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Dispositional Mindfulness and Cardiovascular Functioning Under Stress: Predictions of Social Evaluative Stress Reactivity and Recovery

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DISPOSITIONAL MINDFULNESS AND CARDIOVASCULAR FUNCTIONING UNDER STRESS: PREDICTIONS OF SOCIAL EVALUATIVE STRESS REACTIVITY AND RECOVERY

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Abstract

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Mindfulness – a receptive attentiveness to present experience – has been shown to promote more adaptive emotion regulation (Brown et al. 2008). Additionally, dispositional mindfulness has been shown to predict reduced cortisol response to social stressors (Brown et al, in press) and mindfulness training has been shown to promote more adaptive cardiac functioning at rest (Ditto et al., 2006; Tang et al., 2009; Telles et al., 2005; Zeidan et al., 2010) and in response to social stressors (Kemeny et al., 2012). To better understand the regulatory potential of a mindful disposition on cardiovascular functioning in healthy adult participants (*N* = 63), the study examined the role of dispositional mindfulness in predicting cardiovascular responses to a laboratory social evaluative threat called the Trier Social Stress Task (TSST; Kirschbaum, et al., 1993). Repeated measures multilevel linear modeling tested main effects of a mindful

disposition on a variety of cardiovascular outcomes as well as interactive effects between mindfulness and time on these outcomes. Results showed that mindfulness predicted increased heart rate variability (HRV) across the time span, from baseline to recovery. There were also interactions between mindfulness and time on several dependent variables. Specifically, higher mindfulness predicted decreased heart rate reactivity during the TSST, faster recovery in total HRV, as well as reduced rebound effects during the initial recovery phase for high frequency HRV, low frequency HRV, and the LF/HF ratio. These results, however, were not significant above and beyond the significant relations between rumination, depressive symptoms, and trait anxiety and cardiovascular function. The results lend support to the stress-related regulatory potential of mindfulness, and suggest that this quality of attention may enhance cardiovascular functioning under stress. Further research is needed to examine how mindfulness may buffer the role of such vulnerability factors as rumination, depressive symptoms, and anxiety in predicting stress-related cardiovascular responses to social stress.

Dispositional Mindfulness and Cardiovascular Functioning Under Stress: Predictions of Social Evaluative Stress Reactivity and Recovery

The American Heart Association states that as of 2006, 17.6 million Americans suffer from coronary artery disease, with 8.5 million of those people experiencing an acute heart attack, also known as myocardial infarction (Lloyd-Jones et al., 2010). Additionally, Lloyd-Jones et al. (2010) report that approximately one out of every six deaths in 2006 were due to cardiovascular disease, making it the number one killer of Americans and costing the US economy $177.1 billion in 2010. Elevated heart rate (HR) has been shown to be a risk factor for developing cardiovascular disease (Light, Dolan, Davis, & Sherwood, 1992) possibly due to chronic HR elevations. These can cause small arterial tears that accumulate plaque, leading to atherosclerosis (Krantz & McCeney, 2002). Similarly, elevated HR is related to decreased lifespan (Zhang & Zhang, 2009) and increased chances of early mortality from cardiovascular diseases (Gillman, Kannel, Belanger, & D'Agostino, 1993; Palatini, 1999).

Another predictor of cardiovascular disease is decreased heart rate variability (HRV; Kristal-Bonah, Raifel, Froom, & Ribak, 1995). HRV refers to fluctuations in the intervals between the R waves of heart beats (see Figure 1). HRV is regulated by activation of the vagus (parasympathetic) and sympathetic nerves, the opposing but complementary connections between the heart and the brain (Task Force of the European Society of Cardiology, 1996). Utilizing frequency domain techniques, higher frequency HRV ranges (HF-HRV; 0.15-0.4 Hz) are largely accepted as a representation of parasympathetic activity as these frequency ranges are related both to stimulation of the vagus nerve and to respiratory sinus arrhythmia (RSA), which is the fluctuation in heart rate due to respiration. That is, heart rate increases during inhalation and decreases during exhalation (Berntson et al., 1997).

Figure 1. Heart Rate Variability

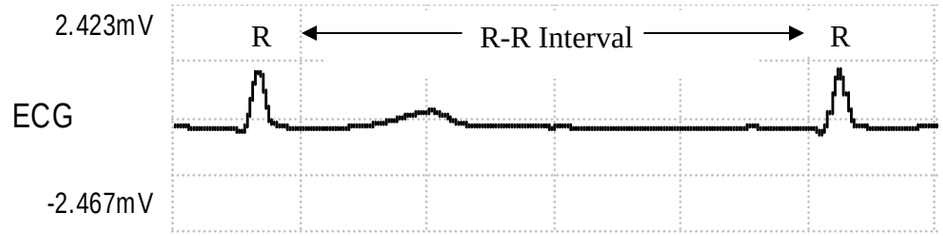

Figure 1. Pictoral representation of an ECG reading containing two heartbeats. The R-R interval is defined as the temporal distance between R spikes. HRV is the fluctuation in R-R intervals over time.

There is far more controversy in the meaning of low frequency HRV (LF-HRV; < 0.15). LF-HRV has traditionally been thought to represent pure cardiac sympathetic nerve activation (Kamath & Fallen, 1993; Malliani, Pagani, Lombardi, & Cerutti, 1991). Yet many researchers have found that LF-HRV can be modulated by both the vagus nerve and cardiac sympathetic outflow and so can represent either sympathetic or parasympathetic activity depending on the situational context (Cooke et al., 1999; Koh, Brown, Beightol, Ha, & Eckberg, 1994; Mezzacappa, Kindlon, & Earls, 1994; Pagani et al., 1986; Berntson et al., 1997). Many researchers also use the ratio between LF and HF HRV to determine whether cardiac sympathetic activation remains high when taking parasympathetic activation into account, especially during challenging tasks in which one would expect greater sympathetic activation (Nater et al., 2006).

Total HRV is dependant on the homeostatic balance between parasympathetic and sympathetic activity and thus has been studied in fields of psychology interested in this balance, such as personality, social, and clinical psychology (Appelhans & Luecken, 2006). In addition to being associated with maladaptive health outcomes such as mortality following myocardial infarction (Bigger et al., 1992; Kleiger, Miller, Bigger Jr., & Moss, 1987; Task Force of the European Society of Cardiology, 1996), decreased total HRV has been predicted by maladaptive psychological tendencies such as high trait anxiety (Fuller, 1992), high perceived stress (Dishman et al., 2000), and depressive symptoms (Carney et al., 2001; Hughes & Stoney 2000).

Several psychophysiological theories have been proposed to explain how HRV is related to psychological functioning. In general, HRV appears to be valuable for flexibly responding to one's environment (Appelhans & Luecken, 2006). For example, Porges' (1997) polyvagal theory suggests that rapid modulation of the vagal nerve is unique to primates and thus is sensitive to personality and social factors, permitting adaptive regulation of emotional responses to social stimuli. Another model addressing the emotion regulatory role of autonomic function is Thayer and Lane's (2000) neurovisceral integration theory. Instead of looking only at the interplay between the hindbrain and the heart, these authors note that forebrain regions such as the cerebral cortex and limbic system, both associated with emotional processing and regulation, are directly connected to hindbrain regions responsible for vagal nerve innervation, and thus mediate HRV. Tests of the neurovisceral integration theory have demonstrated associations between prefrontal activation and mediated HRV response that are likely the result of regulation of attention and affect (Thayer, 2007). While it is important to consider many common biological and demographic predictors of resting HRV, including age, obesity, smoking, and hypertension (Lloyd-Jones et al., 2010), these theories suggest that psychological predictors of emotion regulation during exposure to social stimuli may be just as important. As emotion regulation is an important factor in stress responses (Gross, 2002; Troy & Mauss, 2011) and because perceived stress is predictive of cardiovascular outcomes (Dishman et al., 2000; Fuller, 1992), it is important to understand both the psychophysiological responses to social stress as well as the risk and resilience factors that may contribute to the regulation of these responses.

Stress

Stress, broadly defined as a psychological and/or physiological reaction to real or potential threats in one's environment, was first described in the scientific literature in the early 20th century by Walter Cannon and Hans Selye. Walter Cannon (1932) coined the term "fight or flight" to indicate that the major purpose of the experience of stress is to innervate the sympathetic nervous system (SNS) to gather the requisite energy

to either fight or flee from a threat in the environment. Building on this notion was Hans Selye's (1936) general adaptation syndrome model, which illustrated that prolonged exposure to stress resulted in exhaustion, or chronic activation of the autonomic nervous system (ANS). This then led to maladaptive psychological and physiological outcomes. Theorists and researchers in the later half of the 20th century (e.g., Fenz & Epstein, 1967; Lazarus & Folkman, 1984), began to address the fact, now well known, that stress did not result merely from real, observable stimuli in the environment, but that perception and cognition played an important role in the experience of stress. Cognitive appraisals, or interpretations of potentially stressful stimuli (as good, bad, or neutral), are key to determining whether stress and the consequences of it will accrue and thus demonstrate that the human capacity to ruminate, worry, and plan for future events can heighten and prolong stress in the face of – or even the absence of – environmental threats (Folkman & Moskowitz, 2004).

Furthering the idea that higher-order processes such as cognition are related to the experience of stress, other researchers have noted that social encounters can be a stressful experience for many people (Kirschbaum, Pirke, & Hellhammer, 1993). Social stress is the stress that people may experience due to negative social encounters, and is usually a function of either ego threat or social rejection (Baumeister & Tice, 1990; Craighead, Kimball, & Rehak, 1979). For example, many people experience social stress when they are embarrassed and feel that other people are judging them negatively. Social psychological theories have attempted to explain why ego threat or rejection may lead to stress. For example, social self-preservation theory suggests that people want to defend their egos to maintain their social value and standing (Gruenewald, Kemeny, Aziz, & Fahey, 2004). Sociometer theory argues that an individual's sense of self-worth is dependent on validation from others (Leary, Tambor, Terdel, & Downs, 1995; Leary, 2004); when the social self is threatened, psychological distress (e.g., depression) and aggression can result (Leary, Twenge, Quinlivan, 2006), as can physiological outcomes of stress such as physical pain

(MacDonald & Leary, 1995) and increased stress hormone levels, such as cortisol and alpha-amylase (Dickerson & Kemeny, 2004; Granger Kivlighan, El-Sheikh, Gordis, & Stroud, 2007; Gruenewald et al., 2004; Rohleder et al., 2004). Even brief laboratory inductions of social stress such as the Trier Social Stress Task (TSST; Kirschbaum et al.,1993), a five minute speech and a five minute oral arithmetic task performed in front of a panel of evaluators, have been shown to reliably elicit psychological and psychophysiological social stress responses in a number of studies (Dickerson & Kemeny, 2004). Although there is widespread agreement that social stressors can elicit physiological reactivity in the form of hormonal and immune responses (Dickerson & Kemeny, 2004), there has been much less work investigating autonomic reactivity to social stressors. As activation of the autonomic nervous system is linked to neural processes (Appelhans & Luecken, 2006), a description of the neural correlates of stress is important to understanding how stress is related to ANS activity.

