University of Nevada, Reno

Stress Reappraisal and Mindfulness Buffer Psychobiological Responses to Social Threat

A dissertation submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Psychology

by

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May, 2017

THE GRADUATE SCHOOL

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prepared under our supervision by

EDDIE ERAZO

Entitled

Stress Reappraisal and Mindfulness Buffer Psychobiological Responses to Social Threat

be accepted in partial fulfillment of the
requirements for the degree of

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Abstract

Trait mindfulness and positive appraisals of stress have been shown to buffer psychobiological reactivity to social threat. Yet, public health messages about stress often emphasize the harmful effects of stress and brief mindfulness interventions before stressors have yielded mixed findings. Therefore, the present study was designed to manipulate pre-task stress beliefs in a social threat context and implement mindfulness practice post-task to enhance recovery, rather than pre-task to buffer reactivity. Participants (N = 62) were randomly assigned to complete a social threat laboratory stressor after receiving 1) a stress reappraisal or 2) a lay beliefs prime, involving readings about the adaptive nature or harmful effects of stress, respectively. After the laboratory stressor, participants were randomized again to either rest or practice mindful breathing using a recording. Compared to lay beliefs, the stress reappraisal condition was associated with lower cortisol, self-conscious emotion, somatic arousal, experiential avoidance, anxiety, and negative rumination. In addition, post-task mindful breathing was associated with greater state mindfulness and lower cortisol than resting. These results imply the need for a shift in public health messages from the harmful effects of stress on health to the adaptive function of somatic arousal in coping with stress. Also, brief mindfulness interventions may provide a tool for enhancing recovery from stress. Stress reappraisal and post-stress mindfulness present viable, brief interventions for mental and physical health.

Acknowledgements

I would like to thank my advisor, Dr. Holly Hazlett-Stevens, for the life-changing opportunity to pursue a Ph.D. in clinical psychology and for her encouragement to follow my passion. None of this would have been possible without your faith in me.

I would also like to thank my committee members, Dr. Anthony Papa, Dr. Jane Fisher, Dr. Markus Kemmelmeier, and Dr. Melanie Minarik, for their guidance throughout my dissertation. Special thanks to Dr. Holly Hazlett-Stevens, Dr. Anthony Papa, and Dr. Jane Fisher for the clinical training that shaped me as a clinician.

I want to thank my friends and colleagues for challenging me intellectually and keeping me grounded throughout this journey. Finally, I want to thank my family for their love and belief in my potential to be our first doctor. I feel honored to have had so many people walk this path with me and give me strength when I faltered. May we all celebrate our accomplishments, and those of others that we fostered in any part, as if they were our own.

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Chapter 1: Introduction

Stress is ubiquitous and an inevitable experience of life that is capable of occurring in both psychological and physical forms. It is often defined as "a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (Lazarus & Folkman, 1984, p. 19). A critical factor in this definition is the *appraisal* of the stressor, or congruence between demands and one's resources. Lazarus and Folkman's (1984) transactional model of stress explains that stress is not a direct response to a stressor but rather mediated by cognitive appraisal of demands exceeding one's coping resources. More specifically, primary appraisal of the stressor involves assessment of the significance and severity of the situation whereas secondary appraisal consists of perceived controllability of the situation and one's coping resources. In this model, it is possible that an individual may objectively have the resources to cope with a situation but perceive one's resources as inadequate, resulting in a stress response.

Function of Biological Stress Responses

Evolutionarily, stress has been adaptive in terms of mounting a response to cope with environmental pressures, whether psychological or physical in nature. In particular, the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system's inflammation response to stress have been integral to stress reactivity and survival. These systems work symbiotically to regulate energy and inflammation as they are counterbalanced in terms of their influence on each other.

Inflammation. Inflammation is the key element of the immune system and especially important for physical forms of stress but is also activated in response to

psychological threat. Macrophages (a specialized type of white blood cell), in particular, are important for mounting a systemic immune response to tissue damage and exposure to pathogens via wounds by eliminating foreign material and secreting inflammatory cytokines that attract immune cells and promote tissue repair (Binder, Hirokawa, & Windhorst, 2009). Similarly, microglia are the resident macrophages of the brain, constituting 10-12% of the cells in the brain (Kannan, Balakrishnan, Muzik, Romero, & Chugani, 2009), and are activated in response to infection, inflammation, and injury (Streit, 2002). Both macrophages and microglia secrete pro-inflammatory cytokines, of which tumor necrosis factor alpha (TNF-α), interleukin-1β (IL-1), and interleukin-6 (IL-6) are most implicated in inflammatory processes (Maes, Leonard, Myint, Kubera, & Verkerk, 2011). In acute circumstances, such as burn, injury, and viral/bacterial infection, immune responses involving increased inflammation are adaptive and necessary for survival (Fung, Vizcaychipi, Lloyd, Wan, & Ma, 2012). However, the immune response needs to be counterbalanced in order to prevent excessive and prolonged inflammation.

HPA axis. HPA axis activity has been emphasized as the chief stress response and is responsible for regulation of energy production and coordination of physiological responses to psychological and physical stressors (Dickerson, Gruenewald, & Kemeny, 2009). Perception of stress is thought to occur in the amygdala, which is linked to the HPA axis via projections to the hypothalamus (Sullivan et al., 2004). In effect, stress elicits reactivity of the HPA axis and results in secretion of the stress hormone cortisol (Dickerson & Kemeny, 2004). Glucocorticoids, such as cortisol, secreted by the adrenal glands as a result of HPA axis activation are important anti-inflammatory hormones that downregulate pro-inflammatory immune response gene expression (Vinson, 2009).

Along with immune response suppression, cortisol also mobilizes energy necessary for fight-or-flight responses to real or interpreted threats (Sapolsky, Romero, & Munck, 2000). Dickerson et al. (2009) state that this process is believed to occur through cortisol's ability to mobilize energy stores by releasing the glucose necessary to effectively respond to a stressor.

Stress and Allostatic Load

While the stress response is evolutionarily adaptive to respond to immediate environmental demands for survival in the short-term, excessive stress reactivity is known to contribute to negative health outcomes over time. McEwen (1998) explains that adaptation in the face of potentially stressful challenges involves neuroendocrine mechanisms as part of a process called "allostasis," which is essential to maintaining homeostasis. Further, when these adaptive systems are turned on and off efficiently without being activated too frequently, the body is able to effectively cope with challenges. Fortunately, the immune response has feedback loops that regulate the inflammation and responses in healthy individuals. For example, inflammatory cytokines stimulate the HPA axis, which results in cortisol secretion and downregulated inflammation (Song & Wang, 2011). In addition, cortisol binds to glucocorticoid receptors on the hippocampus, hypothalamus, and pituitary gland to downregulate cortisol secretion (Anacker, Zunszain, Carvalho, & Pariante, 2011). However, there are four patterns of reactivity that can compromise the integrity of the allostatic systems: 1) frequent activation of allostatic systems due to repeated stressors, 2) prolonged recovery due to a failure to shut off allostatic activity after stress resulting from impaired negative feedback, 3) inadequate response of allostatic systems or hypoactive state leading to

elevation of normally counter-regulated allostatic systems, and 4) failure of responses to habituate to stressors (McEwen, 1998). As a result, "allostatic load," or the price of adaptation, can lead to disease through wear and tear on the brain and body. Potential disease outcomes of chronic allostatic system activity or inactivity include post-traumatic stress disorder and depression (McEwen, 1998), metabolic syndrome and diabetes (Black, 2003; Pradhan, Manson, Rifai, Buring, & Ridker, 2001), cardiovascular disease (Danesh, Collins, Appleby, & Peto, 1998), chronic inflammatory disease (Feldmann, Brennan, & Maini, 1996), myocardial infarction (Rosengren et al., 2004), and mortality (Harris et al., 1999).

HPA axis dysregulation. Proposed mechanisms by which stress leads to these disease outcomes include both biological and behavioral explanations. Biologically, HPA axis dysregulation and excessive inflammation have been implicated in disease etiology. HPA axis dysregulation is thought to occur from downregulation of CRH receptors in the pituitary gland (Wardenaar et al., 2011). In addition, glucocorticoid receptor resistance has been shown to result from inhibition of glucocorticoid receptors (e.g., cortisol) by cytokines (Pace, Hu, & Miller, 2007). The result is modulation of the normal feedback system wherein cortisol is no longer counterbalanced with inflammation. For example, an elevated cortisol awakening response (CAR) has been observed in those with anxiety and chronic stress (Vreeburg et al., 2010; Wüst, Federenko, Hellhammer, & Kirschbaum, 2000) whereas a blunted CAR is observed in individuals with depression and cancer (Matousek, Pruessner, & Dobkin, 2011; Stetler & Miller, 2005). Further, an elevated CAR has been shown to predict future depression (Adam et al., 2010) and there appears to be an inverted-U relationship between depression severity and CAR such that

moderate depression is associated with higher CAR levels but mild and severe depression are associated with lower cortisol levels (Wardenaar et al., 2011).

Glucocorticoid resistance and cytokines. In the cases of HPA axis dysregulation and glucocorticoid receptor resistance, excessive and unregulated cytokine production leads to systemic inflammatory processes that contribute to chronic disease processes, such as atherosclerosis, insulin resistance, and neurodegeneration (Libby, Ridker, & Maseri, 2002; Shoelson, Lee, & Goldfine, 2006). Recently, research has expanded the serotonin hypothesis of depression into the inflammatory and neurodegenerative theory of depression (I&ND; Maes et al., 2009). The I&ND theory of depression states that the pro-inflammatory cytokines secreted by microglia under intense or prolonged stress conditions induce enzyme indoleamine 2,3-dioxygenase (IDO). IDO degrades the tryptophan necessary for the brain synthesis of serotonin into quinolinic acid and kynurenine, which are neurotoxic and depressogenic, leading to neurodegeneration and depression (Dobos, Korf, Luiten, & Eisel 2010; Maes, 2011). The role of stress in the etiology of depression, in particular, is important with regard to the behavioral impact of stress on disease.

Stress and Health Risk Behaviors

Along with the biological influence of stress on the genesis of negative health outcomes, stress is associated with a number of behavioral responses considered health risk behaviors. Stress has been shown to increase smoking, alcohol consumption, food-seeking and overeating, and physical inactivity or reduced exercise (Azagba & Sharaf, 2011; Krueger, & Chang, 2008; Pool, Delplanque, Coppin, & Sander, 2015). Noteworthy, smoking is the leading cause of disease and premature death in the world

(World Health Organization, 2011) and is a major risk factor for heart attacks, strokes, CVD, and cancer (Centers for Disease Control and Prevention, 2008; U.S. Department of Health and Human Services, 2010). Regarding physical inactivity and overeating behaviors, obesity research has linked a variety of morbidities to excess body mass, including risks for diabetes, hypertension, coronary artery disease, and depression (Nejat, Polotsky, & Pal, 2010). To make matters worse behaviorally, depression arising from biological mechanisms can complicate medical conditions, such as cardiovascular disease, via health risk behaviors including increased smoking, lack of medication adherence, and less physical activity (Williams, 2011). Therefore, chronic stress is capable of promoting biological and behavioral disease processes independently and contributes to depression which also increases health risk behaviors that exacerbate health outcomes.

Economic Impact of Stress-Related Health Conditions

The fiscal consequences of stress and stress-related disease are staggering. Specifically, the biological and behavioral effects of stress described above (e.g., smoking, physical inactivity, alcohol, diet) are strongly related to cardiovascular disease (Williams, 2011; Yusuf et al., 2004). As of 2008, cardiovascular disease (CVD) is the most costly of all diseases with an estimated $448.5 billion in direct medical expenses and total annual costs may approach an estimated $1 trillion including indirect costs from lost productivity (Nichols, Bell, Pedula, & O'Keeffe-Rosetti, 2010). CVD is the leading cause of death in the United States as of 2010, accounting for 597,689 deaths (CDC 2013). Depression alone accounted for an annual economic burden of $210.5 billion in 2010, which represented a 21.5% increase in just five years since 2005 data (Greenberg,

Fournier, Sisitsky, Pike, & Kessler, 2015). Further, major depressive disorder lifetime prevalence is estimated at a midpoint of 9.4% with 12-month prevalence between 9.3% and 23.0% among individuals with a chronic medical condition. The triad of stress, depression, and chronic medical conditions appears to create interactions that result in worse health outcomes over time with significant associated economic costs.

