, stress is linked to decreased immune functioning and the development of cardiovascular disease (Cohen, Janicki-Deverts, & Miller, 2007; Sergerstrom & Miller, 2004). Given the negative consequences of stress, it is important to identify effective methods of managing stressors that are both easily accessible and affordable. One tool for relieving stress that has gained popularity recently is adult coloring books. In fact, upwards of 14 million coloring books were sold in the United States alone in 2016 (Begely, 2017).

Adult coloring books consist of pre-drawn images that are far more complex than the images provided in children's coloring books. Some researchers have suggested that coloring, similar to meditation, has potential to be a stress-relieving tool for many people. For example, in an interview with CNN, Marygrace Berbian, a certified art therapist and Clinical Assistant Professor at New York University, argued that, "Coloring definitely has the potential to reduce anxiety, create focus, or bring [about] more mindfulness" (Berbian, 2016, p. 5). Despite these claims, there has been relatively little systematic research exploring the efficacy of coloring in managing negative emotions and stressors. There have been three studies on the impact of coloring pre-drawn mandala forms on stress and negative affect (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012). Overall, these studies suggest that coloring is beneficial in

relieving stress. However, it is important to note that past research has overwhelmingly relied on self-report measures of anxiety in determining the effectiveness of coloring as a stress-relieving tool. Therefore, one gap in our understanding of the effects of coloring on stress is the lack of objective, physiological measures, which make it difficult to ascertain whether coloring confers a significant advantage in stress relief beyond that of other methods of relaxation, such as meditation. One physiological measure that is often used in stress management research and could be applied for coloring research is cardiovascular reactivity, heart rate variability in particular. A second gap in the previous literature on coloring is the failure to examine the potential protective effects it could provide when managing stressors in the future. All previous studies on coloring have used an experimental design in which participants undergo an acute stressor prior to coloring (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012). This design is only testing the stress-relieving qualities of coloring, not the potential protective benefits. Alternatively, another design that would allow researchers to examine these potential protective benefits would be having participants complete coloring prior to undergoing an acute stressor. Notably, the effect of coloring would need to be both persistent and significant to remain when participants are undergoing an acute stressor.

Heart rate variability (HRV) refers to the variations in time between each heartbeat. This can be calculated by analyzing the variability in heart rate along the length of the cardiac cycle on an electrocardiogram (ECG). Importantly, it has been theorized that HRV could be a measure of emotion regulation capacity (Porges, 2001; Thayer & Lane, 2000). Specifically, individuals with greater HRV are better able to

manage their emotions and stress, whereas individuals with lower HRV have a blunted physiological response to stress that suggests an inability to cope with stressors. In the context of coloring, this suggests that if coloring is an effective stress-management tool, it should increase an individual's ability to manage their emotions and stress, thereby increasing HRV. Thus, the goal of this thesis is to determine the relationship between coloring and HRV following the introduction of an acute stressor.

In addition to identifying the coloring-stress relationship, this thesis also seeks to identify individual differences that may impact the efficacy of coloring as a stress-management tool. Specifically, previous research suggests personality is related to individuals' ability to manage their emotions and stress. One personality trait that has several negative implications for emotion regulation and stress management is perfectionism (Chester, Merwin, & DeWall, 2015; Rudolph, Flett, & Hewitt, 2007; Rumkani, Sudhir, & Math, 2014). For example, perfectionists have been shown to receive fewer benefits from practicing meditation and report greater emotion dysregulation (Azam, Katz, Fashler, Changoor, & Azargive, 2015). Given the similarities between coloring and meditation, it is plausible that a perfectionist would not receive the same benefits from coloring as a non-perfectionist. However, this possibility awaits systematic examination. As such, the second goal of this thesis is to determine the relationship between perfectionism and coloring on HRV following the introduction of a stressor.

In the subsequent sections, a comprehensive review of the past studies involving coloring follows in order to clearly define the gaps in the previous literature. Next, the autonomic nervous system and vagus nerve will be discussed in the context of HRV. This information is vital for understanding how the measure of HRV is derived and its

implications in stress research. Finally, perfectionism will be discussed as well as its relationship to emotion regulation and HRV. This information will provide a framework for the rationale and procedures for the current study.

## **II. LITERATURE REVIEW**

One new stress-reduction tool that has experienced an explosion in popularity is adult coloring. In fact, an estimated 12 million adult coloring books were sold in 2015 alone (Halzack, 2016). Further, news outlets have been presenting these books as a stress-relieving tool. For example, articles are entitled, “Why adult coloring books are good for you,” (Fitzpatrick, 2016) and, “Adult coloring books promise stress-relief” (Painter, 2015). Despite being marketed as a stress-relieving method, there are few empirical studies to back up these claims. The three studies that have explored the impact of coloring a pre-drawn image on stress suggest that coloring is effective in reducing self-reported state anxiety and negative affect (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012); however, the potential physiological impact of coloring remains unclear. These studies will be discussed in detail below. Given the paucity of research in this area, as well as the significant number of people using it as an emotion regulation technique, it is important to objectively examine the effectiveness of adult coloring using methods beyond self-report.

### **Adult Coloring**

Adult coloring appears to stem from the increased popularity of art therapy, an overarching term that describes therapies involving dance, music, and visual arts (e.g., sculpture, painting; Boehm, Cramer, Staroszynski, & Ostermann, 2014). These therapies are thought to provide individuals with a new form of communication that allows them to express thoughts and emotions that could be difficult to express verbally (Boehm et al., 2014). Importantly, recent research suggests art therapy improves physiological and psychological health (Boehm et al., 2014; Bradt, Dileo, Grocke, & Magill, 2011). In fact,

one meta-analysis found that music therapy decreased self-reported state anxiety and pain while increasing self-reported mood and quality of life for cancer patients (Bradt et al., 2011). Similarly, a meta-analysis found art therapies improve self-reported state anxiety in breast cancer patients (Boehm et al., 2014). The anxiolytic capabilities of art therapy are even seen in healthy populations. For example, students who participated in an art making activity (e.g., painting, coloring, modeling with clay) experienced significant reductions in state anxiety when compared to controls who were given no specific activity (Sandmire, Gorham, Rankin, & Grimm, 2012). In sum, art therapy is a promising area of research for improving health.

One focus of art therapy research related to adult coloring is the creation of mandalas (i.e., a circular design in which participants draw symbols inside; Henderson, Rosen, & Mascaro, 2007; Pisarik & Larson, 2011). Research suggests that art making, and the creation of mandalas in particular, has a significant impact on psychological well-being (Pisarik & Larson, 2011). For example, in one study, participants assigned to a mandala drawing group reported greater authenticity and psychological well-being when compared to a no-task control group (Pisarik & Larson, 2011). In addition, another study, using a population diagnosed with PTSD, found that individuals in the mandala drawing group when compared to the control group who drew an assigned object (e.g., cup, bottle, and pen) reported fewer symptoms of trauma in the month following the activity (Henderson et al., 2007). However, there were no differences in depressive symptoms, anxiety, and spirituality in the month following. Interestingly, another study found that pediatric patients who used iPads to create a mandala during needle sticks exhibited fewer pain and anxiety symptoms when compared to the control group that underwent

standard procedures for shots without the assistance of an iPad (Stinely, Norris, & Hinds, 2015). Despite the promising research on mandala creation, it still remains unclear how mandala creation compares to other types of art-therapies.

There are very few studies that involve the coloring of a pre-drawn design (as you would see in an adult coloring book). Perhaps the most prominent of these studies is Curry and Kasser's (2005) experiment in which participants were randomly assigned to either color a pre-drawn mandala design, pre-drawn plaid design, or a blank sheet of paper. Participants in both the pre-drawn mandala and pre-drawn plaid conditions reported a greater decline in self-reported anxiety following the task when compared to the participants coloring a blank paper (Curry & Kasser, 2005). Overall, these findings suggest that coloring a pre-drawn design mandala or plaid design (like in a coloring book) is more beneficial for reducing anxiety than coloring a blank piece of paper. However, a replication of this study found that only the mandala condition was effective at reducing state anxiety (van der Venet & Serice, 2012); thus, the authors concluded the pre-drawn mandala form was especially effective in the reduction of anxiety. One explanation provided by Curry and Kasser (2005) for why the mandala form is more beneficial than free-form coloring is that the mandala provides the participant with structure that allows the participant to get 'lost' in the process, whereas free-form coloring is marked by periodic breaks in which the participant thinks through his or her next step. However, this fails to take into account why the plaid design condition was less effective than the mandala condition within der Venet and Serice's (2012) replication study.



A majority of the research using the coloring of pre-drawn designs has relied on self-report measures of anxiety. In fact, only one study used physiological measures (i.e., skin conductance, blood pressure, heart rate, and pulse) in addition to self-report measures to determine the effectiveness of coloring on reducing stress (Muthard & Gilbertson, 2016). Specifically, this study employed the Trier Social Stress test in order to increase feelings of anxiety and physiological arousal before assigning participants to either a combined mandala coloring/focused breathing group or a no-task control group to examine whether coloring and breathing reduced time to recovery after an acute social stressor. Results indicated a marginally significant difference in self-reported state anxiety and negative affect between the combined mandala coloring/focused breathing condition and the no-task control group (Muthard & Gilbertson, 2016). It is important to note that there were no differences between the combined mandala coloring/focused breathing group and the no-task control group on physiological measures during the coping task following the acute stressor. In addition, it was impossible to tell what aspect of the combined mandala coloring/focused breathing condition created the reduction in state anxiety and negative affect because there was no mandala coloring only group and no focused breathing only group. Perhaps the focused breathing had a greater impact than the mandala coloring on the self-report measures or vice versa. Thus, the physiological impact of coloring alone remains unexplored.

Overall, the three studies involving pre-drawn mandalas suggest there may be positive effects of mandala coloring when managing anxiety. However, there are a number of methodological shortcomings within these studies. First, the studies often had small sample sizes ranging between 37-84 participants (Curry & Kasser, 2005; Muthard

& Gilbertson, 2016; van der Vennet & Serice, 2012). In fact, the replication study had a sample of 50, which was divided into three conditions: pre-drawn mandala ( $N = 13$ ), pre-drawn plaid ( $N = 15$ ), and blank paper ( $N = 22$ ; van der Vennet & Serice, 2012). This may have contributed to the inconsistency between the Curry and Kasser (2005) study and van der Vennet and Serice's replication. Second, a majority of the research has relied on self-report measures (Curry & Kasser, 2005; van der Vennet & Serice, 2012), which can be biased due to social desirability. The lone study that used physiological measures was confounded by the inclusion of breathing exercises in the coloring condition (Muthard & Gilbertson, 2016). These methodological shortcomings may offer some insight as to the mixed results in the research.

It is also important to note that all previous studies examining the impact of coloring have been interested in the potential stress-relieving qualities of coloring after an acute stressor (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Vennet & Serice, 2012), not the potential protective benefits of coloring. There is evidence to suggest coloring provides some stress-relief following a lab stressor, but it remains unclear how persistent and long-lasting the effects of coloring could be. Perhaps coloring provides some protective benefits that would persist when an individual is undergoing a future stressor. Notably, for coloring to provide protective benefits on stress, the effects would need to be significant and persistent because they would still need to be noticeable during an acute lab stressor.

Despite finding positive effects of mandala coloring, it remains unclear why this method is effective in reducing self-reported anxiety. One explanation provided by Curry and Kasser (2005) speculates that coloring mandalas could reduce anxiety because "it

helps draw individuals into a state similar to mindfulness meditation” (p. 81). The authors point to the striking similarities between mindfulness meditation and coloring in that both activities involve deep focus and create a soothing effect (Curry & Kasser, 2005). If this line of thinking is correct, individuals using coloring should have a similar physiological and psychological experience to individuals using meditation. As such, it is important to understand the relationship between mindfulness meditation and stress to make predictions about the relationship between coloring and stress. Notably, previous studies examining the impact of mindfulness meditation on stress reactivity have found mindfulness training to be an effective method of reducing future stress reactivity (Brewer et al., 2009; Goyal et al., 2014; Kabat-Zinn et al., 1992). No prior research has yet examined the role coloring may play in improving stress reactivity during future events. Considering the paucity of prior research exploring the physiological effects of coloring during future events, this thesis will make the assumption mindfulness meditation and coloring are similar in order to make predictions on the impact of coloring on heart rate variability (HRV). To understand the measure of HRV in relation to stress, a review of the autonomic nervous system and its connection to stress is required.