Neural correlates of stress and cardiovascular function. It has been long understood that there are direct and indirect neural connections between regions of the brain involved in the experience of stress (e.g., the amygdala and the cerebral cortex) and structures related to control of the autonomic system, such as the medulla in the hindbrain and the vagus nerve (for reviews see Berntson & Cacioppo, 2000; Brownley, Hurwitz, & Schneiderman, 2000). Additionally, direct stimulation of cerebral or amygdaloid regions has been shown to directly modulate autonomic function (Inui, Murase, & Nosaka, 1994; Jordan, 1990; Lewis et al., 1989; Neafsey, 1990; Pascoe, Bradley, & Spyer, 1989; Spyer, 1989; Wong, Masse´, Kimmerly, Menon, & Shoemaker, 2007). Activity in other cerebral regions associated with visceral arousal and cognitive control, the insular cortex and the anterior cingulate cortex (ACC) respectively, have also been associated with changes in autonomic function (Critchley, 2005; Matthews, Paulus, Simmons, Nelesen, & Dimsdale, 2004). More recently, amygdala grey matter volume has been linked to both stress-related amygdala activation and greater cardiovascular reactivity (Gianaros et al., 2008). These neural connection findings support polyvagal

theory (Porges, 1997) and neurovisceral integration theory (Thayer & Lane, 2000) and imply that psychological states can influence the autonomic system.

Cardiovascular outcomes of stress. Acute stressors, such as mental arithmetic, cold pressor tasks, speech tasks, and reaction time tasks have been shown to elicit cardiovascular reactivity, such as higher blood pressure and heart rate (Berntson et al., 1994; Steptoe & Sawada, 1989). Studies have also demonstrated that acute, mild stressors, such as shock avoidance (Friedman, Thayer, & Tyrrell, 1996), the Stroop task (Delaney & Brodie 2000; Jain et al., 2001), and mental arithmetic and anger recall (Jain et al., 2001) tend to result in elevated HR, reduced parasympathetic activity indicated by reduced HF-HRV and RSA, and increased sympathetic activity indicated by increases in LF-HRV and the LF/HF ratio. Although some studies report this sympathoexcitation during mental stressors, there tends to be high between-subjects variability in response and it has been suggested that stress-inducing tasks lack sufficient sensitivity and specificity to detect cardiovascular sympathetic reactivity (Freeman, 2006).

Similar issues of sensitivity and reliability of stress tasks have been investigated for the measurement of endocrine function, especially with cortisol. A meta-analysis by Dickerson and Kemeny (2004) demonstrated that not all stress tasks are created equal when investigating physiological outcomes. They found that reliable cortisol reactivity was only predicted by stressors that were uncontrollable and in which a social evaluative threat was present. Utilizing laboratory tasks that induce social stress, such as the TSST, may also be more reliable in predicting cardiovascular outcomes compared to other types of stress-inducing tasks. For example, Nater et al. (2006) demonstrated that participation in the TSST resulted in increased HR, decreased HF-HRV, and increases in both LF-HRV and the LF/HF ratio. Additionally, Smeets (2010) found that increased resting HF-HRV (cardiac vagal tone) was predictive of *increased* cortisol reactivity to the TSST. Although apparently contradictory to Nater et al. (2006), this finding extends previous research (Kunz-Ebrecht, Mohamed-Ali, Feldman, Kirschbaum, & Steptoe, 2003) that demonstrated that although

participants with large cortisol responses to the TSST demonstrated higher resting HRV compared to those with lower cortisol responses, these participants also had a greater inhibition of HRV during the stressor. Research on autonomic recovery also tends to be mixed. Some researchers have noted that recovery happens within several minutes after stressor offset (Mezzacappa, Kelsey, Katkin, & Sloan, 2001) whereas others have shown significant reductions in HR to occur not until 20 minutes post-stressor (Smeets, 2010). Thus, research is needed to elucidate stress-instigated patterns of cardiovascular reactivity and recovery over time.

In summary, neurological correlates of stress such as cortical (e.g., prefrontal cortical) and limbic activation have been directly linked to structures involved in autonomic regulation, such as the medulla, which innervates spinal sympathetic and parasympathetic nerves (Berntson & Cacioppo, 2000). Additionally, research has demonstrated that acute social stressors result in physiological activity in not only endocrine function (Dickerson & Kemeny, 2004), but also in cardiovascular reactivity (Kunz-Ebrecht et al., 2003; Nater et al., 2006; Smeets, 2010). Although more research is clearly needed to elucidate the reactivity and recovery patterns of cardiovascular function during social stressors, there is no question that stressful events can lead to maladaptive psychological and physiological outcomes. These negative outcomes are not a foregone conclusion however. Much research has been dedicated to identifying those personality and environmental factors that help buffer the negative effects of stress.

Resilience factors. Considerable research has demonstrated that resilience factors can buffer the negative effects of stress. One of the most commonly researched resilience factors is social support. Having a supportive social network of family and close friends has long been known to dampen the effects of stressful events (Bonanno, Galea, Bucciarelli, & Vlahov, 2007; King, King, Fairbank, Keane, & Adams, 1998). The importance of social support in dampening the effects of stress is thought to be most prominent in women, according to the tend and befriend model (Taylor et al., 2000). Additionally, those with higher

levels of self-esteem or self-efficacy have demonstrated more adaptive outcomes following stressful events (Cicchetti, Rogosch, Lynch, & Holt, 1993; Werner, 1995). Spirituality and meaning finding have been positively related to resilience although the research is mixed due to problems with definition and measurement (Hood, Hill, & Spilka, 2009; Peres, Moreira-Almeida, Nasello, & Koenig, 2007). Optimism and positive thinking have also consistently demonstrated a significant relationship with reduced stress reactivity, as described by Fredrickson's (2004) broaden and build theory of positive emotions.

Resilience factors have also been investigated in the context of social stressors using the TSST, where a controlled laboratory setting permits an analysis of how resilience factors predict stress reactivity and recovery. Thus far, several individual differences – including social support (Ditzen et al., 2007, 2008; Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003), positive affect (Robles, Brooks, & Pressman, 2009), and the ability to make more adaptive cognitive appraisals (Gaab, Rohleder, Nater, & Ehlert, 2005) have predicted differences in how people respond to social stressors.

As social stress concerns the threat of rejection, criticism, or embarrassment, one possible way to reduce responsiveness to this particularly painful type of stress may be to reduce the influence of egoic concerns on thoughts, emotions, and behavior. Much research has demonstrated that self-relevant appraisal of stimuli in the environment is often automatic and instantaneous (Bargh, Chaiken, Govender, & Pratto, 1992; Fazio, 2001; Fazio, Sanbonmatsu, Powell, & Kardes, 1986) and attention itself tends to be biased towards information that is in the service of the ego (Baumeister et al., 1994; Leary, 2004). This habitual egoic biasing of attention and appraisals in everyday life may have the result of sensitizing people to situations in which the ego is threatened. Dickerson & Kemeny's (2004) meta-analysis revealed that effect sizes for laboratory induced stressors are larger when a social evaluative threat is present compared to more mundane types of stressors such as mental arithmetic or cold-pressor tasks. It appears that threats to the ego are particularly predictive of psychological and physiological stress responses and thus flexibility

in how the ego is expressed may have implications in how one encounters and responds to stressors. Additionally, ego-biased perception prevents a more realistic view of oneself and ones' circumstances, which could hinder more adaptive functioning in stressful situations (Brown & Ryan, 2004). One way to reduce the biasing effects of the ego, potentially leading to less social stress and the psychological and physiological outcomes that accompany it, is mindfulness (Brown, Ryan, Creswell, & Niemiec, 2008).

Mindfulness

Mindfulness is defined as being openly or receptively attentive to one's present experience (Brown & Ryan, 2003). In other words, mindfulness concerns present-centered attention. This implies that mindfulness is related to processing in a more direct, experiential fashion rather than evaluating, introspecting, or reflecting upon experience (Teasdale, 1999). For example, to be mindful of thoughts is to be aware of them as thoughts, without mental elaboration upon them in the form of associated memories, emotional reactions, or expectations. Leary et al. (2006) suggest that reduction in egoic thought is an important element for self-regulation and that mindfulness is one way to achieve that. The mindful inclination towards more present-oriented processing suggests that a more mindful person should be free to observe events and experiences without the burden of past experience or expectancies of the future filtering present experience, with a concomitantly lower level of stress. In support of this notion are studies demonstrating that more mindful people are less constrained by this habitually self-biased way of processing (Brown et al., 2008).

Mindfulness has generally been studied in two different ways: as a trait or via the impact of mindfulness training. Trait, or dispositional mindfulness, has been linked to constructs that imply improved psychological function in the face of stressors, such as reduced depressive symptoms and rumination (Brown & Ryan, 2003; Verplanken, Friborg, Wang, Trafimow, & Woolf, 2007), less verbal (Lakey, Kernis, Heppner, & Lance, 2008) and mortality threat-based (Niemiec et al., 2010) defensiveness, and reduced

emotional reactivity to negative stimuli (Creswell, Way, Eisenberger, & Lieberman, 2007) and relationship conflict (Barnes, Brown, Krusemark, Campbell, & Rogge, 2007). Those higher in trait mindfulness, as assessed by the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) have also been shown to use less maladaptive appraisals (Heppner & Kernis, 2007) and more positive coping styles under stress (Weinstein, Brown, & Ryan, 2009). Additionally, increased mindfulness has been shown to reduce habitual responding during cognitively demanding tasks, such as the Stroop task (Wenk-Sormaz, 2005). Recent evidence has also demonstrated that MAAS-assessed trait mindfulness predicts lower cortisol and negative affective responses to the TSST (Brown, Weinstein, & Creswell, in press).

Training in mindfulness arose from Asian Buddhist psychology, although training in mindfulness does not necessitate any religious ties (Kabat-Zinn, 1994). Similar to how a mindful state of mind is associated with being fully present, the practice of mindfulness enhances this ability by practicing being fully attentive to and aware of present stimuli, including instances of self-centered thought, evaluation, and emotional reactions. Mindfulness practice has been related to lower cortisol responses to stress (Tang et al., 2007) as well as reduced overall distress and ruminative thought and behaviors (Jain et al., 2007). Even brief mindfulness exercises for those who have never practiced before have been related to adaptive responses, including an increased willingness to engage with negative stimuli (Arch & Craske, 2006) and more rapid recovery from induced sad moods (Broderick, 2005).

One manualized intervention developed to train mindfulness is Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982), an 8-week program that incorporates mindfulness practices with the goal of reducing stress. MBSR has been linked to improved health in stressed populations (Grossman, Niemann, Schmidt, & Walach, 2004; Monti et al., 2005), decreased average daily cortisol levels (Carlson, Speca, Faris, & Patel, 2007), increased immune responsiveness to viral infection (Davidson et al., 2003), and reduced self-reported distress (Astin, 1997; Speca, Carlson, Goodey, & Angen, 2000; Tacon, McComb,

Caldera, & Randolph, 2003). Meta-analyses have revealed that MBSR interventions tend to show medium effects sizes, ranging from 0.49 (Grossman et al., 2004) to 0.59 (Baer, 2003).