Public Health and Stress Attitudes in the U.S.

Given the immense impact that stress can have on mental and physical health, it is no wonder that public health efforts have been aimed at education and awareness of this connection. In particular, the American Psychological Association's (APA) *Stress in American Press Room* website reports results of the annual *Stress in America* survey™ intended to "draw attention to the serious physical and emotional implications of stress" (APA, 2015a). The survey examines the state of stress in the United States, including attitudes and perceptions, coping behaviors, and its emotional and physical impact. Based on results from APA's *Stress in America* surveys, the public health message about the detrimental effects of stress has been heard loud and clear. Most Americans (83%) believe that stress can have a strong or very strong impact on a person's health (APA, 2012). More than 9 in 10 American adults (94%) believe that stress can contribute to the development of major illnesses (e.g., heart disease, diabetes, and depression) and trigger heart attacks or even death (APA, 2012). Fortunately, average levels of self-report stress for Americans stress have decreased from 6.2 in 2007 to 4.9 in 2014 on a 10-point scale (APA, 2015). Nonetheless, Americans still endorsed a perceived excess in stress and rated healthy stress levels at 3.7 (APA, 2015). The majority of Americans (75%) reported

experiencing at least one symptom of stress in the past month, such as anger, anxiety, lack of interest/motivation, fatigue, and depressed mood (APA, 2015b).

Stress coping behaviors. While recognizing that stress, in itself, is not necessarily harmful in the short-term, coping strategies are of utmost importance. Although exercise/walking is one of the most common responses for stress management (43%), sedentary and unhealthy behaviors are heavily utilized, including listening to music (44%), watching TV/movies more than 2 hours per day (40%) and surfing the internet (38%). Overeating or eating unhealthy food, smoking, and drinking alcohol remain common stress management strategies as well. Unfortunately, these sedentary and unhealthy behaviors are relied upon significantly more by low-income and female Americans with financial stress as well as Millenials (APA, 2015b). This finding is particularly concerning given that low-income Americans have reduced financial resources for healthcare and young adults already behaviorally at-risk for chronic disease may become the future burden of the healthcare system.

Maladaptive coping exacerbates chronic conditions. To complicate matters further, not only do stress and unhealthy behavioral responses to stress contribute to depression and obesity, but obesity and depression can be exacerbated by stress. As of 2012, approximately 34% of American adults are obese and 10% are depressed and those with these conditions report being unable to relieve their stress and engage in maladaptive coping behaviors (APA, 2012). In addition, obese and depressed individuals endorse higher average levels of stress and attitudes that their stress level has a very strong impact on their physical health than the rest of the population (APA, 2012). To summarize, most Americans are aware that stress can negatively impact a person's health

and contribute to major illnesses, but the majority rely on sedentary and unhealthy behaviors that, ironically, contribute to negative health outcomes and chronic disease. Further, depressed, obese, low-income, and young adults appear to be most vulnerable to the effects of stress on their health via perceptions of stress and maladaptive coping behaviors.

Motivation for behavior change. Apparently, the mission has been accomplished in terms of public awareness, yet awareness of stress-related disorders alone has not yielded significant changes in positive health behaviors. Indeed, Americans endorsed being motivated to change behavior less by reasons such as "Understanding how my behavior may increase my chances of developing a chronic illness" (27%), "Being diagnosed with a chronic condition" (35%), and "Death of a family member or friend due to chronic condition" (16%), in comparison to "Desire to feel better" (60%) and "Desire to reduce amount of stress in my life" (45%; APA, 2007). Taken together, *Stress in America* survey data illustrate that Americans rely on maladaptive coping strategies, despite experiencing health symptoms of stress, and are not motivated by chronic illness to modify or change unhealthy behaviors.

Stress perception and mortality. While knowledge about chronic disease implications of stress may not be sufficient to promote health, is it possible that such awareness may actually be deleterious to the health of Americans? A recent study by Keller and colleagues (2011) sought to answer this question by examining the relationship between amount of stress, perception that stress affects health, and health and mortality among Americans. The authors linked data from the 1998 National Health Interview Survey to prospective National Death Index mortality data through 2006 using

a nationally representative sample of U.S. adults. Analyses revealed that higher levels of reported stress and the perception that stress affects health were independently associated with increased odds of worse health and mental health outcomes. Further, there was an interaction between amount of stress and the perception that stress affects health such that individuals who reported "a lot" of stress and indicated the perception that stress affects health "a lot" had a 43% increased risk of premature death (HR 1.43, 95% CI [1.2, 1.7]). Interestingly, those reporting high stress but little or no belief that stress affects health had the lowest risk of death (HR .83, 95% CI [.6, 1.1]), even compared to those with low stress. These findings support the well-documented deleterious effect of stress on health but, more importantly, suggest the perception that stress affects health can either exacerbate or buffer the effects of stress on health and mortality.

Awareness that stress leads to medical conditions is clearly not enough. Ironically, the APA *Stress in America Press Room* website conveys the message that stress is bad for one's health with articles titled, "Are your children stressed?," "14 warning signs of stress," and "How stress harms your health," not to mention a video titled "Conquering Your Stress" that depicts stress as an evil, red, spiky creature with malicious intent (APA, 2015a). Teaching the public that stress negatively affects health may have a paradoxical effect and actually exacerbate stress and health outcomes.

Biopsychosocial Model of Challenge and Threat

Just as appraisal of a stressor hinges on one's perceived resources to meet demands, appraisal of stress and stress-induced arousal itself may hinge on one's perceived ability to cope. The Biopsychosocial (BPS) Model of Challenge and Threat posits that appraisals of situational demands and available resources interact during

active, goal-directed tasks to engender different stress responses (Blascovich, Mendes, Hunter, & Salomon, 1999). Specifically, those who believe they possess sufficient resources to cope with demands experience a challenge response whereas those perceiving demands as exceeding resources experience threat. Jamieson, Nock, and Mendes (2012) explain that increased arousal in stressful situations (i.e., sweating, heat racing/pounding, shaking, changes in breathing) is often construed as anxiety, nervousness, or fear. In turn, people perceive demands as exceeding resources, which triggers a threat response. The disadvantages of a threat response are reduced cardiac efficiency and vasoconstriction, which prompt an avoidance orientation and prepare the body for damage/defeat (Mendes, Blascovich, Hunter, Lickel, & Jost, 2007). Further, threat is associated with impaired decision-making, accelerated "brain aging," cognitive decline, and cardiovascular disease (Jefferson et al., 2010; Matthews, Gump, Block, & Allen, 1997), which were described earlier as deleterious effects of stress. In comparison, challenge is typically associated with positive outcomes, including increased cardiac efficiency and vasodilation in stressful situations, which signal an approach orientation and increase peripheral blood flow (Blascovich et al., 1999; Dienstbier, 1989; Jamieson, Mendes, Blackstock, & Schmader, 2010; Mendes et al., 2007). Emphasizing the chronic effects of stress may reinforce negative appraisals of stress-induced arousal, leading to threat responses that are associated with worse cognitive and cardiovascular functioning and health outcomes.

Behavioral Inhibition and Approach Systems

Gray's (1976, 1982) theory of motivation provides a framework from which threat and challenge may be understood. His theory postulates that there are two distinct

neural motivational systems that regulate withdrawal and approach behavioral responses to environmental stimuli. Namely, the behavioral inhibition system (BIS) is sensitive to punishment and threat cues and triggers avoidance behaviors, whereas the behavioral approach system (BAS) is sensitive to reward cues and triggers approach behaviors. The BIS/BAS theory has been widely adopted and is one of the most influential biologically based psychology theories with evidence of associated neural structures and activity that will not be outlined here (see Scholten, van Honk, Aleman, & Kahn, 2006). While BIS/BAS sensitivity is biologically based, reactivity is influenced by environmental and social factors (Scholten et al., 2006), such as parenting style and peer interactions (Lahat, Hong, & Fox, 2011). BIS sensitivity, in particular, appears to be highly related to anxiety and a predictor of anxiety disorders and depression (Lahat et al., 2011; Panayiotou, Karekla, & Panayiotou, 2014). However, BIS appears to influence the etiology of anxiety disorders via anxiety sensitivity (AS), or the fear of anxiety-related bodily sensations due to perceived physical, psychological or social consequences (Reiss & McNally, 1985). Further, AS often leads to experiential avoidance behaviors (i.e., negatively evaluating feelings/thoughts and exerting effort to avoid/alter them) that perpetuate psychopathology (Hayes, Wilson, Gifford, Follette, & Strosahl, 2011; Kashdan, Breen, Afram, & Terhar, 2010; Pickett, Bardeen, & Orcutt, 2011; Pickett, Lodis, Parkhill & Orcutt, 2012). Whereas BIS is biologically based, AS and avoidance behaviors are more amenable to change given their learned nature (Panayiotou et al., 2014). Therefore, spreading awareness in the U.S. about the harmful effects of stress may actually be instilling anxiety sensitivity in Americans that promotes ineffective avoidance and control behaviors.

Fear of Fear and Somatic Anxiety Sensations

In the 1933 inaugural address, former U.S. President Franklin Delano Roosevelt stated, "the only thing we have to fear is fear itself." Ironically, while FDR was integral in recovery from the Great Depression, 82 years later, this message pervades public health messages and seems to have become toxic to Americans' health and may be contributing to depression. One might argue that we are, in essence, fostering a culture of panic disorder, which is characterized by fear of fear or fear in response to somatic sensations (Bouton, Mineka, & Barlow, 2001). Paradoxically, fear about the initial anxiety response amplifies the fear and anxiety response. Current theories of panic support the process by which promoting the belief that stress negatively impacts health and leads to major illness can exacerbate anxiety and contribute to a self-fulfilling prophecy. First, catastrophic cognitions theory's (Clark, 1986) core thesis is that panic attacks are caused by catastrophic beliefs about certain internal bodily sensations, which causes the individual to react to these stimuli with immediate, extreme anxiety. For example, thinking, "My heart is pounding, which could be a sign of heart disease or lead to it," generates further health anxiety in a positive feedback loop. Likewise, the vicious circle theory's core thesis is that fear of anxiety symptoms, whether due to discomfort or perceived consequences, creates a positive feedback loop that quickly amplifies anxiety symptoms (Bouton et al., 2001; Ley, 1989). With regard to the BPS Model of Challenge and Threat and BIS, emphasizing the impact of stress on health teaches Americans that stress is something to be feared, which produces negative appraisals of anxiety and results in a cognitively, physiologically, and behaviorally maladaptive threat response.

Social-Evaluative Threat and Biomarkers

As discussed earlier, the HPA axis is a well-established psychobiological mechanism of stress reactivity, which makes cortisol an available biomarker for measuring threat responses. While the HPA axis is a key aspect of the "fight or flight response" to physical threat, it has also been shown to play an integral role in social threat. Social-evaluative threat, characterized by conditions in which a person can be judged negatively or rejected, has received overwhelming support as a psychological stressor capable of eliciting a coordinated emotional and psychobiological response (Dickerson & Kemeny, 2004). In a well-cited meta-analysis of 208 studies, Dickerson and Kemeny (2004) delineated the negative social context necessary to trigger cortisol reactivity and concluded that social-evaluative and uncontrollable elements were associated with the greatest cortisol changes and longest times to recovery. Research investigating the role and essential elements of social conditions in eliciting cortisol responses has resulted in the social self-preservation theory, which specifies that threat to the social self (i.e., esteem, acceptance, and status) resulting from negative social evaluation leads to increases in self-conscious emotions, such as shame (Dickerson & Kemeny, 2004). Further, these self-conscious emotions are theorized to elicit cortisol responses via activation of the HPA axis in an attempt to cope with the stressor and maintain the social self.