### **Autonomic Nervous System Responses to Stress**

The human stress response is closely linked to the autonomic nervous system (ANS) as evidenced by its reactivity to external and internal stimuli (i.e., stressor). Once the ANS is activated, it relays electrochemical information from the brain and spinal cord to other areas of the body thus initiating series of physiological responses to the stressor (Schacter, Gilbert, & Wegner, 2011). There are two distinct branches of the ANS: the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS). Each

branch plays a specific role in responding to stressors, and the branches work tonically together in order to maintain homeostasis in the body. The SNS is associated with the body's "fight or flight" response. When a human is exposed to a stressor, the SNS increases arousal as a means of coping with the situation. During this period of activation, the SNS dilates the pupils, increases the heart rate and respiration, and activates the sweat glands (Schacter et al., 2011). In contrast, the PNS is activated in order to return the body to homeostasis or the resting state (McCorry, 2007). This return to homeostasis is accomplished through constricting the pupils and decreasing heart rate, respiration, and sweat gland activity (Martini, Nath, & Bartholomew, 2012). Considering the decreased arousal seen during PNS activation, this is referred to as the "rest and digest" response. Overall, the SNS and PNS maintain a dynamic relationship, with each being active to varying degrees at all times.

The regulatory nature of the SNS and the PNS is readily apparent when exploring the connection between the cardiovascular system and the ANS. As previously mentioned, when an individual is exposed to a stressor, the sympathetic branch of the ANS reacts by increasing both heart rate and respiration (Straub, 2012). Following the stressor, the parasympathetic branch is tasked with returning the heart rate and respiration to a resting state. Considering both heart rate and respiration are functions within the cardiovascular system, there is a strong link between ANS activation (particularly sympathetic activation) and cardiovascular functioning. As such, the cardiovascular system is extremely sensitive to stress (Straub, 2012).

### **Vagal Tone and Polyvagal Theory**

The 10<sup>th</sup> cranial nerve, or vagus nerve, is specifically responsible for the cardiac functions linked to the PNS. This is primarily accomplished through vagal innervation of the heart (Porges, 2001). Structurally, the vagus nerve connects the sinoatrial (SA) node of the heart to the ANS with both efferent and afferent fibers (Porges, 2001). Overall, the vagus nerve creates a negative feedback loop between the brain and the SA node, or pacemaker, of the heart thus controlling heartbeat (Porges, 2001). The degree of impact the vagus nerve has on the SA node is referred to as cardiac vagal tone. Vagal tone is the internal biological process that occurs when vagus nerve is activated by the PNS, and it is a strong indicator of the functionality of the PNS (Porges, 2007; Straub, 2012). High vagal tone suggests that the PNS is very responsive to stress, whereas low vagal tone suggests a lack a response from the PNS (Straub, 2012). When an individual has high vagal tone, his or her heart slows down while simultaneously his or her beat-to-beat variability of the heart increases (Straub, 2012).

One important theory that connects vagal tone with emotions and provides a theoretical framework for the current study is Polyvagal Theory (Porges, 1995; Porges, 2001; Porges, 2007). Polyvagal theory argues that the mammalian vagus creates a bilateral pathway between the brain and the heart through afferent and efferent vagal fibers. This pathway creates a feedback loop in which the brain is able to send sensory information to the heart, while the heart is able to provide afferent simulation to the brain. The vagus itself is divided into two distinct branches: the ventral branch on the right and the dorsal branch on the left (Porges, 2007). The ventral branch originates in the nucleus ambiguus, a group of motor neurons situated in the medullary reticular formation, and ends in the SA node of the heart (Porges, 2007). Importantly, the ventral branch is

myelinated allowing for quick communication from the brainstem to the SA node of the heart during increased parasympathetic activity (Porges, 1995). In contrast, the dorsal branch of the vagus nerve originates in the dorsal motor nucleus (DMNX) and is not myelinated. For this reason, the ventral branch has earned the name as the “smart” vagus, whereas the dorsal branch is coined the “vegetative” vagus (Porges, 1995).

From these two branches of the vagus, three phylogenetically different neural circuits have evolved (Porges, 2001). These circuits are employed hierarchically and each regulates the heart (Porges, 1998; Porges, 2001). The first phylogenetically oldest neural circuit originates in the DMNX and is referred to as the “immobilization system” because it is associated with freezing responses. The second neural circuit is the “mobilization system” which is associated with the typical fight or flight responses and requires sympathetic-adrenal system activation. Finally, the third neural circuit is the “social communication system”. This system originates in the NA and is responsible for adaptive social behaviors such as facial expressions, head movements, and vocalizations (Porges, 2007).

If an environmental stressor is present, the social communication system is employed first followed by the mobilization system and finally the immobilization system when all other strategies fail. When an environmental stressor is present but deemed manageable, the social communication system influences cardiac activity by way of the nucleus ambiguus and increases vagal tone while simultaneously inhibiting the other systems. This inhibition of the other systems encourages social engagement and self-soothing behaviors when managing a stressor (Porges, 1995). However, if the environment is no longer considered safe, the other systems will be engaged and vagal

influences will be withdrawn. As such, fight or flight and immobilization behaviors will be exhibited in response to the stressor. Overall, this system provides mammals with increased flexibility in coping with environmental stressors depending on what the situation requires.

The neurovisceral integration model further extends Porges' polyvagal theory by adding several functions including attentional regulation and affective processing (Thayer & Lane, 2000). This model identifies a neural network that promotes self-regulation and adaptability and allows researchers to explore physiological, behavioral, and emotional responses using physiological markers such as heart rate variability, cortisol secretion, and startle response (Thayer, Hansen, & Johnsen, 2010). Specifically, the neurovisceral integration model argues that emotions are an important component of coping with environmental stressors. Depending on the person's emotional response, it could help or hinder him or her from reaching a goal, making the emotional response either adaptive or maladaptive. Thus, emotional regulation plays a significant role in the human stress response. Importantly, increased resting vagal tone is associated with people who are better able to regulate their emotions which suggests that having higher vagal tone makes people more adaptable and flexible within an environment than their low vagal tone counterparts (Thayer & Lane, 2000; Thayer et al., 2010).

### **Heart Rate Variability**

Given the implications of vagal tone as physiological marker of emotional regulation capacity, a non-invasive measure of vagal tone is required. One method of measuring vagal tone is heart rate variability (HRV), which uses periodic measures of respiratory sinus arrhythmias (RSA; Porges, 2007). RSA is the naturally occurring

changes in heart rate that are associated with respiratory function (Straub, 2012). Vagal activity increases during exhalation resulting in decreased heart rate, whereas vagal activity decreases during inhalation resulting in increased heart rate. Considering activity within the vagus nerve is one of the factors that impact the length and frequency of the cardiac cycle, one method of measuring HRV is analyzing the subtle changes in the R-R intervals in the electrocardiogram recordings (ECG).

The ECG allows researchers to see the electromechanical events within the cardiac cycle. The cardiac cycle consists of five different deflections that are arbitrarily named P, Q, R, S, and T waves (Brownley et al., 2000). The P wave represents the beginning of the cardiac cycle in which the SA node depolarizes causing the atria to contract (Brownley et al., 2000). During the atria contraction, systole begins as represented by the QRS complex (or interval) occurs (Brownley et al., 2000). The QRS complex consists of the Q, R, and S waves; however, it is generally denoted as QRS because these deflections occur in a rapid succession, thus representing a single event (Brownley et al., 2000). The ventricles begin to contract at the peak of the R-wave (Martini et al., 2012). Late in the heart contraction, the ventricles must repolarize as represented by the T wave in ECG (Brownley et al., 2000). Importantly, the repolarization of the atria is not evident in the ECG because it occurs while the ventricles are depolarizing and is masked by the QRS complex (Martini et al., 2012). Following the contraction, diastole begins as the valves open and flows back into the ventricular chambers, and the cycle begins again (Brownley et al., 2000). In order to analyze the information provided from an ECG, the size of voltage changes must be recorded and the duration of various components within the ECG deciphered (Martini et al., 2012).



When using an ECG, HRV can be measured by analyzing the beat-to-beat variations present between the R-R intervals (i.e., the duration between two consecutive R-waves). Although there are several ways to derive measures of HRV, the current study will use time- and frequency-domain methods to determine the spectral bands before calculating the sympathetic-vagal balance (SVB). Specifically, time-domain methods are based on the original R-R intervals in a chosen time frame that is typically between 0.5 and 5 min (Acharya, Joseph, Kannathal, Min Lim, & Suri, 2006). Two fundamental time-domain calculations are the standard deviation of R-R intervals (SDNN) and the root square of successive difference of intervals (RMSSD; Acharya et al., 2006). Some researchers argue that SDNN is a measure of the low-frequency (LF) range of HRV, whereas RMSSD is often used as a measure of high-frequency (HF) of HRV and RSA. Time-domain methods are easily calculated and may offer insight into cardiac functioning, but they are unable to determine if the changes in HRV are due to sympathetic or parasympathetic activity (Acharya et al., 2006).

In contrast to time-domain measures, frequency-domain methods assign three different bands of frequency (or frequency bands): HF band (0.15-0.40 Hz), LF band (0.15-0.04 Hz), and very low frequency (VLF) band ( $< 0.04$  Hz; Acharya et al., 2006). Then, the R-R intervals are matched with their respective frequency band accordingly. These frequency bands are extracted using a fast Fourier transformation (FFT) for power spectral density (PSD; Acharya et al., 2006). The FFT calculates the inverse of a sequence using an algorithm in order to represent the sequence within a frequency domain. Thus, FFT is a method of decomposing a complex wave.

In order to create a single variable that describes the parasympathetic versus sympathetic activity during a specified period of time, the current study used sympathetic-vagal balance (SVB), which represents the LF/HF power ratio (Bernston et al., 1997). SVB served as the dependent variable in this study because it can be used to reflect whether the PNS or SNS is more dominant in controlling heart rate (Bernston et al., 1997; Karemaker, 1999; Porges, 2007). A SVB score that is greater than one indicates that there is greater sympathetic control of heart rate than parasympathetic, whereas a SVB score less than one implies there is greater parasympathetic control than sympathetic control of heart rate (Bernston et al., 1997). Taken with past literature on the vagus nerve, a SVB score of less than one implies greater vagal control of the heart. In the context of responding to a stressor, individuals exhibiting lower SVB scores during a stressor are demonstrating a great capacity to cope and manage with the stressor than individuals exhibiting higher SVB scores.

Measures of HRV have major implications for both physiological and psychological health. Specifically, some research suggests that reduced HRV plays an important role in the risk of mortality and morbidity in pathological conditions such as myocardial infarctions (Boskovic et al., 2014; Cripps et al., 1991; Princip et al., 2016; Song et al., 2014; Tsuji et al., 1996). Similarly, there is a link between reduced HRV and increased risk of mortality in both elderly populations and patients in the intensive care unit (Bishop, Wise, Lee, Rahden, & Rodseth, 2016; Tsuji et al., 2014). In addition to these negative physiological health consequences of HRV, there are several negative psychological factors related to reduced HRV such as stressful life events (van Ockenburg et al., 2015), depression (Gorman & Sloan, 2000), anxiety (Friedman &

Thayer, 1998; Gorman & Sloan, 2000), and general stress (Chandola Heraclides, & Kumari, 2010). Overall, reduced HRV is a measure of cardiac functioning that has significant implications for physical and psychological health.

It is important to note research suggests that there is ecological validation for the claim that HRV is an accurate measure of emotional regulation capacity. For example, there is an association between self-reported difficulties in regulating negative emotions and decreased resting HRV (Visted, Serensen, Osnes, Svendsen, Binder, & Schanche, 2017). Similarly, higher resting HRV in adults is linked with greater affect stability and self-compassion (Koval, Ogrinz, Kuppens, Van den Bergh, Tuerlinckx, & Sütterlin, 2013; Svendsen et al., 2016). In addition, the relationship between higher resting HRV and subjective well-being may be mediated by the habitual use of emotion regulation strategies (Geisler, Vennewald, Kubiak, & Weber, 2010). As such, high HRV has positive implications for emotion regulation abilities.