In summary, mindfulness research has shown that a mindful disposition, mindfulness training, and mindfulness-based interventions may lead to reduced stress. However the processes through which this happens are still little understood. One way that mindfulness may lead to reduced stress may be in its ability to promote regulation of the autonomic system through altered neurological functioning.

Neural correlates of mindfulness. At a neurological level, studies of mindfulness have generally demonstrated that increased mindfulness is related to increased activity in cortical regions associated with attention, interoception, and cognitive control, and decreased activity in regions associated with self-reference and emotional reactivity. For example, dispositional mindfulness (measured with the MAAS) has been correlated with reduced amygdala and medial prefrontal cortical (mPFC) activity at rest; activity in these same areas was positively correlated with depressive symptoms (Way, Creswell, Eisenberger, & Lieberman, 2010). This research builds on a previous study demonstrating that those higher in dispositional, MAAS-assessed mindfulness demonstrated reduced bilateral amygdala activity during exposure to negative affective stimuli, greater activation in regions of the prefrontal cortex, and a down-reguation of amygdala activation through this greater PFC activation that was suggestive of emotion regulation (Creswell et al., 2007). Also addressing the emotion regulatory potential of mindfulness, Modinos, Ormel, and Aleman (2010) found increased activity in the dorsal medial prefrontal cortex (dmPFC) that was associated with a down-regulation of amygdala activity during reappraisal of negative affective stimuli.

Mindfulness practice has also been shown to lead to neurological changes. For example, participation in MBSR has been shown to lead to reduced activity in the mPFC, and increased activity in interoceptive regions such as the insula and somatosensory cortex while attending to emotionally charged stimuli (Farb et al., 2007; 2010) as well as reduced right amygdala gray matter density at rest (Holzel et al.,

2010). Mindfulness meditation has been linked to structural neural changes, such as increased cortical thickness in various regions of the PFC and the right anterior insula (Lazar et al., 2005; Holzel et al., 2008) as well as greater activation in the rostral anterior cingulate cortex (ACC) and dmPFC (Holzel et al., 2007). Additionally, a study by Tang et al. (2009) comparing five days of mindfulness-based training to relaxation training found that the mindfulness training was associated with increased activity in the ventral ACC. This was in turn correlated with increased HRV, thus demonstrating the possible role of the ACC in the regulation of the autonomic system. In summary, research has demonstrated that mindfulness is associated with regions of the brain (e.g., PFC, ACC, insula, amygdala) shown to be directly or indirectly connected to structures relevant in the control of the autonomic system (for reviews of these neural connections see Berntson & Cacioppo, 2000; Brownley et al., 2000). It is possible that mindfulness leads to changes in neural structure and activation that can influence autonomic function and regulation.

Cardiovascular outcomes of mindfulness. Although there is research demonstrating that certain forms of meditation-based attention training (e.g., Zen, transcendental meditation) lead to reduced respiration rate, lower HR, and increased HF-HRV and total HRV (Lehrer, Sasaki, & Saito, 1999; Peng et al., 2004; Takahashi et al., 1995; Wu & Lo, 2008), there is very little research examining the specific relation between mindfulness and cardiovascular function. One exception to this is the work of Ditto, Eclache, and Goldman (2006) that compared mindfulness meditators to control groups practicing basic relaxation techniques or simply sitting quietly. The authors found that mindfulness meditation was related to significantly greater increases in RSA compared to controls. Similarly, Telles, Mohapatra, and Naveen (2005) found that mindfulness meditators, when compared to a random thinking control group, demonstrated decreased sympathetic activity marked by lower LF-HRV and LF/HF ratio and increased parasympathetic activity marked by increased HF-HRV. Even when contrasted with participants who only thought they were receiving mindfulness meditation training (“sham meditation”), participants who did receive mindfulness

meditation training were found to have lower resting HR (Zeidan, Johnson, Gordon, & Goolkasian, 2010). Another study utilizing mindfulness meditation by Tang et al. (2009) found that mindfulness training led to more adaptive physiological states compared to participants in a relaxation condition, including reduced HR and skin conductance response, as well as increased HF-HRV. All of the aforementioned studies have investigated the role of mindfulness meditation on resting autonomic function.

To date, one published study has demonstrated the effects of mindfulness training on cardiovascular responses to stress. Kemeny et al. (2012) randomly assigned 82 healthy female school teachers to an eight-week mindfulness meditation/emotion regulation training or a wait-list control group and following the training period, exposed them to the TSST. Not only did those participants who engaged in the training report increased mindfulness (as measured by the MAAS) and reduced ruminative thoughts during TSST recovery, but those who practiced mindfulness meditation more demonstrated reduced blood pressure reactivity to the TSST and increased RSA during recovery. Given the multimodal nature of many mindfulness trainings, it is difficult to know from Kemeny et al.'s (2012) reported findings what mechanism is responsible for the cardiovascular effects. Basic research is needed to examine the role of mindfulness itself on resting and stress-induced autonomic function.

The present study

One means to assess mindfulness itself is as a disposition, operationalized as a greater or lesser tendency to experience mindful states over time. Based on past research showing that mindfulness (as a disposition and via training) is associated with adaptive basal and stress-related neural and autonomic functioning, it was predicted that dispositional mindfulness would predict more adaptive cardiovascular functioning in response to a potent social evaluative stressor – the TSST. The specific purpose of the present study was four–fold.

First, it is important to establish the relation between mindfulness and HR in response to a social stressor. Based on past research showing that mindfulness meditation is associated with reductions in basal HR (Tang et al., 2009; Zeidan et al., 2010) it was hypothesized that higher dispositional mindfulness scores would predict decreased HR at baseline and during the TSST as well as faster HR recovery from the TSST (H1).

Second, although research has not investigated the role of mindfulness in promoting greater total HRV, research has demonstrated that trait anxiety, perceived stress, and depressive symptoms, variables negatively correlated with trait mindfulness (Brown & Ryan, 2003), are associated with lower total HRV (Carney et al., 2001; Dishman et al., 2000; Fuller, 1992; Hughes & Stoney 2000). Thus it was hypothesized that higher dispositional mindfulness scores would predict higher total HRV in the TSST environment (H2).

Third, the present study examined whether dispositional mindfulness scores would predict adaptive patterns of LF-HRV and the LF/HF ratio (SNS activity) from baseline to recovery from a social stressor. Based on past research showing that mindful meditators tend to have lower basal LF-HRV and LF/HF ratios (Telles et al., 2005), it was hypothesized that dispositional mindfulness would be associated with lower LF-HRV and LF/HF ratio at baseline, during the TSST, and during recovery (H3).

Fourth, this study tested the hypothesis (H4) that dispositional mindfulness would predict higher HF-HRV and RSA (PNS activity) at baseline, during the TSST, and during recovery, in congruence with past research demonstrating similar patterns of activity among those receiving mindfulness training (Ditto et al., 2006; Kemeny et al., 2012; Tang et al., 2009; Telles et al., 2005). Finally, the study examined whether these relations would remain significant when controlling for biological, demographic, and psychological vulnerability variables known to be related to stress-related cardiac functioning, including respiration rate (Berntson et al., 1997), age and sex (Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004), trait anxiety (Fuller, 1992), and depressive symptoms (Carney et al., 2001; Hughes & Stoney 2000).

Method

Sample Size Determination

A power analysis was conducted to determine appropriate sample size to achieve adequate statistical power to detect effects, assuming a small to medium effect size, in accord with meta-analytic findings on mindfulness training (*d* = .50 approximately; Baer, 2003; Grossman et al., 2004; Hofmann, Sawyer, Witt, & Oh, 2010). A repeated measures MLM-based power analysis was done using Optimal Design software (Raudenbush et al., 2011; Spybrook et al., 2011). With an alpha set at .05, a small to medium effect size, and variance explained by covariates (e.g., age, sex) factored in, *N* = 60 was sufficient to achieve power of .80.

Participants

Participants were 69 healthy adults, mostly female (72.7%), sampled from the population of employees at Virginia Commonwealth University (VCU). Three participants' data were excluded from analyses due to improper procedure execution or a participant's acquaintance with a confederate. Two additional participants' data were excluded due to LifeShirt (cardiovascular) equipment malfunction. One participant's data were excluded for excessive artifact (more than 80% of autonomic data). This left a sample of 63 participants (46 women, 17 men).

The diversity of employees at VCU, one of the largest universities in the state of Virginia, supported the generalizability to study findings to the general population of working, healthy adults in the state. Participant age ranged from 19 to 61 years old (*M* = 38.3). The majority of participants (68.2%) self-identified as White or Caucasian; others identified as Black or African American (22.7%), Hispanic or Latino(a) (1.5%), or Asian (7.6%). There was also considerable diversity in occupational roles, such as security guard, administrative assistant, social worker, librarian, and surgeon. Participants reported their civil status as single (33.3%), married (50.0%), separated or divorced (7.6%), or widowed (9.1%).

Participants were recruited through advertisements distributed throughout VCU in the form of brochures, posters, and mass emails. The study was titled, “Psychological Factors in Challenging Tasks” and there was no specific mention of stress induction in the description of the study as not to bias the participants’ responses. Advertisements for this study can be viewed in Appendix B. Participants received $60 and a personalized report of their responses for participating in the study.

Exclusion Criteria. The experimenter phoned interested participants to introduce the study and check for exclusion criteria (see below). Participants were excluded from the study if they had any existing health conditions (e.g., high blood pressure, diabetes, obesity, any heart condition, psychiatric illness) or used certain prescription (e.g., heart medication) and nonprescription drugs (e.g., aspirin, tobacco) , that could affect their stress responsiveness, put them at risk during the stress procedure, or affect the biological measures assessed in this study (Gruenewald et al., 2004). See Appendix D for the phone screening script showing the complete list of exclusion criteria. Participants were also asked not to engage in behaviors on the day of their laboratory appointment that are known to influence physiological responses, such as performing strenuous exercise, smoking, drinking alcohol or caffeinated beverages, and consuming food one hour before the session (Dickerson & Kemeny, 2004). These exclusion criteria were checked at the beginning of the laboratory portion of the study. The questionnaire used to assess the presence of exclusion criteria on the day of the appointment can be found in Appendix E.

Measures

All psychological questionnaires used in this study can be found in Appendix C.

Mindfulness. Dispositional mindfulness was assessed using the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003). The scale includes 15 statements, such as, “I find it difficult to stay focused on what’s happening in the present.” The MAAS is measured on a 6-point Likert scale ranging from “Almost Always” to “Almost Never” and is computed as a mean score of all 15 items. The MAAS is well validated

and has excellent reliability (Brown & Ryan, 2003; MacKillop & Anderson, 2007). It showed high internal consistency in the present sample, α = .91.

Other trait predictors. Two variables known to be related to cardiac functioning are clinical depression and anxiety disorders (Berntson & Cacioppo, 2004). Although participants self-reporting major types of psychiatric illness were excluded from participating, several stress-relevant psychological symptoms were assessed. Depressive symptoms were measured using the revised version of the Beck Depression Inventory (BDI-IA; Beck, Rush, Shaw, & Emery, 1979). The BDI-IA includes 21 items concerning such symptoms as hopelessness, guilt, fatigue, and unplanned weight change. Each item has four multiple choice options ranging from 0 to 3 with 0 being the least severe option and 3 being the most severe. Scores are totaled, with higher scores indicating more depressive symptoms. The BDI-IA has been shown to be a reliable measure (Beck & Steer, 1984) and was reliable in this sample as well, α = .84.