Trier social stress test. One such laboratory stressor protocol that has been widely used to examine the psychobiological effects of social threat is the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), in which participants deliver a 5-minute job interview speech and complete a 5-minute mental arithmetic task

in front of an evaluative audience panel. The TSST has been shown to reliably lead to a 2- to 4-fold increase in cortisol above baseline (Kirschbaum et al., 1993). Interestingly, social threat also activates the sympathetic nervous system, which increases pro-inflammatory cytokine production via adrenaline and noradrenaline (Eisenberger & Cole, 2012). For example, SET has also been shown to activate the sympathetic nervous system and elicit secretion of pro-inflammatory cytokines, such as TNF-α, relative to a non-SET condition (Dickerson, Gable, Irwin, Aziz, & Kemeny, 2009). In addition, cognitive appraisal of being evaluated was associated with increased cytokine production and the SET condition was associated with decreased ability of glucocorticoids to shut down the inflammatory response. This finding supports the role of glucocorticoid receptor resistance in excessive inflammation due to chronic stress, which contributes to chronic disease over time.

Adaptive origins of SET reactivity. In essence, SET exemplifies the fact that psychological stressors are capable of activating stress systems originally developed to respond to physical threat that are now implicated in chronic disease. Indeed, evolutionary explanations of the concomitant cortisol secretion and inflammation response to stress have emphasized that psychosocial stress historically involved physical dominance struggle with risk of wounding (Raison, Capuron, & Miller, 2006). The authors explain that this accounts for the paradox of needing HPA axis activation (i.e., cortisol) to provide energy for the stressful encounter and cytokines to avoid the increased danger of wound infection presented by glucocorticoid-induced immunosuppression. A stress response that may have been extremely adaptive for survival at one time, however, has become maladaptive in modern civilization

characterized by SET rather than physical threat or insult. Thus, inflammatory stress responses, along with increased lifespan in modern society, contribute to chronic disease.

SET as a paradigm for the BPS model of challenge and threat. Combined, SET and the TSST provide a valuable and convenient paradigm for investigating the effects of threat on cognition and physiology, especially within the context of the BPS Model of Challenge and Threat. The implicit assumption in social-evaluative *threat* is that demands are perceived as exceeding resources to cope. Further, the physiological reactivity (i.e., somatic anxiety symptoms) reliably elicited by SET can be conceptualized as an uncontrollable element of stressful social interactions, which is a major contributor to cortisol changes (Dickerson & Kemeny, 2004). However, psychological and physiological responses to the TSST vary considerably throughout the literature as a function of genetic and psychosocial factors (Dickerson & Kemeny, 2004; Wüst, Federenko, Hellhammer, & Kirschbaum, 2005). Psychosocial factors, then, may be an important point of entry to buffer excessive cortisol responses and recovery time. Therefore, SET stressors are ideal for examining stress appraisal in laboratory settings and the potential buffering effects of reappraisal.

Stress Reappraisal

As explained, stress reactivity is, objectively, vital to survival in terms of mobilizing the body to respond to the demands of the environment. Stress also, objectively, plays an important role in the etiology of many psychiatric disorders and medical conditions. However, the latter is often emphasized, understandably, from a behavioral health and medical model aimed at promoting health behaviors. Fortunately, the maladaptive patterns of reactivity to stress are partially learned and, therefore, may be

modifiable as well. Executive function strategies, especially reappraisal, may hold the key to reframing the stress reactivity that has become the "enemy." Researchers have begun to approach stress from this perspective in order to emphasize and harness the adaptive biological functions of stress reactivity.

Relabeling anxiety as excitement enhances performance. In its simplest form, stress reappraisal can involve labeling one's experience based on the desired emotional state. With regard to the BPS Model of Challenge and Threat, reframing the experience of anxiety as being "excited" or "calm" may prime a challenge or threat orientation, respectively. Brooks (2014) investigated this by testing participants' beliefs about stress coping strategies prior to a social performance and the effects of appraising anxiety as "excitement" or "calmness" (Brooks, 2014). She found that people generally believe that trying to calm down is the best way to cope with pre-performance anxiety. However, in an actual public speech task, participants instructed to reappraise their anxiety as excitement by stating "I am excited" beforehand felt more excited, spoke longer, and were perceived as more persuasive, competent, and confident by raters than those instructed to state "I am calm" or given no instructions. The author concluded that reappraising anxiety as excitement primed an opportunity (rather than threat) mind-set, which improved subsequent performance.

Reappraising anxious arousal as adaptive modulates biomarker responses. **S**imilarly, Jamieson and colleagues (2013a) have been heavily involved with stress reappraisal research examining both performance and physiological effects. For instance, in a real-world application, participants preparing to take the Graduate Record Examination (GRE) randomly assigned to a reappraisal condition were told arousal

actually improves performance, whereas control participants were not given this information (Jamieson, Mendes, Blackstock, & Schmader, 2010). Participants in the reappraisal condition exhibited a significant increase in salivary alpha amylase, a measure of sympathetic nervous system activation, and outperformed controls on the GRE-math section of a practice test. During a 1-3 month follow-up, reappraisal participants scored higher than controls on their actual GRE and greater salivary alpha amylase levels during the laboratory session practice test predicted higher actual GRE-math scores. Results suggest that greater sympathetic nervous system activation via appraisal of anxious arousal as beneficial for performance, rather than harmful, is associated with improved performance. Further, math may provide an objective measurement of performance as a result of stress reappraisal.

Stress reappraisal enhances cardiac functioning during SET. With regard to social performance tasks, Jamieson, Nock, and Mendes (2012) investigated whether stress reappraisal would improve cardiovascular functioning during the TSST and reduce attentional bias to threat after (using an emotional Stroop test with "neutral" and "threat" word lists). Participants were randomly assigned to stress reappraisal, "ignore external cues", or no-intervention conditions. Participants instructed to view their physiological arousal as functional and adaptive demonstrated increased cardiac efficiency, lower vascular resistance, and reduced attentional bias to threat than participants told to ignore the source of stress or given no-intervention. This result is indicative of a challenge, rather than threat, response elicited by stress reappraisal, which suggests reduced BIS activity and, potentially, greater BAS activation.

Interestingly, with regard to the connection between BIS and social anxiety, Jamieson, and colleagues (2013b) replicated the benefits of stress reappraisal during the TSST in socially anxious individuals. In the first experiment, anxious individuals reported greater anxiety and negative affect compared to nonanxious despite demonstrating equivalent physiological reactivity. In the second experiment, both anxious and nonanxious participants instructed to reappraise stress as adaptive and functional exhibited improved cardiac efficiency and reduced attentional bias to threat, compared to their respective control groups.

Given the role BIS plays in social anxiety, these findings are encouraging in terms of evidence that stress reappraisal is effective among anxious individuals and may promote greater challenge-based BAS activation and buffer against threat-based BIS activity. Taken together, these studies provide evidence that: 1) stress reappraisal promotes a challenge-based BAS response rather than threat-based BIS response, even among anxious individuals, 2) biomarkers are responsive to cognitive stress reappraisal and conducive to measuring the beneficial effect on physiological reactivity, and 3) math is a potential objective measure of performance compared to human raters. Further, this research exposes stress reappraisal as a potential brief intervention that could be implemented in healthcare settings to promote adaptive stress responses with biological benefits.

Stress reappraisal in social anxiety. Despite the apparent lay belief that suppressing anxiety and nervousness is the best way to cope, it seems that embracing physiological arousal and reappraising it as functional is more cognitively and biologically adaptive. This may be particularly important among anxious individuals.

Indeed, Stefan G. Hofmann was integral in creating social self-reappraisal therapy for social phobia, which relies heavily on reappraisal of perceived social standards and skills to reduce anxiety (Hofmann & Scepkowski, 2006). Hofmann, Heering, Sawyer, & Asnaani (2009) explain that anticipating the negative consequences of feeling anxious leads individuals to exert effort to down-regulate anxiety, which is difficult because high arousal is automatic and suppression is often ineffective. As mentioned earlier, the negative consequences of stress and anxiety have been publicized, which may be contributing to attempts to suppress in a BIS manner rather reappraise in a BAS manner. Notably, evidence suggests that high socially anxious individuals demonstrate a negative recall bias and greater negative rumination compared to low socially anxious individuals, as observed after a laboratory speech task (Edwards, Rapee, & Franklin, 2006). Therefore, stress reactivity can continue to impact health even after a stressor has terminated, which implies the need for an adaptive post-stressor coping response to supplement stress reappraisal during a task.

Mindfulness, Rumination, and Cortisol Recovery

While stress is a normal part of life with adaptive functions, rumination after a stressor has passed may contribute to the allostatic load pathway explained by McEwen (1998) in which impaired negative feedback prolongs recovery due to a failure to shut off allostatic activity after stress. With regard to SET, greater post-task rumination after the TSST has been associated with amplified and prolonged cortisol responses (Zoccola, Dickerson, & Zaldivar, 2008). Conversely, there are traits that have consistently been associated with buffered cortisol responses to the TSST. In particular, a study investigating the effects of mindfulness on reactivity to the TSST revealed that higher

dispositional mindfulness predicted lower cortisol responses, anxiety, and negative affect (Brown, Weinstein, & Creswell, 2012). The authors assert that the stress-buffering hypothesis of mindfulness (Cohen & Edwards, 1989) provides protection against the pathogenic effects of stress. Mindfulness is rooted in the over 2,600 year-old Buddhist tradition and is often defined as "paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally" (Kabat-Zinn, 1994). A key element of mindfulness is the acceptance of what is present in the current moment (e.g., thoughts, emotions, bodily sensations), whether pleasant or unpleasant, rather than adding energy to one's suffering by trying to escape it (Germer, 2005).

Mindfulness interventions and mechanisms. In recent years, mindfulness has become an important foundation for modern psychosocial interventions for anxiety and depression, such as acceptance and commitment therapy (ACT), mindfulness-based stress reduction (MBSR), and mindfulness-based cognitive therapy (MBCT). Mindfulness-based interventions have been shown to reduce cortisol awakening response levels (Matousek, Dobkin, & Pruessner, 2010) and reduce emotional reactivity to SET (Britton, Shahar, Szepsenwol, & Jacobs, 2012). As few as fifteen minutes of focused breathing has been shown to enhance emotion regulation in the presence of aversive stimuli, compared to a control group (Arch & Craske, 2006).

Proposed mechanisms by which mindfulness reduces anxiety and buffers cortisol reactivity include reduced amygdala activity and increased prefrontal cortex activity to stress as well as reduced amygdala gray matter and thicker cortex with consistent mindfulness practice (Creswell, Way, Eisenberger, & Lieberman, 2007; Goldin & Gross, 2010; Holzel et al., 2011). In essence, mindfulness reduces fear-based reactivity

associated with cortisol responses and promotes executive functioning, such as emotion regulation. Indeed, a meta-analysis of MBSR (an 8-week mindfulness program with weekly group meetings and daily practices) outcomes has revealed that it effectively reduces anxiety, depression, and stress (de Vibe, 2012).