Considering the connection between emotion regulation and HRV, it is necessary to identify adaptive coping techniques that increase HRV in response to stress. Coping techniques can be classified as either adaptive or maladaptive depending on the context of the situation (Holton, Barry, & Chaney, 2016). However, adaptive coping strategies typically include meditation, seeking social support, and exercise, whereas maladaptive coping techniques include drug abuse, avoidance, and overeating (Holton et al., 2016). Importantly, adaptive coping techniques have been associated with increased capacity to manage stressors as indexed by HRV (Azam et al., 2015; Boyle, Staton, Ganz, Crespi, & Bower, 2017; Burg & Wolf, 2012). For example, brief mindfulness meditation practices are associated with increased HRV when exposed to stressful tasks (Azam et al., 2015;

Burg & Wolf, 2012; Tang et al., 2009). Similarly, physical exercise has been an effective method of increasing HRV among adults and older populations (Murad et al., 2012; Sandercock, Bromley, & Brodie, 2005; Soares-Miranda, 2014). Further, individuals with depressive symptoms experienced increased HRV when interacting with close others (Gerteis & Schwerdtfeger, 2016). In other words, social support increased emotion regulation in individuals with depression. In general, adaptive coping techniques facilitate greater emotion regulation and adaptability when exposed to an environmental stressor.

As previously mentioned, it is difficult to determine if adult coloring would be effective as an emotion regulation technique considering the limited research using physiological measures. However, by using Curry and Kasser's hypothesis that adult coloring and mindfulness meditation produce similar psychological and physiological states, predictions can be made about the impact of coloring on HRV. Specifically, past research has shown mindfulness meditation to be an effective emotion regulation technique. Mindfulness meditation has been linked with increased HRV during recovery following an acute stressor (Burg, Wolf, & Michalak, 2012; Shearer, Hunt, Chowdhury, & Nicol, 2016). In addition, a meta-analysis using 39 studies of non-clinical adults found that mindfulness meditation when compared to an inactive control group reduced stress, negative emotions, and anxiety symptoms while also increasing attention, cognition, and mindfulness (Erberth & Sedlmeier, 2012). In addition, several meta-analyses suggest mindfulness meditation training provides protective benefits to measures of stress, coping, negative affect, attention, and self-regulation when compared to inactive controls (Chiesa & Seretti, 2009; Grossman, Niemann, Schmidt, & Walach, 2004; Tang et al., 2009). Notably, one study even suggests a short mindfulness meditation program alters

brain and immune functioning (Richard et al., 2003). Further, another study found participants who underwent mindfulness meditation training demonstrated increased HRV and emotion regulation capacity during an acute stressor (Azam et al., 2015). In other words, evidence suggests mindfulness meditation provides significant protective benefits. Taken together, this research suggests that the psychological state produced by meditation (and perhaps coloring) should increase emotion regulation capacity and HRV during periods of stress by reducing SVB.

### **Perfectionism and Emotion Regulation**

One area that has yet to be explored in the context of adult coloring is potential moderating variables that could impact the anxiolytic effects of coloring. Research suggests that personality influences an individual's ability to regulate emotions and respond to stress (Purnamaningsih, 2017; Sadr, 2016); therefore, different personality traits may impact an individuals' psychological and physiological experience while coloring for stress relieving purposes. One personality trait of particular interest to the current study is perfectionism. Perfectionism can be categorized as either adaptive or maladaptive. An adaptive perfectionist has the knowledge that no one can be completely perfect, but he or she strives to achieve perfection and has high self-standards. In contrast, a maladaptive perfectionist strives for perfection and high self-standards, but also has unrealistic expectations for himself or herself (Chester et al., 2015). Perfectionism has been associated with poor emotion regulation capacity in several studies (Chester et al., 2015; Rudolph et al., 2007; Rumkani et al., 2014). Importantly, this relationship is further reflected physiologically such that maladaptive perfectionists experience a blunted physiological stress response in the lab. This decreased

physiological reactivity suggests an inability to react effectively to stressors. For example, perfectionists exhibit a blunted cortisol response when experiencing an interview stressor task (Richardson, Rice, & Devine, 2014). Similarly, another study found that perfectionists had a reduced HRV response during both a stressor task and meditation task, whereas non-perfectionists only had reduced HRV responses during the stressor task (Azam et al., 2015). This suggests that perfectionists do not experience the healthy physiological reactivity expected when managing a stressor. Taken in the context of the current study, we could expect perfectionists to demonstrate a blunted HRV response in comparison to non-perfectionists and adaptive perfectionists.

### **III. HYPOTHESES AND RATIONALE**

The current study employed a between-subjects design in which participants were randomly assigned to one of two coping conditions: coloring or control. Participants in the coloring condition colored a pre-drawn design prior to undergoing a stressor, whereas the participants in the control condition worked on a word search before completing the same stressor. Throughout the study, HRV, mood, and state anxiety were measured at three different time points: baseline, coping, and stressor.

This study had two main aims. First, the study aimed to examine adult coloring books as a tool for stress management. Past research suggests that coloring pre-drawn designs can reduce self-reported stress, anxiety, and negative affect (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012). The current study sought to extend these self-report findings by examining the protective effects of coloring a pre-drawn image (similar to those seen in adult coloring books) prior to an acute stressor via self-reported state anxiety, as well as cardiovascular markers of physiological stress during the stressor. Cardiovascular correlates of coloring have been understudied. However, it has been hypothesized that coloring confers similar benefits to mindfulness meditation (Curry & Kasser, 2005). Mindfulness meditation has been associated with stress reactivity in the future (Brewer et al., 2009; Goyal et al., 2014; Kabat-Zinn et al., 1992). It logically follows that if coloring is similar to mindfulness meditation it would have the same impact on stress reactivity as mindfulness meditation. As such, it was hypothesized that coloring prior to an acute stressor would be associated with greater sympathetic vagal activity during the stressor when compared to a control group who completes a word search prior to the stressor. More specifically, the first hypothesis was

that the participants who color would have a significantly lower SVB score than the control group during the subsequent stressor. In addition, it was expected that participants who colored would report less state anxiety and negative affect due to the stressor when compared to participants who completed a word search.

The second aim of the study was to determine if perfectionism reduces the protective effects of coloring prior to an acute stressor. Although there has never been a study exploring perfectionism and coloring, one previous study found that perfectionists had a blunted HRV response to a stressor following meditation, whereas non-perfectionists had increased HRV response to the stressor (as measured by changes in the HF band; Azam et al., 2015). As such, the second hypothesis is that perfectionists will have less sympathetic activity and greater anxiety and negative affect during the stressor following the coloring task compared to non-perfectionists. In other words, perfectionists will have a greater SVB, state anxiety, and negative affect than non-perfectionists during the stressor.



## **IV. METHOD**

### **Participants**

Participants were recruited via the Human Participants Pool in the Department of Psychology at Texas State University, and they received course credit for participation. Participants were required to be 18 years or older to participate. Fifty-three participants (49 women) completed the study; however, due to the small sample of men, only women were included in the analyses. The mean age of women in the study was 18.82 ( $SD = 1.33$ ; range 18-24). The women primarily identified as white (79.60%; African-American, 14.30%; Asian, 6.10%). Of the women who identified as white, 53.85% identified as Hispanic. Thirty-four out of the 49 women indicated they had used adult coloring books previously to participating in the study, and four women indicated they had used an adult coloring book at least once in the last week. Exclusion criteria for the study included history or current diagnosis of psychiatric disorders (e.g., anxiety disorder, major depressive disorder) and cardiovascular disease. In addition, participants were asked to abstain from consuming alcohol, tobacco, marijuana, and cold medicines in the 24 hours prior to participating. The recruitment procedures and project methods were approved by the Texas State University Institutional Review Board.

### **Instruments & Measures**

Upon arriving in the lab, participants provided informed consent, then completed an online questionnaire powered by Survey Monkey. The questionnaire contained demographics (i.e., gender, ethnicity, race) and self-report measures of state anxiety, negative affect, and personality, which are described in further detail below.

**State Anxiety.** To determine participants' current anxiety levels, they completed 20 items from the State-Trait Anxiety Inventory (S-TAI) (Spielberger, 1989; Spielberger et al., 1983). Participants were asked to read each of the statements and indicate on a 4-point scale (1 = *not at all*, 2 = *somewhat*, 3 = *moderately so*, 4 = *very much so*) how they felt at that current moment. The items were summed for a total state anxiety score. In the case participants did not answer an item, their summed total was considered missing data. Example statements include phrases such as "I am tense", "I feel upset", and "I feel frightened". This commonly used measure of anxiety has demonstrated strong internal consistency coefficients of .86 to .89 and test-retest reliability (Spielberger et al. 1983). Further, there is considerable evidence to attest to the concurrent and construct validity of the measure (Spielberger, 1989). Anxiety levels were measured at three different time points during the study. The first measure was a baseline measure taken as soon as the participants entered the lab. The second measure was taken directly after the experimental task and served as measure of anxiety during the experimental task. The last measure was taken after the stressor task and served as a measure of stress.

**Negative affect.** In order to assess negative affect, participants completed 10 items from PANAS with adapted instructions (Watson et al., 1988). Participants were asked to read each item and indicate on a 7-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*) the extent to which the statement described them at the current moment. The ten items were later summed to create an index of negative affect. In the case participants did not answer an item, their summed total was considered missing data. Example items included emotion words such as "distressed", "inspired", and "hostile". Past research suggests that PANAS has adequate internal consistency for negative affect

items (Cronbach's  $\alpha = 0.88$ ; Watson et al., 1988). In addition, the negative affect portion of PANAS has strong construct validity with Beck's Depression Inventory (Watson et al., 1988). Negative affect was measured on three separate occasions throughout the study. The first measure was taken as a baseline measure as soon as participants completed informed consent. The second measure was taken immediately following the experimental task (coloring vs. word search) and served as a measure of negative affect during the experimental task. The final measure was taken following the stressor task and served as a measure of stress.

**Perfectionism.** Perfectionism was measured using the 8-item Short Almost Perfect Scale (SAPS) (Rice, Richardson, & Tueller, 2013). Participants were asked to respond to each item and describe their degree of agreement using a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*). Example items for the scale included "Doing my best never seems to be enough", "I expect the best from myself", and "I have a strong need to strive for excellence". The APS-R consists of two components: standards and discrepancy. The standards subscale measures participants' performance expectations, and the discrepancy subscale measures self-critical performance evaluations (Rice et al., 2013). Participants who score high in both components are considered maladaptive perfectionists, whereas participants who score high in standards are considered adaptive perfectionists. Although there are no official cut-offs provided, the average score for the standards subscale is  $M = 24.12$  ( $SD = 3.63$ ) and the average score for the discrepancy subscale is  $M = 13.38$  ( $SD = 5.29$ ). This measure has demonstrated strong psychometric properties such as high score reliability and item-factor loadings (Rice et al., 2013). In addition, the measure has demonstrated criterion-related validity

through associations with measures of neuroticism, conscientiousness, academic performance, and depression (Rice et al., 2013). Perfectionism was measured following the stressor task.

**Heart rate variability.** ECG recording was collected using a Biopac MP150 data acquisition system (Biopac Systems, Goleta, CA). The Biopac MP150 used three adhesive Ag/ AgCl electrodes (8 mm) that were placed directly below participants' right and left collarbone and directly below their left rib. The electrode directly below the participants left collarbone served as the ground electrode. HRV was measured for three separate five-minute time periods. The first measure served as a baseline measure of HRV. During this period participants were instructed to sit quietly and avoid movement. A second measure of HRV occurred during the experimental task in which participants were either coloring or working on a word search. The instructions of sitting quietly and avoiding unnecessary movement were reiterated again. Although HRV was measured for 15 minutes during the experimental task, only the last 5 minutes were included in analyses. Finally, the third measure of HRV occurred during the stressor task. During the stressor task, participants were asked to sit as motionless as possible while completing the task. Only the last 5 minutes of the stressor were included in the analyses.