Rumination is a variable often found to be positively correlated with depression (Nolen-Hoeksema, 2000) and negatively correlated with mindfulness (Brown & Ryan, 2003). It has also been found to predict cortisol responses to the TSST (Denson, Fabiansson, Creswell, & Pedersen, 2009; Zoccola, Quas, & Yim, 2010) and so was also measured in the present study. Rumination was measured using a short (10-item) version of the Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991). The RRS asks participants to report on their style of thinking when they feel sad, blue, or depressed. For example, participants were asked how often they "Think about a recent situation, wishing it had gone better." The RRS is measured on a 4-point Likert scale ranging from "Almost Never" to "Almost Always" with higher scores indicating higher rumination. The RRS was computed as a mean score of all 10 items and was found to be reliable in this sample, α = .81.

Self-reported trait and state anxiety was assessed using the tension-anxiety subscale of the Profile of Mood States (POMS-TA; McNair & Lorr, 1964). The POMS is intended to measure how participants are

feeling either at the present moment (emotional states) or over time (emotional traits). The tension-anxiety subscale includes nine adjectives, such as “Tense” and “Anxious” and is computed as a mean score of all nine items. It is measured on a 5-point Likert scale ranging from “Not at all” to “Extremely”. It is well validated in several populations and the anxiety subscale itself has good reliability across studies (McNair, Lorr, & Droppleman 1971; Albrecht & Ewing, 1989). The tension-anxiety subscale, measured at both a trait and state variable, was reliable in this sample at all time points ($\alpha > .83$).

Cardiovascular function. Heart rate and HRV were assessed using the LifeShirt system hardware and software (Vivometrics, Ventura, CA). The LifeShirt is worn like a t-shirt underneath outer clothing with embedded sensors around the chest and abdomen to gauge respiration rate. The shirt is also equipped with leads that connect three disposable electrodes worn directly on the skin to a PDA apparatus that rests in a hip pouch to record continuous time interval electrocardiogram (ECG) data. Heart rate was assessed directly from the ECG data, and HRV was assessed using interbeat interval data input into spectral analysis in Vivometrics computer software.

Salivary cortisol. Although not of direct interest to the present study, the relation between cortisol and autonomic cardiovascular responses to stress was assessed, as higher resting cardiac vagal tone has been previously associated with increased cortisol response to the TSST (Smeets, 2010). Salivary cortisol was measured at five timepoints (once at baseline and four times post-TSST) to assess proximal neuroendocrine reactions to the stressor and recovery from it. The inclusion of cortisol assessments necessitated additional exclusion criteria, including use of prescribed contraceptives, or pregnancy or breastfeeding in the last 6 months. A complete list of exclusion criteria from the screening interview can be seen in Appendix D. The saliva samples were assayed for cortisol by the General Clinical Research Center (GCRC) at Virginia Commonwealth University. Results regarding the relation of trait mindfulness to cortisol reactivity to and recovery from the TSST have been reported elsewhere (Brown et al., in press; Holt, 2009).

Procedure

The procedure was conducted in two stages. During Part One, the experimenter phoned interested participants to introduce the study and check for exclusion criteria. For those who met the study criteria, a Part One consent form and an initial packet of questionnaires was mailed to each participant's home. This packet contained the MAAS, BDI-IA, RRS and POMS-TA, and a variety of other personality and trait psychological questionnaires not of direct interest to this study.

Part Two involved the laboratory induction of social evaluative stress using the well-validated and commonly used Trier Social Stress Task (TSST; Kirschbaum et al., 1993). The TSST has been shown in numerous studies to reliably elicit social stress responses (Dickerson & Kemeny, 2004). Figure 2 presents the procedure timeline; see also Appendix G for the entire experimental protocol.

Figure 2. Trier Social Stress Task Timeline

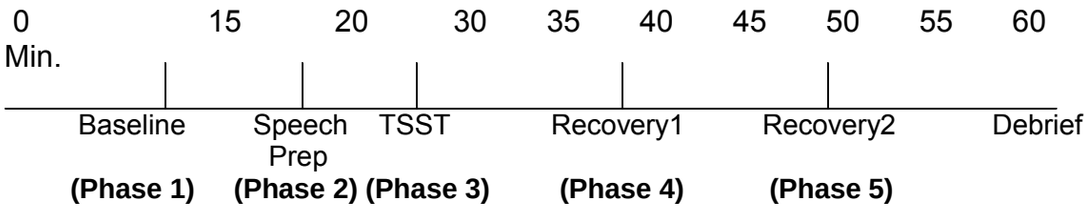

Figure 2. Timeline of the laboratory part of the procedure. Cardiovascular data were collected continuously and binned into 2-minute intervals for each phase. Phase 1 consisted of 2 minutes of resting breathing. Phase 2 represents 4 minutes of speech preparation . Phase 3 represents the 12-minute TSST. The 30 minute recovery period was split into two phases; Phase 4 was the 16 minutes immediately following the TSST and Phase 5 was the 14 minutes towards the end of the session.

Upon entry to the laboratory for the Part Two session, the participants were first re-introduced to the study and were asked to read and sign the Part Two informed consent form. The experimenter then assured that the participants had refrained from engaging in any exclusion behaviors for the day of the appointment (see above). Participants were then fitted for a LifeShirt and led to a private room to change. Once the participant was dressed and the LifeShirt system was working, the participant sat quietly without excessive movement for four minutes to record baseline autonomic functioning. Participants first listened to a metronome and were instructed to inhale for two beats and exhale for two beats for a total of two minutes;

a segment of time labeled paced breathing. After the metronome ceased, participants were instructed to sit quietly for an additional two minutes and this period was used as a resting phase. Only the cardiovascular data collected during the rest period was included in Phase 1 (baseline). The paced breathing segment was used to identify participants with abnormal cardiovascular function irrespective of respiration rate.

An initial packet of questionnaires was then administered, including the POMS-TA to assess baseline psychological state and an initial saliva sample was taken to assess baseline cortisol level. When finished, participants began the TSST protocol. They first listened to recorded instructions that told them to spend five minutes mentally preparing a five-minute public speech on "Why you would be a good candidate for a job as the Program Director of a group in which you would have to work effectively with other VCU employees to come up with solutions to problems typically faced by other employees in your department or unit." The instructions also informed the participant that their performance and the content of their speech would be evaluated. The entire script for the TSST instructions can be viewed in Appendix F. The experimenter then exited the room and after the five-minute speech preparation period (Phase 2), two evaluators entered the room and sat at a desk directly in front of the participant. The evaluators were research confederates trained to give spoken instructions and comments based on a script (Appendix H) while maintaining eye contact and refraining from positive verbal and nonverbal social cues. Confederates were trained to make comments and have facial expressions that reflected neutrality rather than negativity or hostility. One of the evaluators started a five-minute timer and said "Please begin your speech; you have five minutes." If the participant inquired about the time remaining or stopped speaking before their time was up, the evaluator said, "You still have time remaining, please continue" along with other, similar responses. The evaluators maintained a neutral facial expression, constantly stared at the participant, and refrained from any non-verbal affirmatory cues such as "mmm-hmm" or head nodding. These behaviors helped to ensure a stress response through both the speech task and subsequent arithmetic task.

At the end of the five-minute speech, each participant was instructed to perform a mental arithmetic task by counting aloud backwards from 2,083 by 13's for five minutes. The participant was asked to perform the task as quickly and accurately as possible, and to start over at 2,083 if they made a mistake. At one-minute intervals during the arithmetic task, one of the speech evaluators said, "Please go faster." The evaluators also took notes during the tasks to enhance the experimental realism. The evaluators then left the room. The entire task lasted twelve minutes from the time the evaluators entered the room until they left. Video recordings and exact start and stop time recordings were made by the experimenter so as to make precise epochs in the autonomic data. Cardiovascular activity during the TSST was labeled as Phase 3.

The experimenter then returned to collect a second saliva sample and to administer another battery of questionnaires, including the POMS-TA to assess psychological state during the TSST. A cardiovascular recovery period began at the immediate conclusion of the TSST and lasted for 30 minutes. The recovery period was split into two phases for analysis: cardiovascular data taken within the first 16 minutes (Phase 4), and data acquired in the second 14 minutes of the 30 minute interval (Phase 5). The two recovery phases included an unequal number of time points because the total of 15 two-minute intervals does not evenly divide by two. During this recovery period, participants completed additional, periodic questionnaires and the experimenter collected three more saliva samples at 10 minutes, 20 minutes, and 35 minutes post-TSST. In between assessments of stress response, participants were given neutral-content reading material (i.e., *National Geographic* and *Better Homes and Gardens* magazines). After the full recovery period, participants were taken to a private room to remove the LifeShirt; they then returned and were fully debriefed. The experimenter assured that participants were in an acceptable psychological and physiological state before leaving. No participants needed to be referred to counseling services nor did any require additional medical attention. The debriefing script can be viewed in Appendix G. The entire

procedure for the Part Two laboratory session took approximately two hours, which included procedures not directly relation to this study (e.g., blood sampling for immune assays).

Statistical Analyses

The key predictor variable in this study was dispositional mindfulness. There were two general dependent measures of autonomic function: heart rate and heart rate variability. The main purpose of this research was to discover whether dispositional mindfulness predicted differences in resting cardiovascular function, reduced cardiovascular reactivity to and faster recovery from a social stressor above and beyond known covariates of autonomic cardiovascular function (i.e., age, sex, race, depressive symptoms, and trait anxiety). As rumination has been shown to predict cortisol reactivity to the TSST (Denson et al., 2009; Zoccola et al., 2010), trait rumination was also tested as a possible covariate of cardiovascular response.

Data cleaning and separation. All autonomic outcome measures were analyzed using Vivometrics software (Vivometrics, Ventura, CA). Artifact correction was done first to remove any abnormal heart beats, in line with systematic standards (Task Force of the European Society of Cardiology, 1996). Three types of artifact were found and either interpolated or removed. First, although the Vivometrics system provided quite clean data, there were instances in which there was either a missing R wave or an incorrect additional R wave. In these cases, the R-R interval trace was adjusted appropriately. Second, excessive movement can have a large effect on autonomic variables. Movement is measured on a scale from 0 (no movement) to 50 (running fast). Movement that reaches 15 or above can reflect fast paced walking or sudden changes in position such as going from sitting to standing. Time points that included movement that were above the threshold of 15 were eliminated. Lastly, a search was done for ectopic beats. Ectopic beats are abnormally short intervals followed by abnormally long intervals which are due to variations in the electrical conductance system of the heart. See Figure 3 for an example. Ectopic beats, although generally harmless and asymptomatic, can drastically alter the R-R interval. Three criteria were used to determine if a beat was

ectopic. First, the difference between the small and large interval must have exceeded 100ms. Second, the sum of the large interval and the shorter interval must have been within 10% of the sum of the preceding and following normal intervals. Third, the value of the preceding normal interval must have been within 20% of the value of the following normal interval. If all three criteria were met, the beat was labeled as ectopic and the R-R interval trace was interpolated.