Brief mindfulness intervention and cortisol. Given the benefits of mindfulness in terms of reducing stress, anxiety, and cortisol, it follows that mindfulness may be a useful tool in preventing chronic disease. However, the MBSR program demands a significant time commitment that totals over 60 hours between group meetings and at-home practices during an 8-week period. This presents a clear barrier to access and utilization, especially in terms of research and healthcare. Further, research attempting to use brief mindfulness intervention has been riddled with inconsistencies and postulations to explain findings. For example, participants who completed a mere 25 minutes per day of mindfulness meditation for three consecutive days reported lower psychological stress reactivity but demonstrated greater cortisol reactivity to the TSST than participants in an analytic cognitive control training condition (Creswell, Pacilio, Lindsay, & Brown, 2014). The authors posited that brief mindfulness training fostered greater engagement and active coping efforts during the TSST, which resulted in more cortisol reactivity but would attenuate cortisol responses with longer periods of training (Baer, Carmody, & Hunsinger, 2012; Lam, Dickerson, Zoccola, & Zaldivar, 2009). In other words, attempting to be "mindful" may create a second cognitive challenge in addition to the speech task itself, thereby increasing demands and necessitating greater mobilization of resources unlike dispositional mindfulness.

Mindful Recovery from Threat

Fortunately, mindfulness may prove useful in preventing allostatic load by not only buffering stress reactivity, but also by decreasing recovery time from stress. Mindful awareness could provide a post-task response that is incompatible with rumination, which is associated with prolonged physiological reactivity. Further, mindfulness presents an alternative coping response to health risk behaviors that are ineffective and contribute to chronic disease. Together, mindful recovery from a stressor may prevent cognitive, (e.g., rumination), biological (e.g., prolonged HPA axis activation and inflammation), and behavioral (e.g., smoking, drinking, eating) mechanisms that are ineffective and contribute to depression, chronic disease, and depression-mediated chronic disease.

Mindfulness and stress reappraisal. The concept of mindful recovery is fully compatible and complementary to stress reappraisal. Mindfulness promotes perception of stimuli "as they are" rather than layered with judgment, which melds well with the philosophical underpinning of stress reappraisal that stress reactivity is adaptive and functional. Given the objective, evolutionary origins of the fight/flight response and associated somatic sensations, mindfulness necessarily embraces the adaptive and functional nature of stress reactivity. In fact, the first of the Four Noble Truths taught by the Buddha is *dukkha*, which is generally translated as suffering, and considered to be caused be judgment of and resistance to one's experience. Therefore, mindful awareness is also incompatible with the view that stress is "bad" or "the enemy," which may prevent post-stressor BIS activity and the fear of fear/anxiety cycle that exaggerates and prolongs stress responses.

Post-SET mindful recovery to enhance cortisol recovery. Importantly, mindful recovery is novel in that it has not yet been tested within the TSST paradigm. The concept of mindful recovery merges with the stress reappraisal perspective in acknowledging that a robust physiological response to stress (e.g., SET) is not necessarily maladaptive. Rather, additional stress reactivity to the initial stress response and failure to recover quickly appear to be deleterious, with rumination and BIS-related anxiety sensitivity and experiential avoidance playing a central role. As McEwen (1998) explained, stress responses are adaptive for responding to a stressor but allostatic systems need to be turned on and off efficiently to prevent allostatic load and chronic disease. Essentially, the perspective proposed here shifts the focus from stress reactivity *per se*—which is often conceptualized as "high" means "bad" —to perception/reactivity to stress and recovery. The capacity for mindfulness to increase recovery from SET, such as the TSST, has not been examined, let alone in conjunction with the use of a pre-task stress reappraisal prime. Combined, stress reappraisal and mindful recovery hold the potential to buffer cortisol responses (peak and recovery), reduce subjective anxiety, and enhance performance, which exposes a cost-effective brief intervention package for healthcare settings.

The role of mindfulness in U.S. healthcare reform. As discussed earlier, the current U.S. healthcare system is not economically sustainable due to growing costs associated with disease. The great potential for psychosocial interventions has become evident with research showing that stress-management practices reduced the risk of subsequent cardiac events in heart disease patients by 75% compared to usual care (Blumenthal, 1997). The role of mindfulness in U.S. healthcare system reform has been

touted with regard to cost-effective disease prevention. In particular, mindfulness promotes self-awareness, resilience to stress, and responsibility for lifestyle choices (Ruff & Mackenzie, 2009). Ruff and Mackenzie (2009) explained that mindfulness allows a shift from "autopilot" to conscious positive lifestyle changes and makes the body more "stress hardy" and less likely to succumb to the wear and tear of chronic psychological stress.

However, research is needed to determine the most cost-effective, brief, and accessible ways of integrating mindfulness into healthcare settings to produce biomarker change. Fortunately, studies using mindfulness-oriented audiotapes have revealed their potential to improve psoriasis clearance when played during phototherapy (Kabat-Zinn et al., 1998) and reduce blood loss from surgery by 43% when played beforehand (Dreher, 1998). This may provide an invaluable tool in brief healthcare intervention to prevent chronic disease and enhance tertiary prevention outcomes. For example, brief mindfulness practice after stress reactivity may be prescribed in primary care settings or distributed in public health messages online (e.g., the APA *Stress in America Press Room*) to enhance recovery to baseline and prevent the prolonged psychobiological reactivity that can contribute to mental disorders and disease.

Present Study

Americans have clearly received the message that stress can be harmful for one's health, but these negative perceptions of stress appear to be contributing to anxiety, depression, and chronic disease, ironically. Juster, McEwen, and Lupien (2010) emphasized the importance of using known protective factors of allostatic load in research to determine interventions that can be implemented to improve public health.

Fortunately, stress reappraisal and mindfulness have demonstrated the capacity to buffer biological mechanisms of allostatic load. Therefore, the present study utilized the TSST as a model for examining how the negative effects of threat (i.e., SET, which is particularly problematic in modern society) can be buffered through brief, simple interventions, such as stress reappraisal and mindful recovery, that retrain stress perception and responses.

The present study examined the effect of pre-task stress reappraisal, compared to a lay beliefs control condition, and a post-task mindful recovery audio recording, compared to rest, on cortisol and affective responses to the TSST, among college students. In effect, this study is a 2 (pre-task) x 2 (post-task) design. Given the issues that have arisen with brief mindfulness intervention prior to the TSST and successful use of stress reappraisal primes, a stress reappraisal intervention occurred before the TSST and a mindful recovery intervention was guided after the TSST. Based on evidence that executive functioning serves as a moderator between BIS or AS and anxiety, I also tested the moderation effect of pre-task condition on the association between trait BIS and ASI-3 scores (separately) with post-task cortisol responses and self-reported anxiety. Finally, post-task negative rumination, distress from somatic anxiety, state experiential avoidance, state mindfulness, and state anxiety were examined between conditions.

Hypotheses. Hypotheses were as follows: 1) participants who receive the pre-task stress reappraisal prime will exhibit lower peak and total cortisol reactivity than participants in the lay beliefs condition, 2) participants who receive the mindful recovery intervention will demonstrate the quickest cortisol recovery, 3) BIS and ASI-3 scores will be strongly associated with cortisol responses and post-task somatic distress in the lay

beliefs control group, but this relationship will be attenuated in the stress reappraisal condition, 4) participants receiving the stress reappraisal prime will perform better (measured by the math task) and report lower levels of task-related self-conscious emotion, state experiential avoidance, state anxiety, distress from somatic anxiety, and post-task negative rumination than those in the lay beliefs group, 5) mindful recovery will result in lower post-rest negative rumination, state experiential avoidance, and state anxiety and higher state mindfulness than rest alone. The implications if these hypotheses are supported are far-reaching. First, the results would demonstrate that perception of stress is directly related to endocrine responses and attempting to promote public health by touting its adaptive function would be more effective than teaching negative effects. Second, more rapid cortisol recovery in the mindful recovery condition would demonstrate biological benefits of mindful recovery beyond stress reappraisal during a task and highlight post-task mindfulness as a key for brief intervention. This would imply a potential cost-effective brief intervention that could be implemented in integrated healthcare settings to buffer the effects of stress. Third, attenuated associations between BIS scores and cortisol, anxiety, and rumination would support the utility of stress appraisal in buffering BIS-related activation, which would be particularly effective in preventing and treating social anxiety and possibly panic. Fourth, lower task-related self-conscious emotion, state anxiety, state experiential avoidance, distress from somatic anxiety, and post-task negative rumination in the stress reappraisal conditions would demonstrate the ability of stress perception to impact proposed key mechanisms of SET. Finally, lower post-intervention negative rumination, state experiential avoidance, state mindfulness, and state anxiety in the mindful recovery condition would support the

capacity of brief mindfulness intervention to promote nonjudgmental and present moment awareness. Together, these implications would expose stress reappraisal and mindful recovery as a brief intervention package capable of improving public health in the U.S. and creating a more sustainable healthcare system by preventing biological and behavioral mechanisms through which stress contributes to chronic disease and its associated costs.

Chapter 2: Method

Participants

Sixty-two[1] healthy undergraduate students were recruited through the SONA subject pool and fliers posted on campus at the University of Nevada, Reno to receive extra credit. Participants were eligible if they were: 1) eighteen years of age or older, 2) free of chronic medical or psychiatric conditions (e.g., diabetes, depression), 3) not taking medication for a cardiovascular, endocrine, immune, or psychiatric conditions (e.g., anti-inflammatories or immune suppressants, antidepressants, anti-anxiety medications), 4) a non-smoker, 5) not pregnant, and 6) not a regular meditator. These exclusion criteria were in place to ensure that the cortisol data obtained were interpretable with regard to key hypotheses and not affected by biological and biobehavioral confounds. Forty-eight females and fourteen males completed the study. Mean age was 21.60 years (*SD* = 4.95, range = 18-45); 50% of participants were White, 22.6% Hispanic, 11.3% African-American/Black, 11.3 % Other, and 4.8% Asian-American.

Procedure

In order to prevent natural diurnal variation in cortisol from confounding HPA axis reactivity, participants arrived in the laboratory for 2-hour individual sessions at either 2:00 p.m. or 4:00 p.m. After obtaining informed consent, participants were given 40 minutes to complete baseline questionnaires and rest when finished in order to allow cortisol to stabilize. Baseline questionnaires included demographics, the BIS/BAS scales (Carver & White, 1994), the Multidimensional Experiential Avoidance Questionnaire

[1] A total of eighty participants were recruited for the study. However, eight sessions involved protocol issues, two participants discontinued during the speech task, three were ineligible, and five had abnormal, missing, or outlier cortisol values. As a result, these 18 individuals were excluded from analyses. Excluded cases did not differ from the remaining sample based on baseline measures (all ps > .29).

(MEAQ; Gámez, Chmielewski, Kotov, Ruggero, & Watson (2011), the Anxiety Sensitivity Index-3 (Taylor et al. 2007), the Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), the Perceived Stress Scale (Cohen, Kamarch, & Mermelstein, 1983), a brief stress perception questionnaire, the short-form State-Trait Anxiety Inventory (Marteau & Bekker, 1992), and state self-conscious emotion (Dickerson et al., 2008). Participants were randomly assigned to one of two pre-task conditions (stress reappraisal [n = 28, 21 female] or lay beliefs [n = 34, 27 female]) and one of two post-task conditions (mindful recovery [n = 30, 21 female] or rest [n = 32, 27 female]) based on an alternating sequence predetermined for each participant number.

Experimental conditions. The stress reappraisal manipulation educated participants about the adaptive function of physiological arousal in response to stressful situations by replicating the protocol used by Jamieson et al. (2012). Therefore, participants were instructed to read a set of journal article summaries (some real, some fabricated) and answer questions to demonstrate understanding. The articles countered the belief that physiological arousal is harmful in stressful situations and emphasized how the body's responses to stress developed in order to effectively cope with stressors and actually aid performance. Participants were instructed to view anxious arousal as excitement about the task, as implemented by Brooks (2013). Essentially, participants in the stress reappraisal condition were encouraged to view somatic anxiety arousal as adaptive and functional, in contrast to the public health message and consequent lay belief that stress is harmful to health.