In order to analyze the HRV data, the current study used AcqKnowledge software (Version 4.3.1, BioPac Systems, Goleta, CA). This software is capable of detecting the R-R intervals within the raw ECG data at a sampling rate of 200 samples/s and extracting frequency bands. Prior to data analysis, the raw data was bandpass filtered with the high pass at 1Hz and the low pass at 35Hz with 8,000 coefficients. Then, according to AcqKnowledge guidelines (e.g., *Application Note 233*, n.d.), artifacts were removed, and

the data cleaned and preprocessed prior to analysis. The AcqKnowledge software routine included the removal of the ‘noise’ associated with body movements (e.g., yawning, sneezing, etc.) by applying a template of a ‘normal’ QRS complex for the participant within the experimental session as a correlate. Next, an SVB score was calculated in order to extract the frequency bands required for HRV calculation. The software accomplished this through the calculation of the power spectral density using Welch’s method. Welch’s method applies a frequency-transformation to time-sampled waveforms by first segmenting the data, then transforming the segments, and finally averaging the newly transformed segments in order to create a composite frequency-space waveform (Welch, 1967). In order to interpret the results, the sympathetic-vagal balance was calculated. This calculation is defined as the ratio of power for the low frequency band (.04 - .15 Hz) to the high frequency band (.15-.40 Hz). These results were interpreted such that an SVB greater than 1 reflects more sympathetic activity when compared to vagal activity, whereas an SVB less than 1 is an indicator of higher vagal tone.

**Experimental task.** Participants were randomly assigned to one of two, 15-min tasks (coloring, word search). For the coloring condition, participants were instructed to color a copy of a drawing from a popular adult coloring book (Basford, 2015). Participants were instructed to color the drawing as they saw fit. In contrast, the participants assigned to the word search condition were instructed to complete a word search as they saw fit.

**Stressor.** In order to induce acute psychological stress in participants, the current study used a variation of the computerized version of the Paced Auditory Serial Addition Task (PASAT; Gronwall, 1977). This task typically consists of a series of numbers that

are presented in four separate blocks via computer speakers. In the original version participants were instructed to sum the first two numbers heard and verbally state the total. Then, participants sum the second and third numbers heard (forgetting the first number) for a new total. For example, if the first two numbers are 4 and 6, the participant would verbally state 10; then, if the next number in the sequence is 5, the participant would verbally state 11. In the modification used in this study, participants were instructed to sum the first two numbers heard and then add each new number to their total before verbally stating the new total. For example, if the first two numbers are 3 and 8, the participant would verbally state 11; then, if the next number in the sequence is 4, the participant would verbally state 15. This pattern would continue for each of the four blocks of numbers presented. Each block progressively decreases the inter-number interval. Specifically, the inter-number interval for the four blocks is 3, 2, 1.5, and 1 second(s) respectively. Importantly, the PASAT has been associated with increased anxiety, heart rate, and skin conductance, which suggests it is an effective method in inducing a stress response (Ceballos, Guiliano, Wicha, & Graham, 2012; Lejuez, Kahler, & Brown, 2003).

## **Procedure**

Each experimental session took approximately 40 min. A timeline of the procedures for the current study can be seen in Figure 1. Upon entering the lab, the experimenter explained the study procedures and instructed the participant to read and complete the consent form. Next, the experimenter applied the ECG electrodes. When recording ECG, the participant were seated in a comfortable chair and instructed to avoid any extraneous movement and speaking during measurement periods. However, the

participant was not instructed on their breathing during this time; therefore, normal breathing should have persisted throughout the study. After applying the ECG electrodes, the experimenter instructed the participant to complete the first set of questionnaires on the computer which included the baseline measures of anxiety and negative affect as well demographic questions, a perfectionism scale, and a trait anxiety scale.

A baseline measure of HRV was taken for five minutes. During this time, the experimenter instructed the participant to be as still as possible. Then, the experimenter assigned the participant to either complete a coloring task or a word search task. Another measure of HRV was taken for fifteen minutes during the coloring or word search task. However, only the last five minutes of HRV were used in analyses. The participant was instructed to avoid any extraneous movements apart from coloring or writing. After the coloring or word search task was complete, the participant was asked to complete another set of questionnaires on the computer. This second set of questionnaires included a second measure of anxiety and negative affect. Once the questionnaires were complete, the experimenter explained the stressor task. The experimenter instructed the participant to listen to the numbers from the speaker and add each number to their total out loud. In addition, the experimenter requested the participant stay as still as possible. During this stress task, a third five-minute measure of HRV was taken. Following the stress task, the experimenter directed the participant to complete a final set of questionnaires. This set of questionnaires contained a third measure of negative affect and anxiety. After completing the final set of questionnaires, the participant was debriefed and thanked for his/her participation.

<b>Time 1 (Baseline)</b> <b>5 Minutes</b> HRV State Anxiety PANAS	<b>Time 2 (Task)</b> <b>15 Minutes</b> HRV State Anxiety PANAS	<b>Time 3 (Stressor)</b> <b>5 Minutes</b> HRV State Anxiety PANAS
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Figure 1. Timeline illustration of proposed experiment.

### Data Analyses

First, the data was screened for outliers, skewness, and kurtosis. The values of extreme outliers were removed through listwise deletion for the variables of baseline SVB ( $N = 1$ ), coping SVB ( $N = 2$ ), and stressor SVB ( $N = 2$ ). In addition, two participants had missing values for the stressor SVB measure due to equipment malfunction. Thirty-five participants accurately completed all measures within the study, and Table 1 provides the number of participants who completed the individual measures. Listwise deletion was used to manage missing data in the current study. Only complete cases were used when hypothesis testing.

Table 1

#### *Number of Participants Who Completed Measures*

Measure	Time	<i>N</i>
SVB	Baseline	48
	Task	47
	Stressor	46
Anxiety	Baseline	46
	Task	45
	Stressor	45
Negative Affect	Baseline	48
	Task	47
	Stressor	46



The skewness and kurtosis present within all variables were within the acceptable range according to Kline (2009). In order to ensure there were no pre-existing difference between participants assigned to the coloring condition and participants assigned to the word search condition, the categorical variables of gender, ethnicity, and history of coloring book use were analyzed with Chi-Square tests. Similarly, the continuous variables of age, perfectionism standards, perfectionism discrepancy, and baseline measures of SVB, anxiety, positive affect, and negative affect were analyzed with independent samples *t*-tests in which experimental condition (coloring, word search) was the independent variable. Corrections were made to the degrees of freedom when violations of homogeneity were present according to Levene's Test of Homogeneity of Variance.

Prior to hypothesis testing, a manipulation check was run in order to ensure that the stressor was effective in increasing self-reported state anxiety and SVB. The manipulation check consisted of two paired samples *t*-tests, which were collapsed across condition. The first paired samples *t*-test compared baseline state anxiety scores with stressor anxiety scores. It was expected that participants would report significantly greater anxiety following the stressor than at baseline. The second paired samples *t*-test compared baseline SVB scores with stressor SVB scores. It was expected that participants would report significantly greater SVB during than stressor than at baseline.

The first hypothesis was tested via an omnibus repeated measures MANOVA in which DVs are SVB, negative affect and state anxiety, the within-subjects IV is Time (baseline, task, stressor) and the between-subjects IV is experimental condition. This determined whether condition has a significant impact on measures of stress. The second

hypothesis was tested with a repeated measures ANCOVA that included the DV of SVB, within-subject IV of Time (baseline, task, stressor), covariates of perfectionism standard and discrepancy, and between-subjects IV of experimental condition. In the instance that there was a violation of homogeneity of variance for either the MANOVA or ANCOVA employed in hypotheses testing, the procedures outlined by Wilcox (2010) were followed accordingly.

## V. RESULTS

### Background Characteristics

There were 28 women assigned to the coloring group and 21 women assigned to the word search group. Chi-square tests analyses revealed no significant group differences on the categorical variables of ethnicity (Hispanic versus Non- Hispanic) [ $\chi^2(1) = .262, p = .609$ ], race (Caucasian versus Non-Caucasian) [ $\chi^2(1) = 0.219, p = .640$ ], or history of coloring book use (yes vs no) [ $\chi^2(1) = 0.314, p = .575$ ]. A summary of these results is displayed in Table 2.

Table 2

#### *Categorical Group Characteristics at Baseline*

Characteristic	Coloring group ( <i>N</i> = 28)	Word Search group ( <i>N</i> = 21)
	%	%
Hispanic	66.7	33.3
Caucasian	59.0	41.0
Previous Coloring Experience	58.8	41.2

Independent samples *t*-tests revealed no significant differences in the two groups on the continuous variables taken at baseline including age [ $t(47) = -1.28, p = .208$ ], perfectionism standards [ $t(46) = -.263, p = .794$ ], perfectionism discrepancy [ $t(47) = .826, p = .413$ ], negative affect [ $t(27.818) = -1.60, p = .122$ ], anxiety [ $t(29.568) = -1.83, p = .078$ ], and SVB [ $t(46) = -.107, p = .915$ ]. A summary of these results is displayed in Table 3.

Table 3. *Continuous Group Characteristics at Baseline*

Characteristic	Coloring group ( <i>N</i> = 28)	Word Search group ( <i>N</i> = 21)
	M (SD)	M (SD)
Age	18.61 (1.34)	19.10 (1.30)
Perfectionism Standards	24.93 (3.08)	25.15 (2.56)
Perfectionism Discrepancy	17.07 (5.36)	15.95 (3.60)
Negative Affect	14.37 (3.41)	16.95 (6.78)
Anxiety	34.92 (7.01)	40.25 (11.51)
SVB	1.37 (1.42)	1.41 (1.20)

### Manipulation Check

Prior to hypothesis testing, a paired samples *t*-test was run as a manipulation check to determine if the variation of the PASAT was an effective emotional stressor. Participants' baseline anxiety scores were paired with their anxiety scores directly following the stressor. As expected, the paired samples *t*-test suggested a significant difference in self-reported anxiety at baseline ( $M = 36.83$ ,  $SD = 8.82$ ) and during the stressor ( $M = 47.88$ ,  $SD = 12.08$ ) [ $t(41) = -6.623$ ,  $p < .001$ ]. As seen in Figure 2, these results suggest participants underwent a significant increase in anxiety during the stressor.

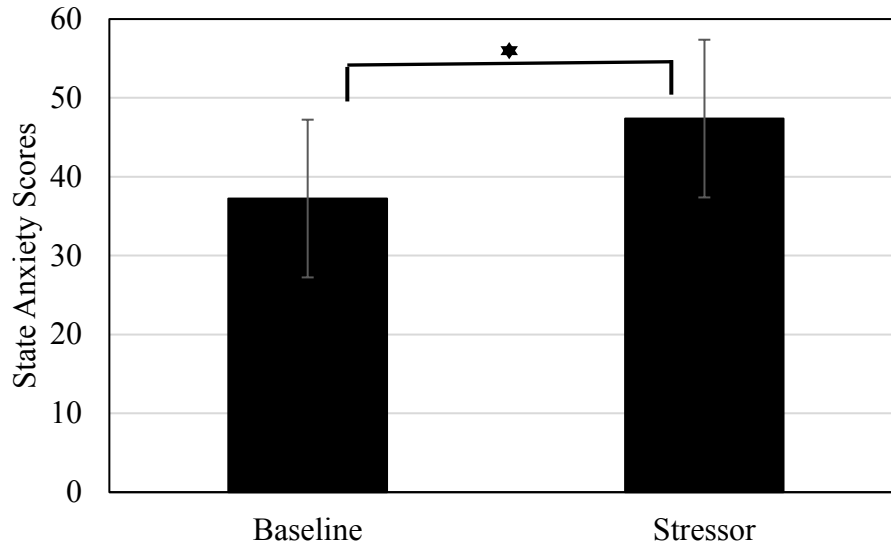


Figure 2. *Mean State Anxiety Scores at baseline and stressor time points.*

Next, a paired samples *t*-test was run as a manipulation check to determine if the variation of the PASAT was an effective physiological stressor. Participants' baseline SVB scores were paired with their SVB scores directly following the stressor. Contrary to expectations, the paired samples *t*-test did not find a significant difference in SVB at baseline ( $M = 1.22$ ,  $SD = 0.96$ ) and during the stressor ( $M = 1.39$ ,  $SD = 0.98$ ) [ $t(44) = -1.064$ ,  $p = .293$ ]. As seen in Figure 3, these results suggest participants did not experience a significant increase in SVB during the stressor.