Figure 3. Ectopic Beat Example

Figure 3. Ectopic beats are abnormally short intervals followed by abnormally long intervals that are due to variations in the electrical conductance system of the heart.

The Vivometrics software utilizes spectral analysis to calculate the separate HRV frequency ranges. In spectral analysis, the variances of all the R-R intervals in a given time-period (i.e., two minutes for resting breathing, two-minute continuous intervals over the 12 minute TSST period, and two minute continuous intervals during 30-minute recovery period) are converted into frequency ranges (< 0.15Hz for LF-HRV and 0.15-0.4Hz for HF-HRV). Normative timing of autonomic reactivity and recovery from a stressor is still an under investigation. Berntson et al. (1997) recommended using two-minute intervals as a minimum when analyzing both LF- and HF-HRV ranges to have sufficient data within the interval to make accurate calculations. Thus the present study used two-minute intervals to provide sufficient data separation to detect the curve of autonomic reactivity and recovery. The area under the curve, calculated for each frequency range in each time period, is referred to as the power spectral density and was calculated separately for HF-HRV and LF-HRV using the Fast Fourier Transform technique (Task Force of the European Society of Cardiology, 1996).

Normality. All data were checked for deviations from normality. Several data points on the state

POMS-TA were identified as outliers (due mainly to floor effects in baseline psychological anxiety levels) and were winsorized (Tabachnick & Fidell, 2007) to maintain the data pattern but normalize the data. All cardiovascular data were normalized before analysis. The use of normalized units for LF- and HF-HRV is a common method for removing differences in overall variance across conditions (Task Force of the European Society of Cardiology, 1996). See Figure 4 for the normalized unit equations for LF- and HF-HRV. All other dependent variables (i.e., HR, Total HRV, mean RSA, and LF/HF ratio) were log transformed to reduce skewness and kurtosis, as is typical when collecting cardiovascular autonomic data (Ziegler et al., 1992).

Figure 4. Normalized Unit Equations for LF-HRV and HF-HRV

$$\textbf{LFnorm} = \frac{\text{LF-HRV}}{\text{(Total HRV - VLF-HRV)}} \qquad \textbf{HFnorm} = \frac{\text{HF-HRV}}{\text{(Total HRV - VLF-HRV)}}$$

Figure 4. VLF-HRV stands for the very low frequency range of HRV and represents frequencies ranging from 0 – 0.04 Hz whereas LF-HRV represents 0.04 – 0.15 Hz and HF-HRV represents 0.15 – 0.4 Hz. Total HRV is the combination of all frequency ranges.

Correlations. Predictor and dependent variables were tested to assure non-collinearity. For example, HF-HRV and Mean RSA are theoretically similar variables and need not be analyzed separately if highly correlated. Cross-dependent variable relations were also assessed to see how self-reported measures of stress and cortisol correlated with autonomic measures. As self-reported stress was assessed at three time points and cortisol was assessed at five time points, the pattern of responses over time was calculated using area under the curve with respect to ground equations for comparison to autonomic data, which was assessed at 25 time points (2 minute intervals each). See Figure 5 for the AUC_G equation used (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

Figure 5. Area Under the Curve Equation

$$AUC_G = \frac{(m_2 + m_1) * t_1}{2} + \frac{(m_3 + m_2) * t_2}{2} + \frac{(m_{i+1} + m_i) * t_i}{2}$$

Figure 5. Area under the curve with respect to ground equations used to reduce psychological stress and cortisol measures for the purpose of comparing these responses to cardiovascular outcomes. In this equation, m represents measurement and t represents time.

Primary analyses. All primary analyses were conducted using restricted maximum likelihood (REML) repeated measures multilevel linear models (MLM) in the PROC MIXED procedure in SAS (e.g., Singer, 1998). By using MLM, both between and within-subjects differences can be analyzed in the same procedure using continuous variables without the need for data reduction. Another advantage of using the MLM approach is the ability to retain cases for which there is missing data. This is important for autonomic data in which the data cleaning procedure, especially for excessive movement, can result in one or more missing data points for each participant.

Multilevel models were run in two different ways. The first method was to test the predictability of dispositional mindfulness on all six dependent variables using time as a repeated measure. As already noted, there were 25 time intervals each consisting of two minutes of data. The second method was to collapse time points into relevant phases (Phase 1 – Phase 5). Phase 1 represented resting cardiovascular function. Phase 2 represented time points during the five-minute speech preparation phase. Phase 3 represented activity during the TSST. Phase 4 represented the first 16 minutes of recovery and Phase 5 represented the final 14 minutes of recovery. The main effect of mindfulness on the dependent variables was tested along with interactions between mindfulness and time, and between mindfulness and phase. As patterns of reactivity and recovery may be curvilinear in nature, quadratic models (e.g., MAAS*phase^2) were tested along with linear interactions (e.g., MAAS*phase).

Denominator degrees of freedom were calculated in all multilevel models using the between/within method. The most appropriate within-person error covariance structure (unstructured, compound symmetry, or autoregression) was chosen based on chi-square tests comparing the -2 restricted log likelihood model fit indices for each outcome taking into account the number of parameters (Singer, 1998). The autoregressive covariance structure was utilized for all dependant variables when analyzed by time. When analyzed by

phase, autoregression was used for total HRV and mean RSA whereas compound symmetry was used for HF-HRV, LF-HRV, LF/HF ratio, and HR.

All predictor variables, including possible covariates, were centered around zero to increase the interpretability of the MLM intercept parameters (Bryk & Raudenbush, 1992; Schwartz & Stone, 1998). Several demographic variables (age, sex, race/ethnicity) and other potentially important procedural covariates, namely sex composition of the two-person evaluator panel and time of session (early or mid afternoon), were thought to affect the results and were therefore tested in each preliminary model and retained for the main models when significant. The categorical covariates were coded as follows: participant sex (male = 0, female = 1); race/ethnicity (Caucasian = 0, Other = 1); session time (early afternoon = 0, late afternoon = 1; afternoon sessions accommodated the diurnal pattern of cortisol). Sex mix of the evaluator panel was contrast coded into two independent variables. First the male/female group was compared to both the males and females (male/female = -2, other = 1). Second, the males and females were contrasted irrespective of the mixed pair (male/female = 0, female/female = 1, male/male = -1). Both variables were simultaneously entered into models for testing. These procedures followed Tabachnick & Fidell (2007) on contrast coding three-level categorical predictors in multiple regression. To determine the significance of the statistical relations, regression coefficients were analyzed at the $p \leq .05$ level.

Results

Six dependent variables were analyzed in the present study: HR, Total HRV, HF-HRV, LF-HRV, the LF/HF ratio, and mean RSA. There were also several predictor variables beyond trait mindfulness that were thought to affect cardiovascular outcomes and so were included in preliminary MLM models and retained for the main analyses where significant (i.e., depressive symptoms, rumination, trait anxiety, respiration rate, age, sex, and race/ethnicity).

Preliminary analyses

Initial multilevel modeling of unconditional means showed a significant amount of variance to be accounted for in all six dependent variables (*p*s < .0001) thus giving support for investigation of prediction of that variance.

Cross-dependent variable relationships. Cross-dependent variable correlation analyses were done to assess relations between cardiovascular outcomes, cortisol, and self-reported state anxiety, based on data aggregated using AUC_G equations. See Table 1 for a complete description of these correlations. Analyses revealed many significant correlations between the different measures of HRV response. For example, LF-HRV and the LF/HF ratio were highly positively correlated (r = 0.96, p < .0001) suggesting that both outcomes are similarly measuring sympathetic activity. Additionally both outcomes, LF-HRV and the LF/HF ratio, were highly negatively correlated with HF-HRV (r = -0.94, p < .0001 and r = -0.98, p < .0001, respectively), a known indicator of parasympathetic function. Some correlations were in the opposite direction hypothesized. For example, total HRV was positively correlated with cortisol (r = 0.06, p < .05) and HF-HRV was positively correlated with self-reported anxiety (r = 0.08, p < .01), although the magnitude of these correlations was small.

Table 1

Cross-dependent variable correlations

	Totalhrv	LFhrv	HFhrv	LF/HFratio	MeanRSA	cortisol	anxiety
HR	-0.44***	0.34***	-0.33***	0.36***	-0.57***	0.08**	0.12***
Total HRV	-	0.01	0.09**	-0.04	0.79***	0.06*	0.05
LF-HRV		-	-0.94***	0.96***	-0.45***	0.06*	-0.02
HF-HRV			-	-0.98***	0.54***	-0.06*	0.08**
LF/HF ratio				-	-0.51***	0.07*	-0.04
Mean RSA					-	0.01	0.09**
Cortisol						-	0.27***

Note. Anxiety scores reflect psychological state during the experimental protocol. Cortisol and anxiety scores are based on AUCg calculations as these were repeated measures assessed at differing numbers of time points.
* p < .05, ** p < .01, *** p < .0001

Covariates. Several variables known to have effects on autonomic cardiovascular data were tested in preliminary multilevel models to assess their predictive value. It was considered important to identify these covariates to assure that the predictors of interest were accounting for variance in the dependent variables after controlling for key covariates.

Respiration rate predicted all dependent variables as expected (*p*s < .01) so was included in all main models. Among the demographic variables tested (i.e., age, sex, and race/ethnicity), age was a significant predictor of total HRV, LF/HF ratio, and mean RSA (*p*s < .05), but not HR, LF-HRV, or HF-HRV (*p*s > .05). Although sex did not significantly predict HR, mean RSA, HF-HRV, and total HRV above and beyond other significant predictors (*p*s > .05), there were sex effects on LF-HRV and the LF/HF ratio (*p*s < .05). Males showed higher sympathetic activity (LF-HRV, *M* = .64, *SD* = .16; LF/HF ratio, *M* = .44, *SD* = .40) compared to females (LF-HRV, *M* = .57, *SD* = .19; LF/HF ratios, *M* = .27, *SD* = .42). Race/ethnicity demonstrated relations on HF-HRV, LF-HRV, and the LF/HF ratio (*p*s < .05). Minority groups demonstrated higher HF-HRV (*M* = .38, *SD* = .18) compared to Caucasians (*M* = .29, *SD* = .17). Caucasians showed higher LF-HRV (*M* = .62, *SD* = .17) and LF/HF ratios (*M* = .38, *SD* = .41) compared to African-Americans and other minority groups (LF-HRV, *M* = .52, *SD* = .19; LF/HF ratio, *M* = .15, *SD* = .41).

Two procedural predictors were tested for possible relations to the dependent variables, namely time of session (early or mid afternoon) and sex mix of the evaluators (male/male, female/female, or male/female). Preliminary MLM analyses showed that time of session was not a significant predictor of any of the dependent variables (*p*s > .05). Also the sex mix of the evaluators did not significantly predict any dependent variables when the aforementioned demographic characteristics of the participants were factored in (*p*s > .05). Table 2 provides complete statistics for these demographic, procedural, and respiratory covariate results for all preliminary models.