In the lay beliefs control condition, participants were provided information about the deleterious effects of stress on health and performance. Participants read information from the APA website titled, "Stress Effects on the Body," which details how stress negatively impacts functioning of the different organ systems, as well as a journal article summary about how stress harms performance. These readings were followed by questions for participants to demonstrate their understanding. Participants were informed how physiological arousal during stress is normal and was once adaptive and functional for ancestors but is now maladaptive for health in modern society. Essentially, participants in the lay beliefs condition received the current public health message that stress can be hazardous to one's health and contribute to chronic disease, which has already become widespread, as shown by APA's *Stress in America* statistics. Both experimental condition primes lasted approximately 10 minutes. Upon completion of the stress reappraisal or lay beliefs prime, all participants answered the brief stress perception questionnaire again as a manipulation check that the prime influenced stress beliefs and provided a baseline saliva sample (#1).

TSST. Once participants completed their respective priming task, instructions for the TSST were given by two evaluators (research assistants dressed in white lab coats) explaining that participants will be delivering a 5-minute speech to the evaluators describing why they are an ideal candidate for their dream jobs. Participants were told that the evaluators are specially trained to rate the speech for believability and convincingness, and that their speeches will be compared to others completing the task. Further, the evaluators explained that the 5-minute speech will be videotaped for additional evaluation. After the instructions, evaluators exited the room and participants

were given paper, pencil, and five minutes to prepare a speech. At the conclusion of the 5-minute preparation period in both conditions, the evaluative panel entered the room and asked the participant to begin his or her speech. Evaluators stood next to each other with a video recorder mounted on a tripod in between them as they facde the participant at about six feet in distance. The evaluators were trained to maintain eye contact, remain stoic, and refrain from providing positive or negative feedback during the speech while feigning notes and checkmarks.

After the 5-minute speech period, participants performed an impromptu 5-minute mental arithmetic task in which they were asked to count backwards in steps of 13 from 1022. Evaluators provided negative feedback to incorrect responses and prompted the participant to begin from 1022. At the conclusion of the TSST, evaluators exited the room and the post-task saliva sample (#2) was administered and collected while participants self-reported state anxiety, somatic anxiety distress, somatic anxiety intensity, self-conscious emotion, and experiential avoidance during the task.

Post-SET recovery. After about five minutes of post-task questionnaires, participants in the mindful recovery condition were asked to complete a 20-minute mindful breathing task with an audio recording guided by Jon Kabat-Zinn, in which they were prompted to bring nonjudgmental awareness to the physical sensations of breathing and redirected to the breath if their attention wandered to thoughts or bodily sensations. In contrast, participants in the reappraisal alone and lay beliefs condition were asked to rest without stimulus for 20 minutes. All participants were then asked to complete post-task questionnaires measuring negative rumination, state experiential avoidance, state mindfulness, state anxiety, and post-task appraisals at the 25-minute post-task time point.

Participants in the mindful recovery condition resumed mindful breathing with a 10-minute recording while those in the other conditions continued to rest until the 40-minute measurements. Participants were provided saliva samples at 10 (#3), 25 (#4), and 40 (#5) minutes after the speech during a 40-minute recovery period. Participants completed a measure of negative rumination while completing the 40-minute saliva sample. Upon completion, participants were debriefed and awarded extra credit. Each session lasted approximately two hours from informed consent to debriefing.

Measures

Demographics. A short demographic questionnaire was used to assess participants' characteristics, including age, ethnicity, and gender.

Perception of stress affecting health. Participants were asked to rate perceptions of whether stress affects health in various ways on a 100-point visual analog scale from 1 (strongly disagree) to 100 (strongly agree), The scale included 5 items, such as "Stress can contribute to the development of major illnesses," positive-worded items were reverse-scored. The total was averaged for a negative beliefs score out of 100. This scale was given at baseline and post-prime as a manipulation check to confirm that the stress reappraisal and lay beliefs primes were effective.

Positive and negative affect/Self-conscious emotion. A modified version of the 20-item PANAS (Watson et al., 1988) was used post-task to measure the effect of social-evaluative threat on affect. In particular, a self-conscious items subscale (Dickerson, Mycek, & Zaldivar, 2008; Lewis, 1971) was used to examine differential emotional and self-consciousness responses to the speech task with or without the stress reappraisal intervention. Example items include *ashamed*, *embarrassed*, and *humiliated*, which

participants rated on a 5-point scale from 1 (very slightly or not at all) to 5 (extremely) in terms of the extent to which they felt during or since the speech. This measure was given at baseline and immediately after the TSST.

Somatic anxiety. A 10-item scale of somatic symptoms was created using the first 10 criteria for a panic attack as defined in the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; American Psychiatric Association, 2013). These items were presented in two ways to measure both self-reported anxiety intensity induced by the speech task as well as how "distressed" or "bothered" they were by the symptoms during the task. The items consisted of common symptoms of anxiety, such as heart pounding/racing, feeling hot/cold, and sweating, which participants rated on a 100-point scale from 0 (not at all) to 100 (severely). This measure was given immediately after the TSST.

Rumination. The 20-item Thoughts Questionnaire (Edwards et al., 2003) was used to evaluate the level of negative rumination an individual was experiencing in a particular moment or has experienced over a given period of time. The negative rumination scale has excellent reliability ($\alpha = .94$) and includes statements such as, "My speech was good" and "I made a fool of myself" that participants rated on a 5-point scale from 0 (Never) to 4 (Very often) in terms of how often they thought about that aspect since completing the TSST tasks. This measure was given at 25 minutes post-task.

Behavioral inhibition/activation. The 24-item BIS/BAS scales (Carver & White, 1994) was used to assess individual differences in the sensitivity of dispositional, behavioral approach and avoid motivation systems. The BIS scale has acceptable reliability ($\alpha = .74$) and consists of items such as, "I worry about making mistakes,"

whereas the BAS scale consists of items such as, “I go out of my way to get things I want.” Participants rated the items on a 4-point scale from 1 (very true of me) to 4 (very false of me) in terms of the extent to which they agreed.

Anxiety sensitivity. The 18-item Anxiety Sensitivity Index-3 (Taylor et al., 2007) was used to examine individual differences in fear of specific anxiety symptoms and associated catastrophic consequences. The ASI-3 has good reliability ($\alpha = .94$) and contains items such as, “It scares me when my heart beats rapidly,” and, “When I tremble in the presence of others, I fear what people might think of me.” The items were rated on a 5-point scale from 0 (very little) to 4 (very much) in terms of how characteristic each item was of the individual.

Trait experiential avoidance. The 62-item Multidimensional Experiential Avoidance Questionnaire MEAQ (Gámez et al., 2011) was used to measure participants’ tendency to avoid aspects of their experience dispositionally. The MEAQ has excellent reliability ($\alpha = .94$) and consists of six dimensions: *behavioral avoidance*, *distress aversion*, *procrastination*, *distraction and suppression*, *repression and denial*, and *distress endurance*. Sample items include, “Happiness involves getting rid of negative thoughts” and “I go out of my way to avoid uncomfortable situations,” which participants rated on a 6-point scale from 1 (strongly disagree) to 6 (strongly agree).

State experiential avoidance. A 4-item state measure of experiential avoidance (Kashdan et al., 2014) was given immediately post-task to assess participants’ attempts to avoid anxiety during the task, such as “How much effort did you put into making anxiety-related feelings or thoughts go away?” Items were rated on a 5-point scale from 1 (very

slightly or not at all) to 5 (extremely). This measure was given at 0 and 25 minutes post-task.

State mindfulness. The Southampton Mindfulness Questionnaire (SMQ; Chadwick et al. 2008) consists of 16 items measuring an individual's tendency to respond to distressing thoughts. The SMQ has good reliability ($\alpha = .89$) and includes statements such as "I lose myself in the thoughts/images," rated on a 7-point scale from 0 (strongly disagree) to 6 (strongly agree). These items were reworded in the past tense and administered 25 minutes after the TSST to reflect cognitive coping across conditions, especially relative to the mindful recovery condition.

State anxiety. The short-form of the State Scale of the Spielberger State-Trait Anxiety Inventory (Marteau & Bekker, 1992) assesses state anxiety in a situation and was used here to examine the differential effects of stress reappraisals intervention on anxiety in response to the speech task. This measure has good reliability ($\alpha = .82$ and of consists of 6 items, such as "I feel calm" and "I feel tense" that participants rated on a 4-point scale from 1 (not at all) to 4 (very much so) in terms of how the statements described how they felt in the moment or felt during the speech. This measure was given at baseline as well as 0 and 25 minutes after the TSST.

Mindfulness. The FFMQ (Baer et al., 2006) consists of 39 items assessing five facets of mindfulness: *observing*, *describing*, *acting with awareness*, *nonjudging of inner experience*, and

nonreactivity to inner experience. The FFMQ includes items such as "When I have distressing thoughts or images, I am able just to notice them without reacting" that participants rated on a 5-point scale from 1 (Never or very rarely true) to 5 (Very often or

always true) in terms of how the statements describe their perceptions of themselves. This measure was used to ensure equivalent groups from random assignment and confirm that observed effects of condition were due to intervention rather than baseline differences.

Post-task appraisal. Participants rated their performance and provided other post-stressor appraisals, such as difficulty of the task, awareness of body sensations, and concern about the stress response on their health. Items were generally rated on a 7-point scales from 1 (not at all) to 7 (very much) with some items that differed (e.g., 1 = very poor, 7 = excellent).

Perceived stress. The Perceived Stress Scale consists of 10 items used to assess an individual's level of stress during the last month. The scale has good reliability (α = .85) and consists of items such as "In the last month, how often have you felt nervous and 'stressed'?" that are rated on a scale from 0 (never) to 4 (very often). This scale was used to ensure equivalent groups at baseline for current stress levels.

Task performance. The math portion of the TSST provided an objective measure of performance. The lowest number that the participant reached was used to determine between group differences.

Cortisol assessment. Salivary cortisol was collected at five time points (baseline and 0, 10, 25, and 40 minutes post-task) in order to capture peak reactivity and examine recovery from the stressor (Dickerson & Kemeny, 2004). Saliva samples were collected using the Salivette sampling device (Sarstedt, Nümbrecht, Germany) containing a cotton swab that participants kept in their mouths for three minutes. Samples remained at room temperature until being stored in a freezer at -20 °C upon completion of the session, and finally sent to a professional and reputable bioassay laboratory in Dresden, Germany.

Saliva samples were frozen and stored at -20 °C in the bioassay laboratory until analysis. After thawing, salivettes were centrifuged at 3,000 rpm for 5 min, which resulted in a clear supernatant of low viscosity. Salivary concentrations were measured using commercially available chemiluminescence immunoassay with high sensitivity (IBL International, Hamburg, Germany). The intra and interassay coefficients for cortisol were generally below 8%.

Log transformed values of cortisol concentrations were used in all analyses due to nonnormality of raw cortisol data. Area-under-the-curve with respect to increase (AUC-I) values of cortisol stress reactivity to the TSST were used for analyses either over all five time points or only the last three when investigating recovery from peak. The AUC-I cortisol measure was calculated using Pruessner's trapezoid formula (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003), using the following equation: AUC-I = [(Cortisol 1 + Cortisol 2)/2 × 20 + (Cortisol 2 + Cortisol 3)/2 × 10 + (Cortisol 3 + Cortisol 4)/2 × 15 + (Cortisol 4 + Cortisol 5)/2 × 15) – (Cortisol 1 × (20 + 10 + 15 + 15)]. Cortisol recovery was measured using a similar equation with only time points 3, 4, and 5: AUC-I = [(Cortisol 3 + Cortisol 4)/2 X 15 + (Cortisol 4 + Cortisol 5)/2 x 15 – (Cortisol 3 x (15 + 15)].