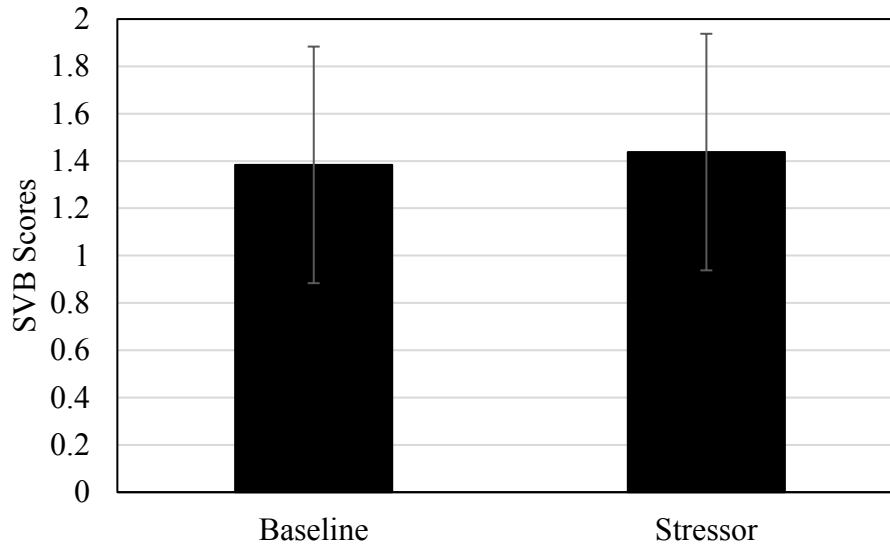


Figure 3. *Mean SVB at baseline and stressor time points.*

### Hypotheses Testing

The first hypothesis of the current study was that participants in the coloring group would exhibit decreased SVB, anxiety, and negative affect during the stressor task. This hypothesis was addressed via an omnibus repeated measures MANOVA in which the dependent variables were SVB, negative affect and state anxiety, the within-subjects IV was Time (baseline, task, stressor) and the between-subjects independent variable was experimental condition (coloring or word search). Contrary to the hypothesis, the omnibus repeated measures MANOVA was not significant [Wilks' Lambda = .922;  $F(6, 128) = .878, p = .513, \eta_p^2 = .977$ ]. The univariate repeated measures ANOVAs revealed a significant effect of time on the measures of anxiety [ $F(2, 66) = 55.637, p < .001, \eta_p^2 = .628$ ] and negative affect [ $F(2, 66) = 24.774, p < .001, \eta_p^2 = .429$ ], but not SVB [ $F(2, 66) = .930, p = .400, \eta_p^2 = .027$ ]. A series of follow-up paired samples  $t$ -tests revealed baseline anxiety measures were significantly greater than task [ $t(42) = 3.904, p < .001$ ] and lower than stressor [ $t(41) = -6.623, p < .001$ ] anxiety measures, and the task anxiety

measures were significantly lower than the stressor anxiety measures [ $t(41) = -11.463, p < .001$ ]. Similarly, a second series of follow-up paired samples  $t$ -tests revealed baseline negative affect measures were significantly greater than task [ $t(47) = 4.899, p < .001$ ] and lower than stressor [ $t(46) = -2.379, p = .022$ ] negative affect measures, and the task negative affect measure was significantly lower than the stressor negative affect measure [ $t(47) = -7.253, p < .001$ ]. A final series of follow-up paired samples  $t$ -tests revealed baseline SVB was not significantly different from task [ $t(45) = .879, p = .384$ ] and stressor [ $t(44) = -1.064, p = .293$ ], and task SVB was not significantly different from stressor SVB [ $t(43) = -1.889, p = .066$ ]. Notably, there were no significant interactions between experimental condition and time on the measures of SVB [ $F(2, 66) = .696, p = .502, \eta_p^2 = .021$ ], anxiety [ $F(2, 66) = 1.028, p = .363, \eta_p^2 = .030$ ], and negative affect [ $F(2, 66) = .183, p = .833, \eta_p^2 = .006$ ]. In other words, coloring had no greater impact on markers of stress than the word search control. Summary variables (means and standard deviations) relevant to the first hypothesis can be seen in Table 4. These values for SVB, anxiety, and negative affect are represented graphically in Figures 4, 5, and 6, respectively.

Table 4. *Group Means of Stress Measures at Baseline, Task, and Stressor Time Points*

Measure	Time	Coloring group ( <i>N</i> = 28)	Word Search group ( <i>N</i> = 21)
		M (SD)	M (SD)
SVB	Baseline	1.36 (1.42)	1.41 (1.20)
	Task	1.25 (0.68)	1.13 (0.84)
	Stressor	1.54 (1.02)	1.30 (1.04)
Anxiety	Baseline	34.92 (7.01)	40.25 (11.51)
	Task	30.12 (6.69)	36.68 (7.16)
	Stressor	45.30 (13.16)	50.50 (9.34)
Negative Affect	Baseline	14.37 (3.41)	16.95 (6.78)
	Task	11.28 (1.78)	14.19 (3.84)
	Stressor	16.14 (5.15)	19.45 (6.51)

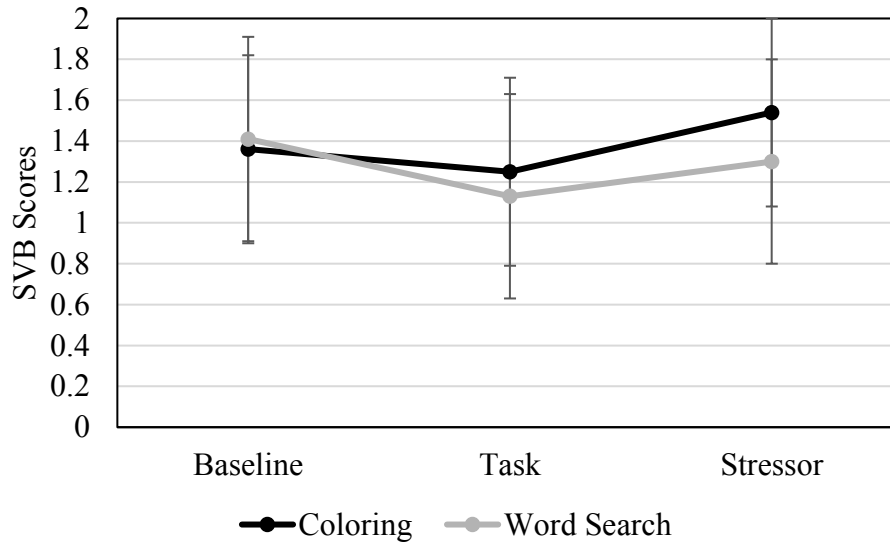


Figure 4. *Mean SVB scores at the baseline, task, and stressor time points*



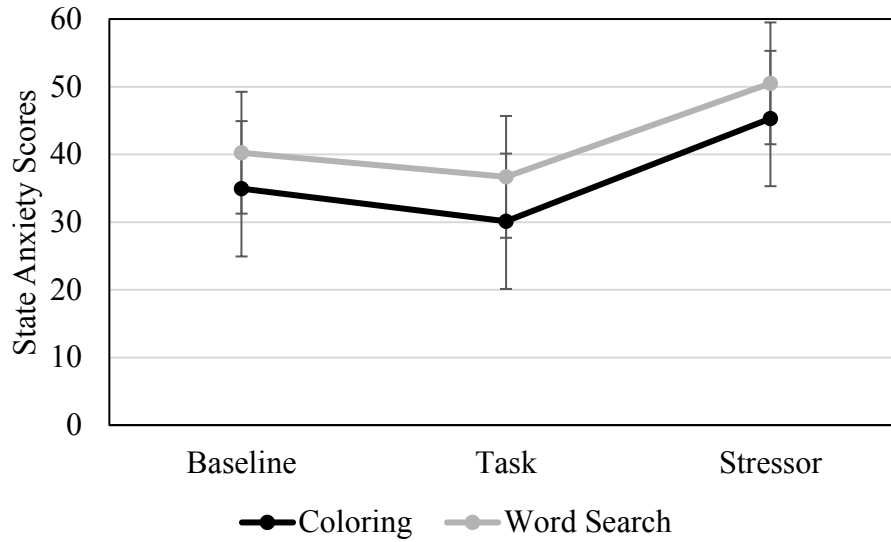


Figure 5. *Mean State Anxiety scores at the baseline, task, and stressor time points*

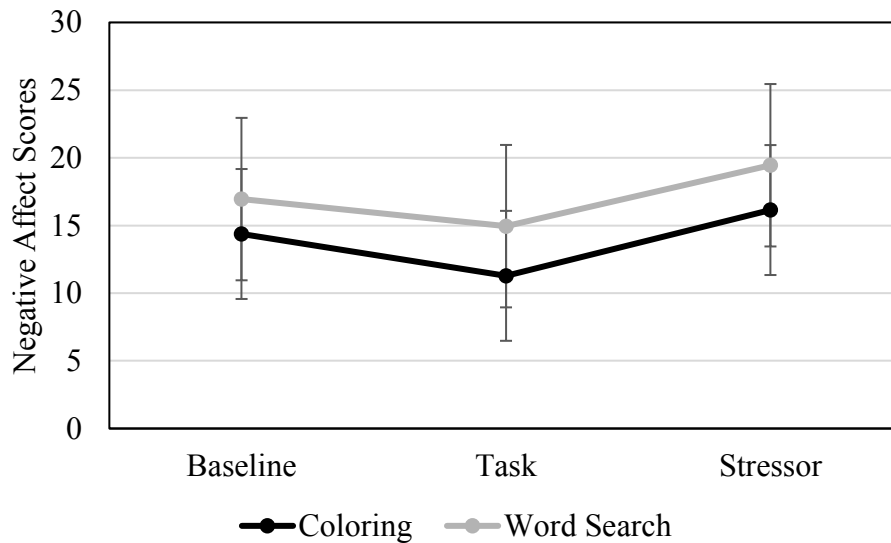


Figure 6. *Mean Negative Affect scores at the baseline, task, and stressor time points*

The second hypothesis of the current study was that perfectionists would have less sympathetic activity and greater anxiety and negative affect during the stressor following the coloring task compared to non-perfectionists. This hypothesis was addressed by including the standards and discrepancy SAPS subscales as covariates within the omnibus repeated measures MANOVA. In contrast to the hypothesis, the omnibus

repeated measures MANCOVA was not significant [Wilks' Lambda = .867;  $F(3, 28) = 1.432, p = .254, \eta_p^2 = .068$ ]. The univariate repeated measures ANOVAs revealed no significant effects of time for the measures of anxiety [ $F(2, 60) = .921, p = .404, \eta_p^2 = .030$ ], negative affect [ $F(2, 60) = .529, p = .592, \eta_p^2 = .017$ ], and SVB [ $F(2, 60) = .653, p = .524, \eta_p^2 = .021$ ]. In addition, there was no significant interaction between experimental condition and time on the measures of SVB [ $F(2, 60) = 1.869, p = .163, \eta_p^2 = .059$ ], anxiety [ $F(2, 60) = 1.530, p = .225, \eta_p^2 = .049$ ], and negative affect [ $F(2, 60) = .475, p = .624, \eta_p^2 = .016$ ]. There were also no significant interactions between the SAPS standards subscale and time on the measures of SVB [ $F(2, 60) = 1.391, p = .257, \eta_p^2 = .044$ ], anxiety [ $F(2, 60) = .568, p = .570, \eta_p^2 = .019$ ], and negative affect [ $F(2, 60) = .900, p = .412, \eta_p^2 = .029$ ]. Similarly, there was no significant interactions between the SAPS discrepancy subscale and time on the measures of SVB [ $F(2, 60) = 1.270, p = .288, \eta_p^2 = .041$ ], anxiety [ $F(2, 60) = 1.374, p = .261, \eta_p^2 = .044$ ], and negative affect [ $F(2, 60) = .149, p = .862, \eta_p^2 = .005$ ].