Table 2

Demographic, Procedural, and Respiratory Covariate Results in Preliminary Models

		B	t	p
Heart rate				
	age	-0.0003	-0.43	0.67
	sex	-0.006	-0.41	0.68
	race/ethnicity	0.0003	0.02	0.98
	respiration rate	0.003	9.84	<0.0001
	session time	0.02	1.55	0.12
	confederate sex	-0.04	-1.64	0.11
HF-HRV				
	age	-0.002	-1.88	0.06
	sex	-0.05	-1.93	0.06
	race/ethnicity	-0.08	-2.7	0.009
	respiration rate	-0.01	-9.29	<0.0001
	session time	-0.03	-1.2	0.23
	confederate sex	0.02	0.58	0.56
LF-HRV				
	age	0.001	1.28	0.15
	sex	0.07	3.28	0.002
	race/ethnicity	0.09	4.36	<0.0001
	respiration rate	0.007	5.36	<0.0001
	session time	0.03	1.28	0.46
	confederate sex	-0.02	-0.91	0.37
Total HRV				
	age	-0.018	-7.06	<0.0001
	sex	0.08	1.31	0.19
	race/ethnicity	0.09	1.51	0.14
	respiration rate	-0.007	-2.86	0.004
	session time	-0.03	-0.51	0.61
	confederate sex	0.15	1.66	0.1
LF/HF Ratio				
	age	0.005	2.54	0.01
	sex	0.16	3.4	0.001
	race/ethnicity	0.19	4.19	0.0001
	respiration rate	0.02	7.26	<0.0001
	session time	0.07	1.51	0.14
	confederate sex	-0.07	-1.11	0.27
Mean RSA				
	age	-0.01	-6.31	<0.0001
	sex	-0.02	-0.39	0.69
	race/ethnicity	-0.03	-0.67	0.51
	respiration rate	-0.02	-19.44	<0.0001
	session time	-0.05	-1.24	0.22
	confederate sex	0.12	1.92	0.06

Notes. Session time refers to laboratory sessions that started at 12:30pm (0) or 2:30pm (1). Confederate sex refers to the sex composition of the TSST evaluator duo (m/f = -2, other = 1; m/f = 0, f/f = 1, m/m = -1). Participant sex was coded as m = 0, and f = 1, and race/ethnicity as Caucasian = 0, Other = 1.

Several psychological trait predictors (i.e., depressive symptoms, trait anxiety, and rumination) were also examined in separate preliminary analyses (one trait per model) as they have previously shown relations with cardiovascular outcomes and/or mindfulness scores. Depression was negatively correlated with mindfulness (r = -0.44, p < .0001) and was significantly predictive of HR, $t(61) = 2.36$, p < .05 and total HRV, $t(60) = -3.23$, p < .01. Trait anxiety was negatively correlated with mindfulness (r = -0.45, p < .0001) and was also significantly predictive of HR, $t(61) = 2.95$, p < .01). Rumination, a variable not previously analyzed in the literature with respect to cardiovascular reactivity to stress but shown to be inversely related to mindfulness, was negatively correlated with mindfulness scores here (r = -0.29, p < .0001) and was significantly predictive of HF-HRV; $t(58) = 2.88$, p < .01, LF-HRV; $t(58) = -4.56$, p < .0001, and the LF/HF ratio; $t(58) = -3.18$, p < .01. All non-significant covariate predictors tested were excluded from the main models to preserve statistical power.

TSST reactivity and recovery. Multilevel models were first tested to determine whether the TSST reliably induced stress, as assessed by the six cardiovascular outcomes. Planned contrasts were done by phase to see if scores during speech prep (phase 2), TSST (phase 3), and both recovery periods (phases 4 and 5) were significantly different from baseline (Phase 1). See Table 3 for planned contrasts in comparison to baseline. For all variables except total HRV, it was clear that the TSST produced marked changes in cardiovascular function (ps < .0001). For total HRV, the change in cardiovascular function is most clearly demonstrated during recovery. That is, although total HRV did not significantly decrease during the TSST, it rebounded significantly beyond baseline during recovery (ps < .05).

Although not one of the four primary hypotheses, reports on cardiovascular recovery speed have varied considerably (Mezzacappa et al., 2001; Smeets, 2010). Thus a question the present study sought to answer concerned the speed of recovery of the six cardiovascular outcomes. Several of the dependent variables (i.e., heart rate, LF-HRV, LF/HF ratio, and mean RSA) demonstrated comparatively rapid recovery

following the TSST in that the means during both phases 4 and 5 were not significantly different from baseline (*p*s > .11; see Table 3). There was also rapid recovery for total HRV and this was the only dependent variable whose levels were significantly higher than baseline levels in both phases 4 ($p < .01$) and 5 ($p < .05$). High frequency HRV differed from the other dependent variables in terms of recovery speed in that the mean for phase 4 was still significantly lower than baseline ($p < .05$) and did not recover until phase 5 ($p = .10$), which began at 16 minutes post-TSST.

Table 3

Dependent variable means (SD) at each TSST phase.

	HR	Total HRV	HF-HRV	LF-HRV	LF/HFratio	MeanRSA
Phase 1	1.87(.07)	3.06(.53)	0.38(.20)	0.54(.21)	0.17(.49)	1.81(.31)
Phase 2	1.91(.07)***	2.98(.43)	0.33(.16)*	0.58(.17)	0.27(.37)	1.64(.26)***
Phase 3	1.97(.07)***	2.99(.47)	0.23(.12)***	0.69(.14)***	0.53(.33)***	1.56(.24)***
Phase 4	1.87(.06)	3.20(.44)**	0.32(.16)*	0.59(.16)	0.29(.36)	1.74(.27)
Phase 5	1.86(.06)	3.17(.44)*	0.33(.17)	0.57(.17)	0.28(.39)	1.73(.26)

Note. Baseline scores (Phase 1) consist of the two-minute pre-task rest interval. Phase 2 is the speech preparation (anticipatory stress) segment. Phase 3 is the TSST. Phases 4 and 5 are both recovery periods. HF-HRV and LF-HRV are represented by normalized units (*nu*) and the other variables were log transformed to achieve normality. Values are marked with asterisks if they significantly differed from baseline.
* $p < .05$, ** $p < .01$, *** $p < .0001$

Primary analyses

The specific hypotheses of the present study were that higher dispositional mindfulness would predict (H1) decreased HR at baseline and during the TSST as well as faster HR recovery from the TSST; (H2) higher total HRV across the full TSST session; (H3) lower LF-HRV and LF/HF ratio at baseline, during the TSST, and during recovery; and (H4) higher HF-HRV and RSA at baseline, during the TSST, and during recovery.

Tests of the first hypothesis (H1) revealed no significant main effects of trait mindfulness on HR when analyzed by time ($p = .25$) or by phase ($p = .23$) when controlling for respiration rate. Additionally there were no linear interactions between MAAS and time ($p = .58$) nor between MAAS and phase ($p = .65$). There was

however, a significant quadratic interaction between mindfulness and phase on HR, $t(60) = 1.73$, $p = .05$. Post-hoc correlations with Tukey adjustments revealed that mindfulness was negatively correlated with HR during the TSST ($r = -0.16$, $p < .01$). See Figure 6(a) for a graphical representation of this interaction and Tables 4 and 5 in for a complete summary of HR results. However, this quadratic interaction was not significant after controlling for variance in HR explained by depressive symptoms and trait anxiety, MAAS $t(60) = 1.48$, $p = .14$.

Figure 6a-e. MLM models for interactions by phase

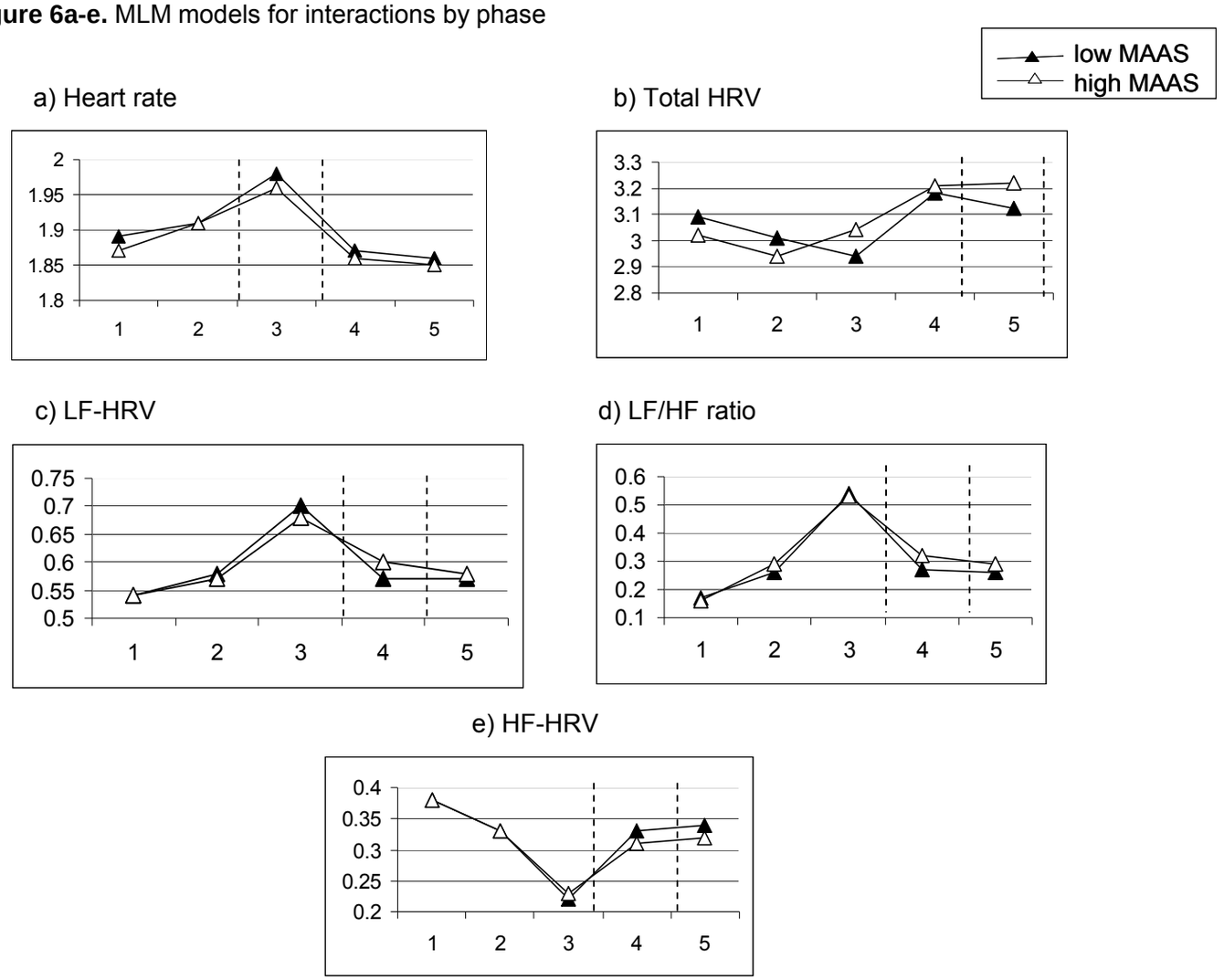

Figure 6a-e. A median split of MAAS scores were done solely for graphical representation. All analyses were done using repeated measures MLM. LF-HRV and HF-HRV values are normalized units and all other dependent variables were log transformed to achieve normality. Phase is represented on the x axis. Areas outlined in dashed segments reflect phases that were significant when analyzed by post-hoc Tukey adjusted correlations.