Statistical Analysis

All analyses were conducted using SPSS 22. One-way ANOVAs were used to confirm equivalent groups from random assignment with regard to stress and perception of stress affecting health, baseline mindfulness, anxiety sensitivity, perceived stress, BIS, and ASI scores. For hypothesis 1, testing whether the pre-task stress reappraisal prime results in reduced cortisol compared to the lay beliefs prime, a full factorial 2 (sex) x 2

(pre-task condition) x 2 (post-task condition) x 5 (time) generalized linear mixed model (GLMM) was used to test the interactions of condition and gender with time, and their individual effects, on all cortisol responses (time points 1-5). Linear regression was used to examine the effect of stress reappraisal on peak cortisol (time point 3, 10 minutes after task) and total AUC-I (time points 1-5) relative to the lay beliefs control group. Regarding hypothesis 2, testing whether post-task mindful recovery results in lower cortisol than rest alone, a full factorial 2 (sex) x 2 (pre-task condition) x 2 (post-task condition) x 5 (time) GLMM was used to evaluate the interactions of condition and gender with time on cortisol recovery (time points 3-5). Linear regression was used to examine the effect of post-task mindfulness intervention on AUC-I for cortisol recovery (time points 3-5) compared to rest. For hypothesis 3, the interaction effects of BIS and ASI-3 with condition predicting AUC-I and post-task distress from somatic anxiety distress for each group were compared by using dummy-coded treatment variables to test the prediction that BIS and ASI would be positively associated with cortisol and somatic anxiety distress but moderated by pre-task condition. In addition, full factorial 2 (sex) x 2 (pre-task condition) x 2 (post-task condition) x 5 (time) x 3 (BIS/ASI) GLMMs were used to test the interactions of BIS and ASI with time on cortisol. Separate GLMMs were run with BIS or ASI divided into thirds from raw continuous data as the categorical variable across all cortisol responses (time points 1-5). For hypothesis 4, one-way ANOVAs were used to test the prediction that the stress reappraisal prime would be associated with better math performance and lower immediate post-task self-conscious emotion, state experiential avoidance, state anxiety, somatic anxiety intensity, and somatic anxiety distress, as well as negative rumination at 25 minutes post-task,

compared to the lay beliefs prime. Finally, for hypothesis 5, linear regression models including pre- and post-task condition and their interaction were used to test the prediction that post-task mindfulness intervention would result in lower negative rumination, state anxiety, state experiential avoidance, and state mindfulness at 25 minutes post-task and lower negative rumination at 40 minutes post-task, compared to rest. Robust covariances were used to handle violations of model assumptions in GLMMs. Cortisol outliers were identified based on GLMM residuals for any time point that was greater than three standard deviations from the residuals mean. Participants (n = 62) were only included in analyses if there were valid cortisol values for all five time points after identification of outlier and missing cortisol values. Four cases were removed due to outlier cortisol values and one case was removed due to missing baseline cortisol. Cases excluded during cortisol analyses were removed from all further analyses to ensure consistent interpretation of data for self-report variables.

Chapter 3: Results

Preliminary Analyses

There were no significant differences between stress reappraisal vs. lay beliefs or mindfulness vs. rest conditions with regard to demographic variables (ethnicity, age, gender), hormonal contraceptive use, trait experiential avoidance, trait mindfulness, stress levels, stress beliefs, anxiety sensitivity, behavioral inhibition/approach system scores, or baseline self-report states of interest (anxiety and self-conscious emotion; all *p*s > .10). Men demonstrated higher cortisol levels than women, $F(1, 300) = 13.55$, $p < .0005$, and hormonal contraceptive use was significantly associated with cortisol levels, $F(1, 230) = 5.92$, $p = .016$, but did not differ between conditions, $t(46) = .47$, $p = .64$. Therefore, gender was included in all cortisol analyses and additional analyses were conducted for women to control for hormonal contraceptive use when examining condition effects. Baseline cortisol was equivalent between conditions for men, $t(12) = .70$, $p = .50$, and for women, $t(46) = 1.24$, $p = .22$. A manipulation check revealed that the stress reappraisal vs. lay beliefs primes effectively modified beliefs about stress in the expected directions from baseline, $F(1, 120) = 170.33$, $p < .0001$.

Hypothesis 1. Effect of Pre-Task Prime on Cortisol

The speech task successfully elicited a cortisol increase over time across conditions, $F(4, 300) = 64.60$, $p < .0001$. Regarding Hypothesis #1, testing whether the pre-task stress reappraisal prime results in reduced cortisol compared to the lay beliefs prime, a 2 (sex) x 2 (pre-task condition) x 2 (post-task condition) x 5 (time) GLMM revealed a significant time x pre-task condition interaction effect with lower cortisol responses in the stress reappraisal condition compared to lay beliefs, $F(4, 270) = 3.25$, *p*

= .013, controlling for post-task condition (see Figure 1). The main of effect of pre-task condition on cortisol was not significant, $F(1, 270) = 1.37$, $p = .242$. Gender did not moderate the effect of pre-task condition on cortisol over time, $F(4, 270) = .98$, $p = .417$. Controlling for hormonal contraceptive use, women who received the stress reappraisal prime exhibited lower cortisol responses as a main effect, $F(1, 200) = 4.68$, $p = .032$, but the interaction of pre-task condition with time was not significant, $F(4, 200) = .80$, $p = .529$. AUC-I for all five time points did not differ based on pre-task condition when controlling for gender, $B = -.07$, $t(61) = -.58$, $p = .561$, or for hormonal contraceptive use, $B = -.13$, $t(47) = -.89$, $p = .379$. Peak cortisol did not differ between pre-task conditions controlling for gender, $B = -.17$, $t(61) = -1.47$, $p = .148$, or for hormonal contraceptive use, $B = -.20$, $t(47) = -1.47$, $p = .148$.

Hypothesis 2. Effect of Post-task Condition on Cortisol

Regarding Hypothesis #2, testing whether post-task mindful recovery results in lower cortisol than rest alone, a 2 (sex) x 2 (pre-task condition) x 2 (post-task condition) x 3 (time) GLMM revealed that gender moderated the main effect of post-task condition on cortisol recovery, $F(1, 162) = 4.46$, $p = .036$, not did not moderate the effect of post-task condition on cortisol over time, $F(2, 162) = 2.22$, $p = .112$. Controlling for hormonal contraceptive use, women who completed mindful breathing post-task demonstrated lower cortisol during recovery, $F(1, 120) = 12.20$, $p < .001$, and quicker recovery over time, $F(2, 120) = 3.21$, $p = .044$ (see Figure 2). An interaction of pre- and post-task condition among women revealed that cortisol was further decreased by receiving both stress reappraisal and mindful recovery, $F(1, 120) = 4.52$, $p = .036$. Men did not demonstrate a significant post-task condition difference in cortisol, $F(1, 30) = 1.06$, $p =$

.312. There was not a significant main effect of post-task condition on cortisol, $F(1, 162) = .08$, $p = .775$, and there was not a significant interaction of post-task condition with cortisol over time, $F(2, 162) = .64$, $p = .529$. AUC-I for post-task recovery phase (time points 3-5) did not differ based on post-task condition when controlling for gender and pre-task condition, $B = .22$, $t(61) = .57$, $p = .57$, or for hormonal contraceptive use, $B = .02$, $t(47) = .04$, $p = .97$.

Hypothesis 3. Relationships of BIS and ASI with Cortisol and Somatic Anxiety

Contrary to Hypothesis #3, testing the prediction that BIS and ASI would be positively associated with cortisol and somatic anxiety distress but moderated by pre-task condition, BIS was associated with lower AUC-I, $B = -.24$, $t(61) = -2.05$, $p = .044$, and somatic distress, $B = .11$, $t(61) = .90$, $p = .373$. Interestingly, ASI was associated with greater somatic distress, $B = .34$, $t(61) = 3.04$, $p = .004$, but lower cortisol, $B = -.26$, $t(61) = -2.21$, $p = .031$. Condition did not moderate the effects of BIS or ASI on cortisol or somatic distress (all ps $> .43$). GLMMs revealed interaction effects of both BIS, $F(8, 205) = 6.93$, $p < .001$, and ASI, $F(8, 205) = 5.95$, $p < .001$, with time such that they were negatively associated with cortisol, controlling for gender and conditions. Pre-task condition did not moderate the effect of BIS, $F(8, 205) = 1.16$, $p = .324$, or ASI, $F(8, 205) = 1.37$, $p = .211$, on cortisol.

Hypothesis 4. Effect of Pre-Task Prime on Self-Report Variables

Consistent with previous TSST research, the speech task elicited increases from baseline for self-conscious emotion, $F(1, 120) = 157.53$, $p < .0001$, and anxiety, $F(1, 120) = 115.89$, $p < .0001$. A significant time x condition interaction effect emerged for self-conscious emotion, $F(1, 120) = 5.88$, $p = .017$, but not anxiety, $F(1, 120) = 5.88$, p

= .199. Supporting Hypothesis #4 that stress reappraisal prime would be associated with better math performance and negative psychological states during the task, participants in the stress reappraisal condition performed better on the math task, $F(1, 60) = 2.24$, $p = .029$, and reported lower immediate post-task anxiety, $F(1, 60) = 4.31$, $p = .042$, self-conscious emotion, $F(1, 60) = 10.26$, $p = .002$, somatic anxiety intensity, $F(1, 60) = 12.07$, $p < .0001$, somatic anxiety distress, $F(1, 60) = 11.99$, $p < .0001$, experiential avoidance, $F(1, 60) = 5.83$, $p = .019$, and negative rumination, $F(1, 60) = 5.57$, $p = .022$, than those in the lay beliefs condition.

Hypothesis 5. Effect of Post-Task Condition on Self-Report Variables

For Hypothesis #5, testing the prediction that post-task mindfulness intervention would be associated with greater state mindfulness and lower negative psychological states at 25 minutes post-task, both stress reappraisal and mindful recovery predicted higher post-task state mindfulness at 25 minutes compared to lay beliefs, $B = 1.07$, $t(61) = 2.82$, $p = .007$, and rest, $B = .827$, $t(61) = 2.21$, $p = .031$, respectively, with a negative interaction revealing that mindful recovery was less strongly associated with state mindfulness if participants had received the stress reappraisal prime, $B = -1.13$, $t(61) = -2.22$, $p = .030$. However, controlling for pre-task condition, post-task condition did not significantly predict self-conscious emotion, $B = -.09$, $t(61) = -.75$, $p = .456$, or experiential avoidance, $B = -.08$, $t(61) = -.64$, $p = .524$, at 25 minutes post-task. There was a trend toward significance for lower state anxiety at 25 minutes post-task for the mindful recovery condition, $B = -.22$, $t(61) = -1.80$, $p = .077$. Negative rumination did not differ between post-task conditions at 25 minutes, $t(61) = -.66$, $p = .51$, or 40 minutes, $t(61) = .76$, $p = .449$, controlling for pre-task condition. See Table 1 for means and

standard deviations for each self-report dependent measure at each time point for each condition. Pre-task condition did not moderate the effect of post-task condition on these variables (all *p*s > .42). Noteworthy, stress reappraisal was still associated with lower self-conscious emotion, $B = -.36$, $t(61) = -2.97$, $p = .004$, experiential avoidance, $B = -.26$, $t(61) = -2.07$, $p = .043$, and negative rumination, $B = -.30$, $t(61) = 2.38$, $p = .021$, at 25 minutes post-task, controlling for post-task condition.

Chapter 4: Discussion

The main purpose of the present study was twofold: 1) examine whether a pre-task brief stress reappraisal intervention buffers psychobiological responses to SET, compared to a lay beliefs prime, and 2) test the capacity of a *post-task* mindfulness intervention to enhance psychobiological recovery to baseline, compared to resting. Primary psychobiological variables included were cortisol, self-conscious emotion, state anxiety, experiential avoidance, negative rumination, state mindfulness, and somatic anxiety distress/intensity. Further, the study was designed to test whether stress reappraisal is capable of modulating the associations of BIS and ASI with cortisol and somatic anxiety distress.