## **VI. DISCUSSION**

Previous studies have suggested that the coloring of a pre-drawn images (i.e., adult coloring books) may be a useful tool for relieving symptoms of stress and anxiety (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012). However, prior to recommending adult coloring books for stress relief, more research is required to determine the efficacy of using coloring for stress relief. One area that has yet to be thoroughly explored in the literature is the relationship between coloring and physiological symptoms of stress and anxiety. Specifically, past research has failed to explore the potential benefits and protective effects of coloring prior to undergoing a stressful experience or task. Finally, no prior research has investigated the impact of personality traits such as perfectionism on protective benefits of coloring prior to an acute stressor. This thesis extends the literature by taking steps to fill in these gaps. Results from the present study suggest coloring is not an effective method for managing a stressor in the future. In addition, perfectionism did not have a significant moderating effect on stress within the current study. These findings will be expanded upon in the following sections.

Prior to addressing study hypotheses, the effectiveness of the modified version of the PASAT in inducing stress was confirmed. As seen in Figure 2, the modified version of the PASAT was effective in increasing self-reported measures of state anxiety from the baseline time point to the stressor time point. Importantly, this indicates participants were subjectively experiencing emotional stress during the task, as expected. However, as seen in Figure 3, the modified version of the PASAT was not effective at increasing measures of SVB. One explanation for this unexpected finding is that the participants had

unusually high baseline measure of SVB ( $M = 1.38$ ,  $SD = 1.31$ ), which may have impacted participants' physiological reactivity. Notably, the participants' self-report state anxiety and negative affect baseline scores were also quite high, although they did not seem as elevated as the HRV values. One explanation for why these baseline measures may have been so high is that participants were having anticipatory effects of the upcoming math task. They had been informed of the math task during the consent process. In turn, these anticipatory effects may have attenuated any reductions from baseline during the coping task. This explanation is supported by a previous study that found participants who were aware of an upcoming stressor demonstrated higher negative affect prior to the stressor than the participants who were not aware of the stressor (Neubauer, Smyth, & Sliwinski, 2017). Alternatively, it is possible the task was stressful enough to impact the self-report measures, but it was not stressful enough to activate the ANS. This is especially possible if these results are examined under a neurovisceral lens, which argues in favor of ANS activation within social situations (Thayer & Lane, 2000; Thayer et al., 2010). According to the neurovisceral approach, HRV is used as a physiological index for emotion regulation (Thayer & Lane, 2000; Thayer et al., 2010). As such, the speeded math task used as a stressor in the current study may not have impacted HRV in the same manner as a social stressor would have. It is possible a different stressor would have been more effective. For example, the Tier Social Stress Test is very effective at inducing stress and involves a social element that pairs well with theoretical basis for HRV (Kirschbaum, Pirke, & Hellhammer, 1993). Despite these null findings for HRV, the efficacy of the modified PASAT is evident in the self-reported measures of state anxiety observed in the current study.

Future studies should take several points into consideration if when using SVB as a biomarker for stress. First, the current study may not have given participants long enough to acclimate to the lab setting, and they still felt uncomfortable with this setting during the baseline measure of HRV. This would be similar to the white-coat effect for doctors in which patients exhibit symptoms of hypertension and markers of emotion dysregulation due to the anxiety of being in a clinical setting (Neumann, Jennings, Muldoon, & Manuck, 2005; Shehab & Abdulle, 2011). Second, 5 minutes might not have been a long enough time period to get an accurate baseline measure of HRV, which would explain the variability in results. However, it is important to note a similar study examining the relationship between HRV and perfectionism during a stressor also used a 5-minute baseline (Azam et al., 2015). Finally, there is still the possibility HRV is a poor method of measuring participants' emotion regulation capacity; however, further research and replication is required prior to reaching this conclusion.

The first aim of this study was to examine whether adult coloring books could be an effective tool for the management of future stressors. It has been theorized that coloring provides similar psychological benefits to mindfulness meditation (Curry & Kasser, 2005). Considering mindfulness meditation is associated with stress reactivity (Brewer et al., 2009; Goyal et al., 2014; Kabat-Zinn et al., 1992), it logically follows that coloring also may impact stress reactivity. To address this possibility, the current study employed an experimental design in which participants were either assigned to a coloring or word search task prior to undergoing an acute stressor task. Self-report measures of state anxiety and negative affect were used in conjunction with HRV to evaluate the relationship between coloring and markers of stress. This method expanded upon

previous research in two important ways. First, prior research has primarily relied on self-report measures of stress and anxiety instead of physiological measures (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Vennet & Serice, 2012). Second, the current study was the first to employ the stressor after the coloring task instead of prior to the coloring task. In other words, the current study examined whether coloring could provide an individual with protective benefits during a subsequent stressor as opposed to relaxing after a stressor. As such, it was hypothesized the coloring condition would have significantly lower SVB score than the control group during the stressor because lower SVB scores are indicative of greater HRV, parasympathetic activity, and emotion regulation capacity (Thayer & Lane, 2000; Thayer et al., 2010). In addition, it was expected that participants who colored would report less state anxiety and negative affect when compared to participants who completed a word search. Overall, if the coloring condition provides greater protective benefits than the word search condition, it was expected participants in the coloring condition would report less stress and anxiety across all measures during the stressor.

Contrary to hypotheses, coloring prior to the stressor was found to provide no more protective benefits to SVB than completing a word search prior to the stressor; thus, there was no significant difference in SVB scores during the stressor between the two conditions. In other words, coloring before an acute stressor did not provide participants protective benefits on their physiological markers of stress. Notably, there were no significant changes in HRV throughout the duration of the study; thus, the results for this hypothesis are limited in scope. As the first study to use HRV in conjunction with coloring, it is impossible to compare these findings directly to previous studies. However,

there has been one previous study that used physiological markers of stress in conjunction with a coloring task. Muthard and Gilbertson (2016) designed an experimental study in which participants were assigned to either a combined mandala coloring/deep breathing task or a no-task control group following a stressor (i.e., Trier Social Stress Test). The physiological measures of blood pressure, heart rate, pulse, and electrodermal activity and self-report measures of state anxiety and negative affect were used to compare the groups on levels of stress and anxiety. Within this study, the combined mandala coloring/deep breathing task was only marginally more effective at improving self-reported state anxiety and negative affect when compared to the no-task control group. Similar to the current study, there were no significant findings for the physiological measures of stress. Notably, this indicates coloring did not have a physiologically impact when using a social stressor (i.e., Trier Social Stress Test) and non-social stressor (i.e., PASAT). However, it is important to highlight that Muthard and Gilbertson (2016) were examining the stress-relieving benefits of coloring after a social stressor, whereas the current study examined the potential protective benefits of coloring prior to a non-social stressor.

There are several explanations for why coloring before a stressor did not provide the expected physiological protective effects during a stressor within this experimental study. First, the current study only had participants color for a limited period of time (i.e., 15 minutes). Although 15 minutes of coloring is comparable to previous studies examining the stress-relieving qualities of coloring (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012), this limited period of time might not be long enough to produce significant, persistent physiological effects that would buffer

the effects of a subsequent stressor. This would be especially true if some of the protective benefits stem from the completion of the drawing. None of the participants in the current study finished coloring the pre-drawn image within the 15 minutes; therefore, this issue remains unexplored. Second, there could be more physiological protective benefits from coloring when the participants use the technique regularly (e.g., weekly). Perhaps habitual use of coloring would provide a greater calming and more enduring effect than using it one time. Although participants were asked how often they colored in the previous week, there were only four participants who reported any coloring activity in the week prior. As such, it was impossible to include this variable in analyses, and it remains unclear if these individuals would have greater benefits from the activity than individuals who do not regularly color, which remains an avenue for future study. A third explanation for these findings is the method chosen to index HRV. The current study indexed HRV with SVB, which is a single variable that takes into account the sympathetic and parasympathetic activity during a period of time by calculating LF/HF power ratio (Acharya et al., 2006; Kang & Kim, 2009). Previous studies have used a variety of alternatives to SVB, including examining the LF and HF bands separately (Azam et al., 2015) and calculating the standard deviations of the R-R intervals (Sghir, Löffler, Ottenbacher, Stumpp, & Hey, 2012). It is possible one of these methods may be more sensitive to physiological changes induced by coloring and stress; however, these methods are limited because they only take into the activity of one branch of the ANS at a time, whereas the use of SVB allows for the examination of their interactions. Importantly, this method of calculation does not match with the theoretical basis for using HRV as a measure of emotion regulation capacity (Thayer & Lane, 2000; Thayer et al.,



2010). As such, SVB remains a strong measure of HRV within the context of this thesis. A final explanation for these findings is that coloring is not actually as similar to mindfulness meditation as Curry and Kasser (2005) hypothesized. The predictions of this thesis were formed based on previous research on mindfulness meditation and stress reactivity. If coloring does not provide similar, persistent effects like mindfulness meditation, it would follow logically that the results of the current study would not match the hypotheses.

In contrast to previous studies that have found coloring to be more effective than the control group at reducing self-reported stress and anxiety following a stressor (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012), coloring was found to provide no more protective benefits on self-reported anxiety and negative affect than completing a word search prior to undergoing a stressor. These results can be reconciled with those of previous studies on coloring because while coloring may provide stress-relieving qualities after stress, these benefits may not persist long enough to provide protective benefits during a future stressor. However, this would suggest coloring is not actually as similar to mindfulness meditation as Curry and Kasser (2005) hypothesized. Specifically, mindfulness meditation has previously been related to changes in stress reactivity (Brewer et al., 2009; Goyal et al., 2014; Kabat-Zinn et al., 1992), and the results of this thesis do not support this finding for coloring.

One issue within the previous studies that may contribute to the inconsistencies in the literature are the differences in control groups used within these studies. Assigning participants in the control group to a different type of coloring or drawing task is especially popular among studies examining the calming effects of coloring a pre-drawn

image such as a mandala. For example, Curry and Kasser (2005) and van der Vennet and Serice (2012) both compared different types of coloring on self-report measures of anxiety. Specifically, these studies were interested in whether the mandala image was most effective at reducing stress; therefore, the participants either colored a pre-drawn mandala design, pre-drawn plaid design, or a blank sheet of paper. It is worth noting there were inconsistencies between these two studies on which condition was most effective. Curry and Kasser (2005) found the mandala and plaid conditions to be equally more effective than the blank paper condition, whereas van der Vennet and Serice (2012) found the mandala condition to be more effective than both the plaid and blank paper conditions. Different drawing tasks are also used as control conditions within the art therapy research on mandala creation. For example, one study assigned participants in the control condition an object to draw (e.g., cup, bottle, and pens) instead of creating a mandala (Henderson et al., 2007). Similarly, another study assigned participants to either draw inside a circle thereby creating a mandala or draw inside a square as control condition (Babouchkina & Robbins, 2015). Overall, heterogeneity in the types of control conditions used in previous studies has produced results that are difficult to reconcile with one another, speaking for the need for more studies to help clarify and differentiate various types of art therapies.

Another type of control condition that is popular in art therapy is the no-task control group. One study compared a combined mandala coloring/deep breathing task to a no-task control group and only found marginally significant results on measures of self-reported anxiety and negative affect (Muthard & Gilbertson, 2016). Another study assigned participants to either a mandala creation group or no-task control group and

compared the groups on self-reported measures of authenticity and psychological well-being following the task (Pisarik & Larson, 2011). It is impossible to tell how comparable the word search condition is to an assigned drawing task or no-task control group as used in previous studies; however, it is worth reconsidering the types of control groups used because they may be contributing to inconsistencies within this literature. In addition, by using these types of controls, it remains unclear how coloring compares to other types of art therapies and other relaxing activities such as puzzles or games.

These results also call to question the hypothesis that coloring creates similar psychological and physiological responses to mindfulness meditation (Curry & Kasser, 2005). In contrast to the findings of the current study, completing a mindfulness meditation program has been shown to provide persistent protective benefits (Azam et al., 2015; Chiesa & Seretti, 2009; Grossman et al., 2004; Tang et al., 2009). In fact, mindfulness meditation has been associated with changes in brain and immune functioning (Richard et al., 2003). Considering coloring does not appear to provide the same degree of benefits as mindfulness meditation, it is possible coloring does not provide the same physiological and psychological experience as mindfulness meditation as expected.