Table 4

MLM Results by Time

		B	t	p
Heart rate	controlling for respiration			
	MAAS	-0.009	-1.14	0.25
(linear interaction)	MAAS*time	0.0003	0.56	0.58
(quadratic interaction)	MAAS*time*time	<-0.0001	-0.5	0.61
	Depression	0.003	2.36	0.02
	Rumination	-0.002	-0.16	0.88
	Anxiety	0.02	2.95	0.005
HF-HRV	controlling for race and respiration			
	MAAS	-0.008	-0.74	0.46
(linear interaction)	MAAS*time	-0.0005	-0.4	0.69
(quadratic interaction)	MAAS*time*time	-0.0001	-0.56	0.57
	Depression	-0.0003	-0.16	0.87
	Rumination	0.05	2.88	0.006
	Anxiety	0.01	1.21	0.23
LF-HRV	controlling for sex, race, and respiration			
	MAAS	0.02	1.38	0.17
(linear interaction)	MAAS*time	0.001	0.44	0.66
(quadratic interaction)	MAAS*time*time	<0.0001	0.05	0.96
	Depression	-0.0007	-0.41	0.68
	Rumination	-0.07	-4.56	<.0001
	Anxiety	-0.01	-1.04	0.3
Total HRV	controlling for age and respiration			
	MAAS	0.07	2.02	0.048
(linear interaction)	MAAS*time	0.004	0.16	0.87
(quadratic interaction)	MAAS*time*time	-0.0002	-0.5	0.62
	Depression	-0.02	-3.23	0.002
	Rumination	-0.05	-0.97	0.33
	Anxiety	-0.08	-2.07	0.04
LF/HF Ratio	controlling for age, race, sex, and respiration			
	MAAS	0.02	0.84	0.41
(linear interaction)	MAAS*time	0.0009	0.3	0.76
(quadratic interaction)	MAAS*time*time	0.0001	0.31	0.75
	Depression	0.0002	0.05	0.96
	Rumination	-0.12	-3.18	0.002
	Anxiety	-0.03	-1.1	0.27
Mean RSA	controlling for age and respiration			
	MAAS	0.02	1.12	0.27
(linear interaction)	MAAS*time	-0.0002	-0.1	0.92
(quadratic interaction)	MAAS*time*time	<.0001	0.08	0.94
	Depression	-0.006	-1.91	0.06
	Rumination	0.02	0.64	0.53
	Anxiety	-0.03	-1.14	0.26

Table 5

MLM Results by Phase

		B	t	p
Heart rate	controlling for respiration			
	MAAS	-0.01	-1.22	0.23
(linear interaction)	MAAS*phase	-0.0006	-0.45	0.65
(quadratic interaction)	MAAS*phase*phase	0.002	1.89	0.059
	Depression	0.003	2.06	0.04
	Rumination	-0.005	-0.34	0.73
	Anxiety	0.02	2.37	0.02
HF-HRV	controlling for race and respiration			
	MAAS	-0.01	-0.84	0.4
(linear interaction)	MAAS*phase	-0.007	-2.26	0.02
(quadratic interaction)	MAAS*phase*phase	-0.004	-1.52	0.13
	Depression	0.002	0.67	0.51
	Rumination	0.06	2.56	0.01
	Anxiety	0.02	0.97	0.33
LF-HRV	controlling for age, race, and respiration			
	MAAS	0.01	0.87	0.39
(linear interaction)	MAAS*phase	0.007	2.21	0.03
(quadratic interaction)	MAAS*phase*phase	0.002	0.95	0.34
	Depression	-0.001	-0.41	0.68
	Rumination	-0.07	-3.22	0.002
	Anxiety	-0.008	-0.44	0.66
Total HRV	controlling for age and respiration			
	MAAS	0.08	2.2	0.03
(linear interaction)	MAAS*phase	0.02	2.21	0.03
(quadratic interaction)	MAAS*phase*phase	-0.003	-0.37	0.71
	Depression	-0.02	-3.64	<0.001
	Rumination	-0.05	-1.02	0.31
	Anxiety	-0.08	-2.19	0.03
LF/HF Ratio	controlling for race, sex, and respiration			
	MAAS	0.03	0.89	0.38
(linear interaction)	MAAS*phase	0.01	2.01	0.04
(quadratic interaction)	MAAS*phase*phase	0.007	1.23	0.22
	Depression	-0.004	-0.69	0.49
	Rumination	-0.14	-2.71	<0.01
	Anxiety	-0.04	-0.86	0.39
Mean RSA	controlling for age and respiration			
	MAAS	1.71	0.5	0.62
(linear interaction)	MAAS*phase	0.78	0.79	0.43
(quadratic interaction)	MAAS*phase*phase	-0.17	-0.23	0.81
	Depression	-0.006	-1.9	0.06
	Rumination	0.02	0.71	0.48
	Anxiety	-0.03	-1.09	0.28

Tests of H2 revealed a main effect of dispositional mindfulness on total HRV scores; higher MAAS scores predicted increased HRV across time , $t(59) = 2.02$, $p < .05$ and across phases, $t(59) = 2.20$, $p < .05$ above and beyond the effects of age and respiration rate. Post-hoc analyses (i.e., correlations done by phase with Tukey adjustments) revealed that MAAS scores were significantly predictive of increased total HRV scores specifically during phase 5 ($r = 0.11$, $p = .05$). See Figure 7 for a graphical representation of this relation.

Figure 7. MLM model for Total HRV by time

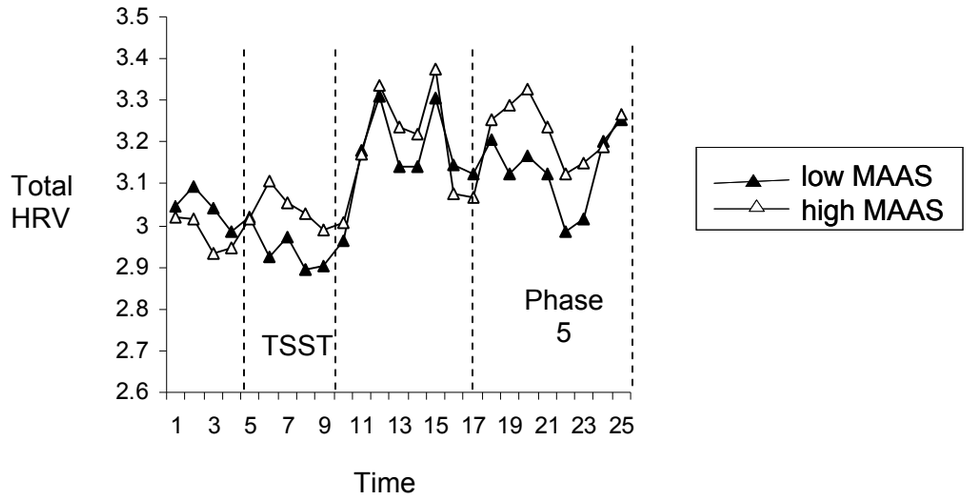

Figure 7. A median split of MAAS scores was done solely for graphical representation. Total HRV values were log transformed to achieve normality.

There was also a significant linear interaction between mindfulness and phase on total HRV, $t(61) = 2.21$, $p = .03$; see Figure 6(b) for a graphical representation of this interaction. Tukey adjusted post-hoc correlations revealed that mindfulness was positively correlated with total HRV during phase 5 ($r = 0.11$, $p = .05$). However, depressive symptoms also significantly predicted total HRV response, $t(60) = -3.23$, $p < .01$ and the main effect of trait mindfulness was not significant after controlling for depressive symptoms when analyzed by time, $t(58) = .03$, $p = .41$ and by phase, $t(58) = .82$, $p = .41$ nor was the interaction between

MAAS scores and phase, $t(60) = 1.13$, $p = .26$. See Tables 4 and 5 for a complete summary of total HRV results.

Tests of H3 revealed no significant main effects of trait mindfulness on LF-HRV when analyzed by time ($p = .17$) or by phase ($p = .39$) nor on the LF/HF ratio when analyzed by time ($p = .41$) or by phase ($p = .38$) when controlling for age, sex, race, and respiration rate. There was a significant linear interaction between mindfulness and phase on both LF-HRV, $t(61) = 2.21$, $p = .03$; and the LF/HF ratio, $t(61) = 2.01$, $p = .04$. Tukey adjusted post-hoc correlations revealed that mindfulness correlated with higher values on both LF-HRV ($r = 0.17$, $p < .001$) and the LF/HF ratio ($r = 0.13$, $p = .01$) during phase 4. See Figure 6(c-d) for a graphical representation of these interactions. However, these interactions were not significant above and beyond the relations between rumination and LF-HRV, MAAS $t(60) = 1.73$, $p = .08$; and the LF/HF ratio, MAAS $t(60) = 1.62$, $p = .11$. See Tables 4 and 5 for a complete summary of LF-HRV and LF/HF ratio results.

Tests of H4 revealed no significant main effects of trait mindfulness on HF-HRV when analyzed by time ($p = .46$) or by phase ($p = .40$) nor on mean RSA when analyzed by time ($p = .27$) or by phase ($p = .62$) when controlling for race/ethnicity and respiration rate. Although there was not a significant linear interaction between mindfulness and phase on RSA, $t(61) = .43$, $p = .79$, there was a significant linear interaction between mindfulness and phase on HF-HRV, $t(61) = -2.26$, $p = .02$. Tukey adjusted post-hoc correlations revealed that mindfulness correlated with lower HF-HRV ($r = -0.12$, $p = .03$) during phase 4. See Figure 6(e) for a graphical representation of this interaction. However, this interactive relation to HF-HRV was not significant above and beyond the variance explained by rumination, MAAS $t(60) = -1.18$, $p = .06$. See Tables 4 and 5 for a complete summary of HF-HRV results.

Discussion

The primary purpose of this study was to examine whether trait mindfulness would predict patterns of cardiovascular reactivity to and recovery from a potent psychosocial stressor. Social evaluative threat is a common form of social stress and the Trier Social Stress Task (TSST; Kirschbaum et al, 1993) is a well-validated elicitor of social stress responses (Dickerson & Kemeny, 2004). This study first found that the TSST elicited social stress responses as indicated by changes in autonomic cardiovascular function, including increased HR and LF/HF ratio, and decreased HF-HRV and mean RSA. These results indicate that the TSST procedure was successful in inducing social stress-related cardiovascular changes in this study. Additionally, one of the purposes of the present study was to examine recovery speeds of cardiovascular function following the TSST as differing results have been previously reported (Mezzacappa et al., 2001; Smeets, 2010). Most of the dependent variables (i.e., HR, total HRV, LF-HRV, LF/HF ratio, and mean RSA) demonstrated recovery within 16 minutes post-TSST. Recovery speed was slower for HF-HRV however, in that scores were not significantly different from pre-task resting values until after 16 minutes post-TSST.