Cognitive Appraisal of Stress Reactivity

Lazarus and Folkman's (1984) transactional model of stress asserts that a stress response results from cognitive appraisal of demands exceeding one's coping resources. Extensive research has shown that SET is capable of eliciting psychobiological stress reactivity, including cortisol, inflammation, self-conscious emotion, anxiety, and rumination (Dickerson et al., 2004; Dickerson et al., 2009; Zoccola & Dickerson, 2012). Within the BPS Model of Challenge and Threat (Blascovich et al., 1999), the somatic arousal itself associated with stress reactivity can be perceived as threatening (Jamieson et al., 2012). This combination of external and internal stressors creates greater demand and may overload an individual's coping resources. Theoretically, the perception of somatic arousal as threatening should heighten responses to stressful situations. In contrast, a brief stress reappraisal intervention reduced threat-based reactivity and enhanced cardiac efficiency during the TSST (Jamieson et al., 2012). With current public

health campaigns emphasizing the real negative health consequences of stress and reifying stress as pathogenic (e.g., APA, 2015a), it is important to assess the actual impact of this message on health responses to stress. Therefore, the present study was developed on the premise that stress reactivity, including somatic arousal, is adaptive for coping with immediate environmental demands, followed by an adaptive return to baseline once the stressor has ended. In contrast, stress reactivity only becomes maladaptive when perceived as threatening and therefore persists after the stressor ends. To examine whether a pre-task brief stress reappraisal intervention buffers psychobiological responses to SET, stress reappraisal and lay beliefs primes were implemented before the TSST using a set of short readings and questions about how stress is either adaptive/helpful or maladaptive/harmful, respectively. The stress reappraisal vs. lay beliefs primes effectively modified beliefs about stress in the expected directions. Consistent with hypotheses, participants in the stress reappraisal condition demonstrated lower cortisol responses, performed better on the math task of the TSST, and reported less self-conscious emotion, state anxiety, experiential avoidance, somatic anxiety distress, somatic anxiety intensity during the TSST, compared to those in the lay beliefs condition. Post-hoc analysis revealed that stress reappraisal was also associated with greater state mindfulness and lower negative rumination at 25 minutes post-task. In effect, stress reappraisal may function via cognitive restructuring and accurate perception of stress reactivity as well as mindful acceptance of one's internal experience.

These findings suggest that the current public health messages about the negative effects of stress, though well-intended, are likely having the paradoxical effect of heightening biological stress responses due to distress about one's stress. Individuals

receiving information about the harmful nature of stress are more likely to have chronically elevated stress responses, as observed in lay beliefs participants in this study. This could help to explain the pattern of higher premature mortality among those who believe stress negatively affects health (Keller et al., 2012). It is worth reiterating that the pre-task primes were a mere 10 minutes in length and yet hold the potential for persistent and pervasive influence on physical health. In the long-term, the lay beliefs approach to stress reactivity may promote HPA axis dysregulation and "runaway" inflammation processes, which are associated with depression and myriad medical conditions, like cardiovascular disease (Anacker et al., 2011; Dickerson et al., 2009; Maes et al., 2011; Slavich & Irwin, 2014). Instilling a stress reappraisal cognitive framework may help to prevent these stress-related mental disorders and medical conditions.

The differences observed in psychosocial variables between conditions are just as important in terms of their implications for mental disorders. Although not directly related to physical health, anxiety, experiential avoidance, somatic anxiety distress, self-conscious emotion, and negative rumination play an important role in mental health and behavioral functioning. For example, experiential avoidance, anxiety, and somatic anxiety distress are characteristic of panic disorder and were heightened by a lay beliefs prime, relative to stress reappraisal. Therefore, receiving this message may increase the likelihood of developing panic disorder and increase avoidance of situations that may trigger anxiety. Similarly, self-conscious emotion, experiential avoidance, and anxiety are involved in social anxiety disorder and both negative rumination and experiential avoidance are associated with major depressive disorder. Broadcasting a negative

message about stress could be contributing to the pernicious development of mental disorders in America.

Unfortunately, the current lay beliefs about stress engender greater experiential avoidance of bodily sensations and do not allow for any level of stress to be perceived as healthy or acceptable since stress is equated with mental disorders and disease. Although not tested in this study, it is plausible that the greater anxiety, self-conscious emotion, experiential avoidance, somatic anxiety distress, and negative rumination associated with current lay beliefs would also trigger more health risk behaviors. For example, smoking, alcohol use, and overeating can be triggered by stress and used as a means of emotion regulation (Azagba & Sharaf, 2011; Krueger, & Chang, 2008; Pool, et al., 2015). It follows that greater stress and desire to control it would motivate greater use of these health risk behaviors. In turn, lay beliefs compound the negative effects of stress by not only exaggerating biological reactivity but also, potentially, increasing the likelihood of resorting to health risk behaviors. Ironically, this creates a self-fulfilling prophecy in which the message that stress is harmful to health and performance makes this outcome more probable. The current APA message about stress may frighten some people into seeking a therapist, but at what cost to the rest of the population? Fortunately, even longstanding negative beliefs about stress can be undone and corrected within a brief and cost-effective 10 minute intervention.

Post-task Mindfulness Intervention and Recovery

Further, given the inverse relationship between trait mindfulness and emotional and biological (e.g., cortisol) reactivity to stressors such as SET (Brown et al., 2012), mindfulness interventions intended to buffer stress responses have been employed

(Britton et al., 2012; Creswell et al., 2014). However, brief mindfulness training before the TSST resulted in less psychological distress but greater cortisol reactivity (Creswell et al., 2014). The post-TSST mindfulness intervention in this study involved consecutive 20- and 10-minute mindful breathing recordings.

The findings in this study provide preliminary evidence that mindful breathing after a stressor aids cortisol recovery to baseline. Also consistent with hypotheses, women in the mindfulness condition demonstrated lower cortisol levels than those in the rest condition, controlling for pre-task condition. Consistent with hypotheses, mindful recovery was associated with greater state mindfulness at 25 minutes post-task. Interestingly, this effect was also observed for stress reappraisal. However, mindful recovery was not associated with reduced state anxiety, self-conscious emotion, experiential avoidance, or rumination, compared to rest. There was evidence for an additive effect of stress reappraisal and mindful recovery among women in which the combination was associated with even lower cortisol reactivity than either alone. However, these effects were not observed among men. This gender discrepancy between may be partially explained by differences in sample size with a relatively small number of men. Importantly, mindful recovery was associated with reduced cortisol among women regardless of pre-task condition. This suggests that mindful breathing promotes return to baseline even after receiving the lay beliefs prime that stress is harmful and is not simply potentiated by the stress reappraisal prime. Past research utilizing brief mindfulness intervention *before* the TSST to reap similar benefits of trait mindfulness and full mindfulness courses, such as the 8-week MBSR program (e.g., Brown et al., 2012), yielded inconsistent results with higher cortisol but lower psychological distress.

By positioning a brief mindfulness practice *after* the TSST, this study illustrated the capacity of a brief mindfulness intervention to enhance cortisol recovery even without any previous mindfulness training.

McEwen (1998) asserted four patterns of stress reactivity that can compromise the integrity of the allostatic systems, such as the HPA axis. One of these patterns was prolonged recovery due to a failure to shut off allostatic activity after stress resulting from impaired negative feedback. Mindful breathing may provide an advantage over simply resting in terms of terminating allostatic activity once the stressor has ended. In this manner, biological coping efforts are shut off once they are no longer adaptive or necessary. Contrarily, those who experience prolonged cortisol elevations from failure to recover, as seen in the rest condition, are more susceptible to glucocorticoid receptor resistance and the consequent unregulated inflammation that contributes to depression and cardiovascular disease (Anacker et al., 2011; Maes et al., 2011; Slavich & Irwin, 2014).

Regarding psychosocial variables, there were no statistically significant differences between post-task conditions except for state mindfulness. Interestingly, state mindfulness at 25 minutes post-task was higher for both stress reappraisal and mindful recovery conditions but further amplified by receiving both interventions. While the association between post-task mindful breathing and state mindfulness was consistent with hypotheses and reveals the potential for brief mindfulness intervention to support adaptive stress responses, detecting the same association with the stress reappraisal condition was unexpected. Similarly, the stress reappraisal condition was associated with lower negative rumination 25 minutes post-task relative to the lay beliefs condition, but

this effect was not found for the mindful recovery condition relative to resting. One plausible explanation for the lack of statistical significance for negative rumination between post-task conditions is that mindfulness practice often increases awareness of internal experiences, such as thoughts, especially without prior experience. However, mindfulness practice holds the potential to change one's *relationship* with these negative thoughts so that they are not as distressing. Overall, the post-task condition results for self-report variables likely expose the transient nature of emotions after a stressor rather than a deficiency of mindful recovery from stress. In turn, it is crucial to employ a buffering strategy, such as stress reappraisal, before coping with a stressor.

Relationships of BIS and ASI with Cortisol and Somatic Anxiety

Contrary to hypotheses, BIS was associated with lower AUC-I and somatic anxiety distress whereas ASI was associated with lower AUC-I but greater somatic distress. Pre-task condition did not moderate the effects of BIS or ASI on cortisol or somatic distress. The negative correlations between BIS/ASI and cortisol in this study are puzzling at first glance but may be explained by their relation to depression. BIS plays a role in both anxiety and depression (Kasch, Rottenberg, Arnow, & Gotlib, 2002; Lahat et al., 2011) and depression has been linked to HPA axis dysregulation (Stetler & Miller, 2005; Wardenaar et al., 2011). Further, AS is characterized by experiential avoidance of physical sensations of anxiety, which was higher in the lay beliefs condition along with cortisol. One possible explanation is that participants with higher BIS and ASI scores were more likely to enter the study with preexisting HPA axis dysregulation from a history of allostatic load and exhibit blunted responses.

Theoretical Integration and Significance

The BPS Model of Challenge and Threat holds that that the appraisal of one's resources as sufficient to cope with demands leads to a healthy *challenge* response whereas the perception that demands exceed one's resources triggers a pathogenic *threat* response. This applies to situational stressors as well as internal experiences, such as bodily sensations, that may be construed as fear and cue a threat response. Similarly, the theoretical underpinning of social self-preservation theory is that *threat* to the social self elicits a coordinated psychobiological stress response in order to mobilize resources to cope with the stressor. While the social stressor itself may serve as a threat, unwanted thoughts, emotions, and bodily sensations during a stressor may trigger experiential avoidance and serve as an additional threat because they are uncontrollable. Therefore, the public health message that stress is harmful to health may contribute to the perception that somatic arousal is threatening during social stress, which heightens psychobiological stress reactivity.

Taken together, the perception that one is unable to cope with the demands of a social stressor and the negative interpretation of associated bodily sensations constitute two sources of simultaneous threat. Stress reappraisal intervention shifts both threat processes to challenge by instilling the perception of somatic arousal as: 1) enhancing one's resources to cope with demands (external), and 2) adaptive and functional rather than harmful (internal). One mechanism by which this process occurs is cognitive restructuring, as used in cognitive behavior therapy for mental disorders. Acknowledging the benefits of somatic arousal provides a more accurate, balanced, and complete perception of stress reactivity, thereby, reducing anxiety sensitivity and stress about one's

stress. Another potential mechanism by which the stress reappraisal intervention may reduce threat is promoting acceptance of one's internal and external experience. In essence, stress reappraisal in itself may serve as a brief mindfulness intervention by building awareness of bodily sensations and emotions and teaching that stress responses do not need to be resisted or judged negatively.