The second aim of this thesis was to examine the impact of the personality trait of perfectionism on the effectiveness of coloring books in managing a stressor. This aim was addressed by measuring perfectionism at baseline via the Short Almost Perfect Scale (SAPS) and including the measure as a covariate in analyses. It was hypothesized that individuals high in perfectionism would have greater SVB (i.e. less sympathetic activity), anxiety, and negative affect during the stressor following the coloring task compared to

non-perfectionists. Contrary to the hypothesis, perfectionism did not have a significant impact on participants' physiological and self-report measures during the stressor. This is in direct contrast to a previous study that found perfectionists exhibit a blunted HRV response to a stressor following a coping task (Azam et al., 2015). Within this study, perfectionism was measured with the Perfectionism Cognitions Inventory (PCI). Similarly, this finding also contrasts with a study that found perfectionists, as measured by the Short Almost Perfect Scale (SAPS), exhibit a blunted cortisol response during a stressor task in the lab (Richardson et al., 2014). The differences in the scales used could provide one explanation for not finding a moderating effect of perfectionism. Although the SAPS has demonstrated strong psychometric properties (Rice et al., 2013), within the current sample, there was very little variability on either the standards or discrepancy subscales and the majority of participants would not be considered especially perfectionistic. Statistically, this makes it difficult to detect differences between individuals based on their perfectionism scores. Future studies should consider using the full Almost Perfect Scale Revised (APS-R; Slaney, Rice, Mobley, Trippi, & Ashby, 2001) to increase variability in responses or consider identifying a sample of perfectionists during the recruitment process.

One limitation of many studies in art therapy (this thesis included) is the small sample used. This study had a sample of 49 women who were assigned to either the coloring condition ( $N = 28$ ) or word search condition ( $N = 21$ ), which is comparable to previous studies in this area of research who have had samples ranging between 37-84 (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012). In fact, one study (van der Venet & Serice, 2012) employed a sample of 50 divided into

three coloring groups: pre-drawn mandala ( $N = 13$ ), pre-drawn plaid ( $N = 15$ ), and blank paper ( $N = 22$ ). Nevertheless, a sample of 49 may not have been large enough to detect more subtle effects of coloring, especially physiological reactivity. Similarly, the sample of 37 participants in Muthard and Gilbertson (2016) also may not have been large enough to detect small differences on the physiological measures of blood pressure, heart rate, pulse, and electrodermal activity. Therefore, it is still a possibility that coloring provides a small psychological and physiological protective effect, but this study and previous studies have not had enough power to detect this effect. Future studies should look to using larger samples in conjunction with physiological measures to more accurately evaluate the relationship between coloring and physiological markers of stress. In addition, future studies should consider examining the changes in SVB over time within the task (e.g., first 5 minutes, second 5 minutes, and last 5 minutes) and stressor in order to model the dynamics of both coloring and the stress response with respect to HRV. It is possible coloring provides different benefits at different stages of the task and stressor.

A second limitation of this thesis is the lack of generalizability of the results. Due to the small number of men ( $N = 4$ ) who participated in the current study, it was impossible to analyze potential gender differences. The only other study involving coloring and physiological markers of stress also had a very small sample of men ( $N = 6$ ) and was unable to include gender differences as a possible factor (Muthard & Gilbertson, 2016). However, a similar study that examined the stress-relieving qualities of coloring using self-report measures of anxiety and stress with a more equal gender distribution did not report any gender differences in the effectiveness of coloring for stress reduction (Curry & Kasser, 2005). In addition, these findings are only generalizable to college

students who are typically young and healthy. This is the same population used in the three previous studies that explored the relationship between coloring and self-reported anxiety following an acute stressor (Curry & Kasser, 2005; Muthard & Gilbertson, 2016; van der Venet & Serice, 2012). This could be problematic because the art therapy literature cited as supporting evidence for the potential effectiveness of adult coloring often uses populations with either chronic psychological or physiological health problems. For example, a meta-analysis investigating the efficacy art therapy for improving self-reported anxiety used studies on breast cancer patients (Boehm et al., 2014). Another meta-analysis examined the effectiveness of music therapy within cancer patients more generally (Bradt et al., 2011). Further, several studies have explored the efficacy of mandala creation in treating patients who have experienced trauma (Henderson et al., 2007; Pizarro, 2004). Notably, all of these studies are using populations who are managing a chronic stressor instead of an acute stressor. Perhaps the type of stressor (e.g., acute vs. chronic, social vs. nonsocial) and/or other aspects of the stressor (e.g., severity, duration, or perceived ability to cope) impact the anxiolytic effectiveness of coloring. Future studies should try and expand the research on coloring to include different populations than female college students. Considering the popularity of adult coloring books in other populations outside of undergraduate students (Halzack, 2016), it is important to determine the efficacy of coloring in different populations using appropriate control groups.

A third limitation of this thesis was the self-report measures used to test the potential protective benefits of coloring prior to undergoing a stressor. The present study only used self-report measures of state anxiety and negative affect in analyses.

Importantly, both state anxiety and negative affect are measuring negative emotion. However, researchers could also examine protective benefits by measuring positive emotions and determining whether coloring increases positive emotions. Perhaps the protective benefits to coloring are not obvious when measuring negative emotion because they only have a lasting, persistent effect on positive emotions. Future studies should consider using measures of positive emotion such as the PANAS positive affect subscale when measuring the efficacy of coloring.

A final limitation of the current was the failure to take into account covariates that are known to influence HRV. This was done in an attempt to minimize participant burden and length of time in the lab. Although the current study used strict exclusion criteria in which participants had to abstain from consuming alcohol, tobacco, marijuana, and cold medicines in the 24 hours prior to participating, previous research has shown HRV can also be influenced by fitness levels (De Meersman, 1993; Pober, Braun, & Freedson, 2004), time of day (Massin, Maeyns, Withofs, Ravet & Gerard, 2000), sleep deprivation (Zhong et al., 2005), heavy drinking (Thayer, Hall, Sollers, & Fischer, 2006), caffeine consumption (Koenig, 2013), and the menstrual cycle in women (Brar, Singh, & Kumar, 2015; Tenan, Brothers, Tweedell, Hackney, & Griffin, 2014). Any combination of these other variables could contribute to a decreased or blunted the HRV response in participants. It is important to note the current study was designed such that participants served as their own control. By using within-subjects measures (baseline, experimental task, and stressor), many factors that impact HRV would have remained constant over the course of the study. Nevertheless, the previously mentioned factors do impact HRV reactivity and may still have affected the results despite using within-subjects measures.

This could explain why perfectionism was not a significant covariate within the current study. It was hypothesized that perfectionists would experience a blunted HRV response. Perhaps one of these possible covariates would have had a greater impact than perfectionism on a participants' HRV response to a stressor. Or perfectionism may have a greater impact upon completion of the coloring process when the individual has the opportunity to appraise his or her completed drawing. Alternatively, there may only be a small number of perfectionists in the population and researchers need to screen for more extreme perfectionisms scores (e.g., top 25% or one standard deviation from the mean) to examine the relationship between perfectionism, coloring, and HRV.

Despite these limitations, this thesis extended the coloring literature in several ways. First, this was the first study to investigate the impact of coloring prior to an acute stressor as a means of managing future stress. Contrary to the hypothesis, coloring was found to be equally as effective as a word search in controlling markers of stress, negative affect, and anxiety during an acute stressor task. Although tentative, these findings suggest coloring may not provide protective effects for managing future stressful situations beyond those conferred by other pleasurable distractions like puzzles. This is an important result considering recent news articles may have exaggerated the extent to which adult coloring books are an effective method of coping with stress (Fitzpatrick, 2015; Painter, 2016). Second, this thesis was also one of the first studies to explore the physiological effects of coloring. More specifically, the present study was the first to examine the impact of coloring on HRV. The only previous study that looked at physiological markers of stress during coloring used a combined mandala coloring/deep breathing task (Muthard & Gilbertson, 2016). This made it difficult to interpret the



effects of mandala coloring and deep breathing separately on cardiovascular correlates. Results from the present study found coloring had no significant impact on HRV. This suggests coloring might not actually be as similar to mindfulness meditation as previously hypothesized, and it is possible coloring will not provide the same protective benefits as mindfulness meditation. Third, no previous studies have examined the potential moderating effects of personality traits such as perfectionism on the efficacy of coloring. Despite previous research finding a moderating effect of perfectionism when using mindfulness meditation to reduce stress (Azam et al., 2015), the current study found no significant moderating effect of perfectionism. Overall, this thesis fills several gaps within the coloring literature and suggests ideas for future research.

## LITERATURE CITED

- Acharya, R. U., Joseph, P. K., Kannathal, N., Lim, C. M., & Suri, J. S. (2006). Heart rate variability: A review. *Medical and Biological Engineering and Computing*, 44(12), 1031-1051.
- Azam, M. A., Katz, J., Fashler, S. R., Changoor, T., Azargive, S., & Rivto, P. (2015). Heart rate variability is enhanced in controls but not maladaptive perfectionists during brief mindfulness meditation following stress-induction: A stratified-randomized trial. *International Journal of Psychophysiology*, 98, 27-34. doi: 10.1016/j.ijpsycho.2015.06.005
- Begely, S. (2017, March). Is the Adult Coloring Book trend coming to an end? *TIME*. Retrieved from <http://time.com/4689069/coloring-book-bubble-bursts/>
- Berberain, M. (2015, January). Personal interview with K. Fitzpatrick, Daily Burn. Retrived from <http://www.cnn.com/2016/01/06/health/adult-coloring-books-popularity-mental-health/index.html>
- Bishop, D. G., Wise, R. D., Lee, C., von Rahden, R. P., & Rodseth, R. N. (2016) Heart rate variability predicts 30-day all-cause mortality in intensive care units. *Southern African Journal of Anesthesia and Analgesia*, 22(4), 125-128. doi: 10.1080/22201181.2016.1202605
- Boehm, K., Cramer, H., Staroszynski, T., & Ostermann, T. (2014). Art therapies for anxiety, depression, and quality of life in breast cancer patients: A systematic review and meta-analysis. *Evidence-Based Complementary and Alternative Medicine*, 2014, 1-9.

- Boyle, C. C., Stanton, A. L., Ganz, P. A., Crespi, C. M., & Bower, J. E. (2017). Improvements in emotion regulation following mindfulness meditation: Effects on depressive symptoms and perceived stress in younger breast cancer survivors. *Journal of Consulting and Clinical Psychology*. doi: 10.1037/ccp0000186
- Bradt, J., Dileo, C., Grocke, D., & Magill, L. (2011). Music intervention for improving psychological and physical outcomes in cancer patients. *Cochrane Database Systematic Review*, 8(8). doi: 10.1002/14651858.CD006911
- Brar, T. K., Singh, K. D., & Kumar, A. (2015). Effect of different phases of menstrual cycle on heart rate variability (HRV). *Journal of Clinical and Diagnostic Research*, 9(10), CC01-CC04. doi: 10.7860/JCDR/2015/12795.6592
- Brewer, J. A., Sinha, R., Chen, J. A., Michalsen, R. N., Babuscio, T. A., & Nich, C. (2009). Reactivity in substance abuse: Results from a randomized, controlled Stage I pilot study. *Substance Abuse*, 30(4), 306-317. doi: 10.1080/08897070903250241
- Brownley, K. A., Hurwitz, B. E., & Schneiderman, N. (2000). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.). *Handbook of psychophysiology* (pp. 224-264) (2nd ed.). New York, NY: Cambridge University Press.
- Ceballos, N. A., Giuliano, R. J., Wicha, N. Y., & Graham, R. (2012). Acute stress and event-related potential correlates of attention to alcohol images in social drinkers. *Journal of Studies on Alcohol and Drugs*, 73(5), 761-771.

- Chandola, T., Heraclides, A., & Kumari, M. (2010). Psychophysiological markers of workplace stressors. *Neuroscience Biobehavioral Review*, 35(1), 51-57. doi: 10.1016/j.neubiorev.2009.11.005
- Chester, D. S., Merwin, L. M., & DeWall, C. N. (2015). Maladaptive perfectionism's link to aggression and self-harm: Emotion regulation as a mechanism. *Aggressive Behavior*, 41, 443-454. doi: 10.1002/ab.21578
- Chiesa, A. & Seretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: A review and meta-analysis. *The Journal of Alternative and Complementary Medicine*, 15(5), 593-600.
- Cohen, S., Janicki-Deverts, D., Miller, G. E. (2007). Psychological stress and disease. *JAMA*, 298(14), 1685-1687. doi: 10.1001/jama.298.14.1685
- Curry, N. A. & Kasser, T. (2005). Can coloring mandalas reduce anxiety? *Art Therapy: Journal of the American Art Therapy Association*, 22(2), 81-85. doi: 10.1080/07421656.2005.10129441
- De Meersman, R. E. (1993). Heart rate variability and aerobic fitness. *American Heart Journal*, 125(3), 726-731. doi: 10.1016/0002-8703(93)90164-5
- Fitzpatrick, K. (2016). Why adult coloring books are books are good for. Retrived from <http://www.cnn.com/2016/01/06/health/adult-coloring-books-popularity-mental-health/>
- Gorman, J. M., & Sloan, R. P. (2000). Heart rate variability in depressive and anxiety disorders. *American Heart Journal*, 150(4 Suppl), 77-83.

- Goyal, M., Singh, S., Sibinga, E. M. S., Gould, N. F., Rowland-Seymour, A., Sharma, R... Haythornthwaite, J. A. (2014). Mediation programs for psychological stress and well-being: A systematic review and meta-analysis. *JAMA Internal Medicine*, 174(3), 357-368. doi: 10.1001/jamainternmed.2013.13018
- Gronwall, D. M. (1977). Paced auditory serial-addition task: A measure of recovery from concussion. *Perception and Motor Skills*, 44(2), 367–373.
- Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction. *Journal of Psychosomatic Research*, 57(1), 35-43.
- Halzack, S. (2016, March 12). The big business behind the adult coloring book craze. *The Washington Post*. Retrieved from [https://www.washingtonpost.com/business/economy/the-big-business-behind-the-adult-coloring-book-craze/2016/03/09/ccf241bc-da62-11e5-891a-4ed04f4213e8\\_story.html](https://www.washingtonpost.com/business/economy/the-big-business-behind-the-adult-coloring-book-craze/2016/03/09/ccf241bc-da62-11e5-891a-4ed04f4213e8_story.html)
- Hammen, C., Kim, E. Y., Eberhart, N. K., & Brennan, P. A. (2009). Chronic and acute stress and the prediction of major depression in women. *Depression and Anxiety*, 26(8), 718-723. doi: 10.1002/da.20571
- Hammen, C. & Shih, J. H. (2008). *Stress generation and depression*. In K. S. Dobsin & D. J. A. Dozios (Eds.), *Risk factors in depression* (pp. 409-428). San Diego, CA: Elsevier.
- Henderson, P. Rosen, D., & Mascaro, D. (2007). Empirical study on the healing nature of mandalas. *Psychology of Aesthetics, Creativity, and the Arts*, 1(3), 148-154.

- Kabat-Zinn, J., Massion, A. O., Kristeller, J., Perterson, L. G., Fletcher, K. E., Pbert, L., Lenderking, W. R., & Santorelli, S. F. (1992). Effectiveness of a meditation-based stress reduction program in the treatment of anxiety disorders. *American Journal of Psychology*, 149(7), 936-943.
- Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The 'Trier Social Stress Test' – A tool for investigation psychobiological responses in a laboratory setting. *Neuropsychobiology*, 28, 76-81. doi: 10.1159/000119004
- Kline, R. B. (2009). *Becoming a Behavioral Science Researcher: A Guide to Producing Research That Matters*. New York, NY: Guilford Publications.
- Koeing, J., Jarczok, M. N., Kuhn, W., Morsch, K., Schäfer, A., Hillecke, T. K., & Thayer, J. F. (2013). Impact of caffeine on heart rate variability: A systematic review. *Journal of Caffeine Research*, 3(1), 22-37. doi: 10.1089/jcr.2013.0009
- Lejuez, C. W., Kahler, C. W., & Brown, R. A. (2003). A modified computer version of the Paced Auditory Serial Addition Task (PASAT) as a laboratory-based stressor. *The Behavior Therapist*, 26(4), 290-293.
- Martini, F. H., Nath, J. L., & Bartholomew, E. F. (2012). *Fundamentals of Anatomy and Physiology* (9th edition). San Francisco, CA: Pearson Education, Inc.
- Massin, M. M., Maeyns, K., Withofs, N., Ravet, F., & Gérard, P. (2000). Circadian rhythm of heart rate and heart rate variability. *Archives of Disease in Childhood*, 83(2), 179-182.

- McCorry, L. K. (2007). Physiology of the autonomic nervous system. *American Journal of Pharmaceutical Education*, 71(4), 1-11.
- Muthard, C. & Gilbertson, R. (2016). Stress management in young adults: Implications of mandala coloring on self-reported negative affect and psychophysiological response. *Psi Chi Journal of Psychological Research*, 21(1), 16-28.
- Neubauer, A. B., Smyth, J. M., & Sliwinski, M. J. (2017). When you see it coming: Stressor anticipation modulates stress effects on negative affect. *Emotion*. doi: 10.1037/emo0000381
- Neumann, S. A., Jennings, J. R., Muldoon, M. F., & Manuck, S. B. (2005). White-coat hypertension and autonomic nervous system dysregulation. *American Journal of Hypertension*, 18(5), 584-588. doi: 10.1016/j.amjhyper.2004.11.034
- Pisarik, C. T. & Larson, K. R. (2011). Facilitating college students' authenticity and psychological well-being through the use of mandalas: An empirical study. *Journal of Humanistic Counseling*, 50(1), 84-98. doi: 10.1002/j.2161-1939.2011.tb00108.x
- Pober, D. M., Braun, B., & Freedson, P. S. (2004). Effects of a single bout of exercise on resting heart rate variability. *Medicine and Science in Sports and Exercise*, 36(7), 1140-1148.
- Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology*, 32, 301-318.
- Porges, S. W. (2001). Polyvagal theory: Phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology*, 42, 123-146.

- Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, 74(2), 116-143.
- Purnamaningsih, E. H. (2017). Personality and emotion regulation strategies. *International Journal of Psychological Research*, 10(1), 53-60. doi: 10.21500/20112064.2040
- Rice, K. G., Richardson, C. M., & Tueller, S. (2013). The Short Form of the Revised Almost Perfect Scale. *Journal of Personality Assessment*, 96, 368-379. doi: 10.1080/00223891.2013.838172
- Richard, D., Kabat-Zinn, J., Schumacher, J., Rosenkranz, M...Sheridan, J. F. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine*, 65(4), 564-570.
- Richardson, C. M. E., Rice, K. G., & Devine, D. P. (2014). Perfectionism, emotion regulation, and the cortisol stress response. *Journal of Counseling Psychology*, 61(1), 110-118. doi: 10.1037/a0034446
- Rudolph, S. G., Flett, G. L., & Hewitt, P. L. (2007). Perfectionism and deficits in cognitive emotion regulation. *Journal of Rational-Emotive & Cognitive-Behavior Therapy*, 25(4), 343-357. doi: 10.1007/s10942-007-0056-3
- Rukmini, S., Sudhir, P. M., & Math, S. B. (2014). Perfectionism, emotion regulation, and their relationship to negative affect in patients with social phobia. *Indian Journal of Psychological Medicine*, 36(3), 239-245.
- Sadr, M. M. (2016). The role of personality traits predicting emotion regulation strategies. *International Academic Institute for Science and Technology*, 3(4), 13-24.



- Sandmire, D. A., Groham, S. R., Rankin, N. E., & Grimm, D. R. (2012). The influence of art making on anxiety: A pilot study. *Journal of the American Art Therapy Association, 29*(2), 68-73. doi: 10.1080/07421656.2012.683748
- Schacter, D. L., Gilbert, D. T., & Wegner, D. M. (2011). *Introducing psychology*. New York, NY: Worth Publishers.
- Seegerstrom, S. C. & Miller, G. E. (2004). Psychological stress and the human immune system: A meta-analytic study of 30 years of inquiry. *Psychological Bulletin, 130*(4), 601-630. doi: 10.1037/0033-2909.130.4.601
- Sghir, H. & Löffler, S. & Ottenbacher, J. & Stumpp, J. & Hey, S. (2012). *Investigation of different HRV parameters during an extended Trier social stress test*. Paper presented at the 7th Conference of the European Study Group on Cardiovascular Oscillations, Kazimierz Dolny, Poland.
- Shehab, A. & Abdulle, A. (2011). Cognitive and autonomic dysfunction measures in normal controls, white coat and borderline hypertension. *BMC Cardiovascular Disorders, 11*(3), 1-8. doi: 10.1186/1471-2261-11-3
- Slaney, R. B., Rice, K. G., Mobley, M., Trippi, J., & Ashby, J. S. (2001). The Revised Almost Perfect Scale. *Measurement and Evaluation in Counseling and Development, 34*(3), 130-145.
- Spielberger, C. D. (1989). *State-Trait Anxiety Inventory: Bibliography* (2nd ed.). Palo Alto, CA: Consulting Psychologists Press.
- Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

- Straub, R. O. (2012). *Health psychology: A biopsychosocial approach* (3rd ed.). New York, NY: Worth Publishers.
- Tang, Y., Ma, Y., Fan, Y., Feng, H...Fan, M. (2009). Central and autonomic nervous system interaction is altered by short-term meditation. *PNAS*, *106*(22), 8865-8870.
- Tenan, M. S., Brothers, R. M., Tweedell, A. J., Hackney, A. C., & Griffin, L. (2014). Changes in resting heart rate variability across the menstrual cycle. *Psychophysiology*, *51*, 996-1004.
- Thayer, J. F., Hall M., Sollers, J.J. 3rd, & Fischer, J. E. (2006). Alcohol use, urinary cortisol, and heart rate variability in apparently healthy men: Evidence for impaired inhibitory control of the HPA axis in heavy drinkers. *International Journal of Psychophysiology*, *59*, 244-250.
- Thayer, J. F. & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorder*, *61*, 202-216.
- van der Venet, R. & Serice, S. (2012). Can coloring mandalas reduce anxiety? A replication study. *Art & Music & Movement Therapy*, *29*(2), 87-92. doi: 10.1080/07421656.2012.680047
- van Ockenburg, S. L., Tak, L. M., Bakker, S. J. L., Gans, R. O. B., de Jonge, P., Rosmalen, J. G. M. (2014). Effects of adverse life events on heart rate variability, cortisol, and C-reactive protein. *Acta Psychiatrica Scandinavica*, *131*(1), 40-50. doi: 10.1111/acps.12286

- Visted, E., Sørensen, L., Osnes, B., Svendsen, J. L., Binder, P., & Schanche, E. (2017). The association between self-reported difficulties in emotion regulation and heart rate variability: The salient role of not accepting negative emotions. *Frontiers in Psychology*, 8(328), 1-9.
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology*, 54(6), 1063.
- Welch, P. (1967). The use of fast Fourier transform for the estimation of power spectra: A method based on time averaging over short, modified periodograms. *IEEE Transactions on Audio and Electroacoustic*, 15(2), 70-73.
- Wilcox, R. R. (2010). *Fundamentals of Modern Statistical Methods: Substantially Improving Power and Accuracy*. New York, NY: Springer.
- Young, C. C. & Dietrich, M. S. (2015). Stressful life events, worry, and rumination predict anxiety symptoms in young adolescents. *Journal of Childhood Adolescent Psychiatric Nursing*, 28(1), 35-42. doi: 10.1111/jcap.21102
- Zhong, X., Hilton, J., Gates, G. J., Jelic, S., Stern, Y. Ronald, M. N., DeMeersman, R. E., & Basener, R. C. (2005). Increased sympathetic and decreased parasympathetic cardiovascular modulation in normal humans with acute sleep deprivation. *Journal of Applied Physiology*, 98(6), 2024-2032. doi: 10.1152/japplphysiol.00620.2004