Theoretically, this represents an important intersection between the stress reappraisal and mindfulness interventions. As described by Kabat-Zinn (2013), coping with stress can consist of either an automatic/habitual stress reaction or a mindfulness-mediated stress response. Whereas the automatic/habitual stress reaction is characterized by prolonged and hyperarousal, attempted inhibition of stress, and allostatic load, the mindfulness-mediated stress response involves reduced arousal, increased awareness and acceptance of internal experience, and quicker recovery of allostasis (e.g., cortisol secretion). The increased state mindfulness and reduced cortisol observed in both stress reappraisal and mindful recovery, with a lower effect of mindful breathing on state mindfulness if participants had received the stress reappraisal prime, suggests a common factor is operating. Stress reappraisal intervention contains mindfulness elements and vice versa with a potential common core of acceptance and awareness over judgment and experiential avoidance. To integrate the BPS Model of Challenge and Threat with social self-preservation theory and the findings of this study's treatments, both stress reappraisal and mindfulness interventions reduce threat reactions and promote a challenge orientation that effectively buffers psychobiological responses to social stress that are implicated in social self-preservation theory.

Treatment Implications

Although chronic stress can lead to negative health consequences and there is an ever-growing literature supporting this accepted relationship, simply bringing this to the public's attention may actually exacerbate stress reactivity and be more detrimental in the long run. A more nuanced and holistic approach to educating Americans about the nature of stress and connection between mental and physical health is needed. Stress reappraisal is one such strategy to accurately convey information about the nature of stress and improve current public health campaigns. Modifying existing public health messages, such as the APA's Stress in America website, accordingly to reflect stress reappraisal is one major outlet for course-correction. Modern psychological treatments have already begun to embrace a stance in which stress is not seen as an enemy. Acceptance and commitment therapy (ACT) created by Steven Hayes, MBSR, and the transdiagnostic Unified Protocol created by David Barlow and colleagues focus on effectively working with, and responding to, unpleasant emotions and bodily sensations, such as anxiety and its somatic symptoms. While stress appraisal is well-equipped to handle stress reactivity occurring within the context of a stressor, there remains the need for a technique to address excessive and unwarranted stress reactivity in the absence of a real threat. In particular, stress reappraisal maps well onto one of the Unified Protocol's techniques involving self-reflection on whether the level of anxiety in the moment is necessary given the situational demands. Integrating these modern perspectives of stress into public health messages may help to unlock the utility of stress reactivity while simultaneously inoculating Americans to the possible negative effects.

Additionally, mindfulness is growing in popularity in the United States since the Western secularization of the Buddhist tradition and with accumulating research about the health benefits. However, barriers to dissemination that have plagued mindfulness interventions, such as MBSR, are access, cost, and time demand (Abercrombie, Zamora & Korn, 2007; Roth & Robbins, 2004). This has prompted the implementation of brief adaptations of mindfulness interventions with mixed results (Arch & Craske, 2006; Creswell et al., 2014). Mindful breathing after a stressor appears to offer a biological benefit beyond simply resting and is an easily accessible technique that does not require intensive practice. Further, mindful breathing can be readily integrated into psychological treatment sessions and free audio recordings are widely available online. Aside from psychobiological recovery, post-stressor mindful breathing may also provide an alternative behavioral coping strategy in lieu of health risk behaviors such as smoking, alcohol use, and overeating.

Primary care is an especially appropriate setting for these two brief interventions to be implemented for public health promotion and disease prevention. An estimated 90% of primary care visits have a psychosocial basis (Strosahl, 2002) and approximately 20% of primary care patients have an anxiety disorder (Kroenke, Spitzer, Williams, Monahan, & Löwe, 2007). Given the time constraints of primary care visits, whether with a physician or behavioral health clinician, treatment techniques must be brief in nature and easily understood. Educating patients about stress reappraisal before and during a stressor as well as mindful breathing afterward can be accomplished using multiple methods. First, these techniques do not require specialized psychology training and can be quickly explained by either the primary care physician or nurse. Second, in an integrated care

setting with co-located behavioral health, a "warm hand-off" to a trained clinician can be used to provide these techniques and practice. Third, stress management handouts or brochures with stress reappraisal-oriented information and mindful breathing instructions can be provided to patients with stress or anxiety complaints. Combined, stress reappraisal and mindful breathing could be easily disseminated and provide cost-effective primary psychosocial prevention that fosters adaptive perceptions of (and responses to) stress. It should be noted that stress reappraisal and mindful breathing are brief interventions intended as primary psychosocial prevention for the general public and, potentially, mild cases of anxiety. These interventions are not a substitute for empirically supported treatment for mental disorders (though may provide supplementary value), nor are they an immunization to stress-related chronic disease. For those experiencing severe, chronic stress, a more intensive intervention, such as MBSR may be indicated. Nonetheless, stress reappraisal and mindful recovery provide a brief and simple course-correction from current public health messages that may be iatrogenic by pathologizing stress.

Limitations

There are a number of limitations in this study that should be considered when interpreting the results and determining their generalizability. First, phase of menstruation was not assessed in the current study and some research has revealed blunted cortisol reactivity to stress during the follicular phase (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999). However, numerous studies have failed to detect any effect of menstrual phase on cortisol responses to stress (Dickerson et al., 2008; Zoccola et al., 2008; Bouma, Harriëtte, Ormel, Verhulst, & Oldehinkel, 2009). Second, it is plausible

that behavioral inhibition and anxiety sensitivity may have previously been associated with robust cortisol changes to social stress that eventually led to HPA axis dysregulation and blunted cortisol responses in this study. For example, the lay beliefs condition induced greater somatic anxiety distress (i.e., anxiety sensitivity) and produced greater cortisol. Over time, this may lead to allostatic load and negative health consequences. Third, a much larger number of participants than expected were identified as outliers and removed. The remaining sample size of 62 participants across four conditions was smaller than similar research (e.g., Britton et al., 2012; Creswell et al., 2014); thus, lower statistical power may have prevented the ability to detect some smaller effects and could explain unexpected null findings. Fourth, the statistical methods used to analyze cortisol results in this study do not allow for examination of effect sizes to determine the clinical significance of *p*-values. Fifth, the TSST used in this study is designed to be a very difficult task and is not representative of daily stressors. The effectiveness of pre- and post-task interventions tested may vary with daily life stressors. Sixth, participants were randomized to either stress reappraisal or lay beliefs primes without a control condition. This design was chosen to ensure independent groups and due to prevalent public health messages about the negative effects of stress. However, there is no way of confirming whether the lay beliefs condition represents how a control condition would have responded. Seventh, the first assessment of negative rumination occurred 25 minutes after the TSST, which may have been long enough for negative rumination to subside naturally and preclude detection of a post-task condition effect that could have existed earlier. Finally, while resting silently without cell phone or computer use is the standard post-task control condition for TSST research, comparing it to an active recovery intervention (i.e.,

mindful breathing) in this study leaves the possibility that the mindfulness audio recording simply served as a form of distraction, soothing speech, or prompt to close one's eyes. The generalizability of the control rest condition is limited given that individuals in the real world may have likely used their phone for distraction. Nonetheless, the higher self-reported state mindfulness in the mindful recovery condition at 25 minute post-task suggests that the audio recording did indeed instill a state of mindfulness rather than serve a more passive role.

Future Directions

The findings of this experiment show promise for the utility of brief interventions, such as stress reappraisal and mindful breathing in promoting public health and psychosocial prevention of mental disorders and chronic disease. However, further research is needed to determine the real-world application of these techniques. As addressed in the limitations, the TSST is a very difficult task and not representative of daily stressors. A daily diary study format would provide a more valid test of the effectiveness of these brief intervention techniques in response to one's routine stressors. Difficulty and familiarity with the task may moderate some of the effects observed in this study such that stress reappraisal is more or less effective in buffering psychobiological responses. In addition, participants in this study randomized to the mindful recovery condition practiced mindful breathing for a total of approximately 30 minutes, which is not typically a viable coping response. Future research examining post-stressor mindful breathing may help to determine the minimal amount of mindful breathing to "shut off" allostatic activity and enhance recovery to baseline. This study did not investigate post-task desired behavioral responses or preferences for coping with stress. Future research

examining whether mindful breathing can effectively serve as an alternative to health risk behaviors, such as smoking, alcohol use, and overeating, may illuminate the potential harm reduction utility of mindfulness and capacity to support healthy behavior change. Finally, longitudinal studies, such as (Keller et al., 2012) testing the long-term effects of stress reappraisal compared to negative beliefs about stress may provide compelling evidence for cost-effectiveness and the power of stress message framing to influence disease and mortality in the United States.

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Appendix A: Tables

Table 1. Baseline and post-task means (and *SD*s) of self-report variables by condition

	Stress Reappraisal (*n* = 28)		Lay Beliefs (*n* = 34)	
	Baseline *M* (*SD*)	Post-task *M* (*SD*)	Baseline *M* (*SD*)	Post-task *M* (*SD*)
Negative Stress Beliefs	380.32 (70.91)	177.43 (95.27)	379.07 (63.36)	454.24 (58.60)
Self-Conscious Emotion	9.90 (2.34)	26.61 (9.58)	9.43 (2.68)	35.59 (12.02)
Anxiety	11.35 (4.43)	17.64 (4.56)	12.04 (5.59)	19.85 (3.82)
Experiential Avoidance	N/A	15.71 (5.04)	N/A	18.97 (5.47)
Somatic- Bothered	N/A	188.68 (127.41)	N/A	371.12 (253.10)
Somatic- Intensity	N/A	178.00 (117.43)	N/A	358.50 (253.09)

Appendix B: Figures

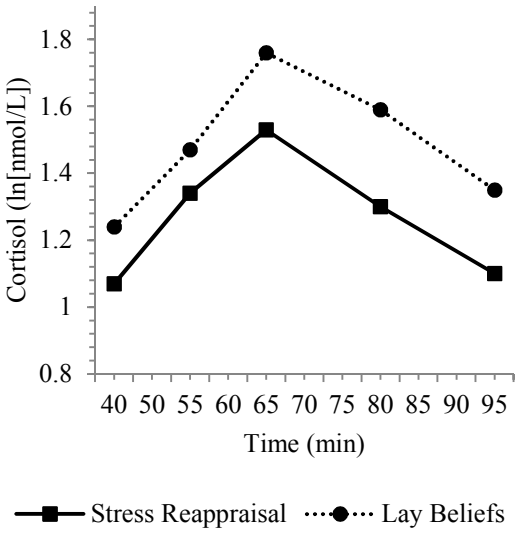

Figure 1. Means of predicted cortisol responses over the laboratory session between stress reappraisal and lay beliefs conditions, controlling for post-task condition. Minutes 0–40 represent the resting baseline period; minutes 41–55 represent the TSST; and minutes 56–95 represent recovery. Transformed cortisol values from analyses were used.

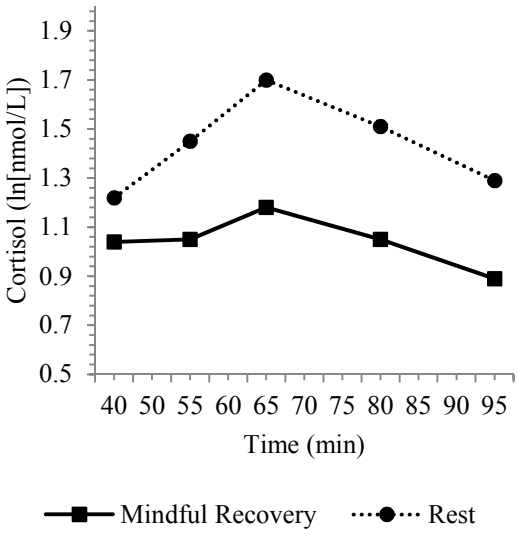

Figure 2. Means of predicted cortisol responses over the laboratory session between mindful recovery and rest conditions among women, controlling for pre-task condition and hormonal contraceptive use. Minutes 0–40 represent the resting baseline period; minutes 41–55 represent the TSST; and minutes 56–95 represent recovery. Transformed cortisol values from analyses were used.