Turning to the main focus of the study, the first hypothesis was that trait mindfulness would predict decreased HR at baseline and during the TSST as well as faster HR recovery from the TSST. There was no significant predictive relation between mindfulness and resting HR, which does not coincide with previous research demonstrating reduced resting HR among those trained in mindfulness (Tang et al., 2009; Zeidan et al., 2010). However there was an interaction between mindfulness and session phase on HR, in that trait mindfulness significantly predicted decreased HR reactivity during the TSST. Dispositional mindfulness did not predict HR recovery from the TSST nor was the mindfulness x phase interaction significant after controlling for other psychological trait predictors of HR, namely depressive symptoms and anxiety.

The second hypothesis of the present study was that higher dispositional mindfulness would predict higher total HRV in the TSST environment. Trait mindfulness did predict increased HRV across the time span as hypothesized. However there was also an interaction of mindfulness and phase on HRV, such that higher mindfulness predicted higher HRV during the later recovery phase in particular. This result, however, was not significant after controlling for a significant relation between depressive symptoms and HRV.

The third hypothesis of this study was that mindfulness would predict reduced sympathetic cardiovascular functioning, measured in terms of LF-HRV and the LF/HF ratio, at baseline, during the TSST, and during recovery. However there were no main effects of mindfulness on either outcome. As with HR and total HRV though, there was a significant interaction between mindfulness and phase on both of these outcomes, such that trait mindfulness significantly predicted the trajectory of sympathetic nervous system responses. Trait mindfulness was particularly correlated with *increased* LF-HRV and LF/HF ratio during the initial recovery phase. These results appear to be opposite of the hypothesis that MAAS scores would predict reduced LF-HRV and LF/HF ratio. However, inspection of Figure 6 (c-d) suggests that mindfulness predicted a flatter slope overall in that while those higher in mindfulness are only somewhat lower in SNS cardiovascular reactivity to the TSST, there is a significantly reduced rebound effect after the cessation of the stressor. This resulted in higher levels of LF-HRV and LF/HF ratio for those with higher mindfulness than for those with lower mindfulness, especially during initial (phase 4) recovery. In other words, it appears that those higher in mindfulness demonstrated less autonomic “overcorrection” when recovering from the TSST stressor. Previous research (Telles et al., 2005) has found that mindfulness meditators showed lower levels of both LF-HRV and LF/HF ratio at rest. The present study found no significant relations of mindfulness to resting values of these HRV indicators. However it is notable that the resting phase in the present study was quite brief, and preceded an expected “challenging task,” as indicated in the study advertising. These factors may have limited the study’s ability to detect the resting state relations in question.

The fourth hypothesis of the present study was that mindfulness would predict increased parasympathetic cardiovascular functioning, measured in terms of HF-HRV and RSA, at baseline, during the TSST, and during recovery. There were no significant main effect or interaction results for mean RSA, which does not correspond to Ditto et al.'s (2006) findings showing that mindfulness meditators showed greater RSA at rest. There also were no main effects of mindfulness on HF-HRV. An interaction between mindfulness and phase was seen for HF-HRV, in that trait mindfulness predicted the slope of HF-HRV over time, particularly predicting *decreased* HF-HRV during the initial recovery phase. In an opposite pattern to the results seen for H3 (and as expected, since sympathetic and parasympathetic function are inversely related), those higher in trait mindfulness demonstrated only somewhat higher HF-HRV during the TSST, although there was a significantly lower rebound effect on HF-HRV during the initial recovery phase. Inspection of Figure 6e demonstrates this flattened slope for those higher in mindfulness. Again it appears as if mindfulness predicts reduced autonomic "overcorrecting" when recovering from the stressor. Mindfulness did not predict HRV outcomes during rest, which for HF-HRV does not correspond to previous, mindfulness training-based findings (Tang et al., 2009; Telles et al., 2005). Again, this could be explained by the fact that there was only a brief resting phase in this study (2 minutes) that may also have been compromised by an anticipation of "challenge."

Summarizing these findings, dispositional mindfulness was found to predict one or more portions of the trajectory of cardiovascular responses on all dependent variables except mean RSA. These results were significant above and beyond known covariates of cardiovascular function, namely age, sex, race/ethnicity, and respiration rate (Freeman, 2006; Kudielka et al., 2004). The findings are consistent with recent research demonstrating that higher MAAS mindfulness scores predicted lower cortisol responses to the TSST (Brown et al., in press). In the present study, trait mindfulness significantly predicted lower HR reactivity during the TSST and higher total HRV, particularly during the later recovery phase. The relation

between mindfulness and outcomes analyzed using spectral analysis were somewhat more complex. While in the hypothesized direction, mindfulness did not significantly predict differences in sympathetic (LF-HRV, LF/HF ratio) and parasympathetic (HF-HRV, RSA) cardiovascular reactivity to the TSST. Trait mindfulness was more powerful in predicting reduced rebound effects for HF-HRV, LF-HRV, and the LF/HF ratio and thus produced flatter trajectories of reactivity and recovery, evidenced by the significant interactions between mindfulness and phase on all three outcomes (see Figures 6c-e). The meaning of this concerns the fact that the autonomic nervous system functions in a homeostatic way. Parasympathetic activity decreases as sympathetic activity increases and vice versa. Additionally, it is common for parasympathetic function to "overreact" after irregular increases to sympathetic activity, such as during stress, in the process of returning to baseline levels of functioning (Mezzacappa et al., 2001). The present results suggest that mindfulness prevents this overreaction to alterations in homeostatic balance. This is conjecture, however, and more research is needed to test this possibility.

Importantly, the results concerning mindfulness were not significant above and beyond other psychological predictors previously associated with cardiovascular function, including depressive symptoms (Carney et al., 2001; Hughes & Stoney 2000) and trait anxiety (Fuller, 1992). These predictors, along with rumination, a variable related to depression, have also been negatively correlated with trait mindfulness (Brown & Ryan, 2003; Verplanken et al., 2007). An interesting pattern in the results pertaining to these stress vulnerability factors was that some tended to predict outcomes that were analyzed using spectral analysis and others tended to predict general cardiovascular outcomes (i.e., HR and total HRV) but rarely were these mixed. For example, rumination only predicted outcomes that underwent spectral analysis (HF-HRV, LF-HRV, and the LF/HF ratio) whereas depressive symptoms and trait anxiety only predicted variables that did not undergo spectral analysis (i.e., total HRV and HR). While the meaning of this is unclear, the results demonstrate that dispositional characteristics can predict psychophysiological reactivity to and

recovery from social stressors, and thus should be accounted for when assessing cardiovascular function in social stress-relevant contexts.

The fact that mindfulness significantly predicted the trajectory of responses to a psychosocial stressor on several cardiovascular outcomes suggests a possible buffering effect on the primary appraisal of and secondary responses to stress. Specifically, mindfulness may moderate the role of psychological stress vulnerability factors in cardiovascular responses by reducing their physiological effects. This idea is consistent with recent research by Kemeny et al. (2012); an eight-week training in mindfulness meditation and emotion regulation led to faster blood pressure recovery following participation in the TSST (compared to wait-list controls) and this result may have been explained by the fact that those in the training condition reported increased MAAS scores as well as decreased ruminative thoughts following the TSST.

The present study also contributes to a growing body of research on mindfulness meditation, which has demonstrated that relative to controls, mindfulness meditators demonstrate more adaptive cardiovascular functioning at rest, as indicated by increased RSA (Ditto et al., 2006) and HF-HRV (Tang et al., 2009; Telles et al., 2005) as well as decreased LF-HRV, LF/HF ratio (Telles et al., 2005) and HR (Tang et al., 2009; Zeidan et al., 2010). While trait mindfulness was not a significant predictor of cardiovascular function on these outcomes at rest in the present study this, as already noted, may have been due to procedural limitations.

Previous research (Farb et al., 2007; 2010; Holzel et al., 2008; 2010; Lazar et al., 2005; Modinos et al., 2010; Way et al., 2010) has demonstrated several neurological correlates of mindfulness (i.e., ACC, PFC, amygdala) that are known to be connected to regions relevant in the control of autonomic function (Berntson & Cacioppo, 2000; Brownley et al., 2000; Tang et al., 2009; Thayer, 2007) and have been theorized to be important in cardiovascular reactivity (Thayer & Lane, 2000). Tang et al. (2009) demonstrated that mindfulness training led to neurological changes in the ventral ACC, which in turn

correlated with increased HRV. Further research is needed to understand the direct and indirect neural pathways influenced by mindfulness that contribute to reduced cardiovascular responses to social stressors.

The present study is the first to test the direct relation between trait mindfulness and cardiovascular outcomes in a social evaluative stressor context. Thus the role of mindfulness in stress-relevant cardiovascular responses, especially during recovery, deserves further investigation. Much research on mindfulness has been devoted to demonstrating the health benefits of mindfulness training through programs such as Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1990). The effectiveness of MBSR and related mindfulness interventions has been documented in meta-analytic studies (Baer, 2003; Grossman et al., 2004; Hofmann et al., 2010). Yet a key, applied question arising from the present findings is to ask what intervention ingredients are responsible for intervention effectiveness. For example, by understanding whether increases in dispositional mindfulness are responsible for cardiovascular or other health benefits, mindfulness interventions may be better tailored to individuals with specific physiological and health issues to enhance their relevance and success.

Limitations and Future Research

There are several noteworthy limitations to this study. First, the study was correlational in design and therefore causal conclusions regarding the role of mindfulness in stress-related cardiovascular outcomes cannot be inferred. Future, experimental research is needed to examine the causal role of mindfulness and other resilience and vulnerability factors on stress reactivity and recovery. Such research will help to guide interventionists seeking to enhance the effectiveness of mindfulness-based training and interventions. This study found that mindfulness was not a main effect predictor of cardiovascular responses when variance due to several vulnerability factors was accounted for. Further research is needed to address whether mindfulness may play a more complex role in predicting cardiovascular responses including, as already noted, as a moderator of the role of rumination, depressive symptoms, or anxiety on these outcomes.

This study had novel hypotheses, and further research is needed to replicate and extend these findings, which may include exploration of the relations of mindfulness to other social stress-relevant cardiovascular responses, including blood pressure, an important health indicator. The application of the multilevel statistical methods using in this study were novel as well and should be considered for future research on this topic. With the exception of Kemeny et al.'s (2012) study, research examining cardiovascular reactivity to the TSST (Kunz-Ebrecht et al., 2003; Nater et al., 2006; Smeets, 2010) or at rest for mindfulness meditators (Ditto et al., 2006; Tang et al., 2009; Telles et al., 2005; Zeidan et al., 2010) has utilized various forms of ANOVA modeling. This type of analysis permits only rudimentary analysis of the pattern of stress responses over time. Many researchers examining psychophysiological reactions to stress who are interested in this patterning of activity over time have reduced data using area under the curve (AUC; Pruessner et al, 2003) calculations, which prohibit examination of predictive relations to distinct portions of the pattern of responses (e.g., phase, as in the present study). The use of MLM permits the analysis of an unlimited number of time points of dependent variable data, thus making it possible to examine more complex patterns of response. Additionally, MLM can incorporate either continuous or categorical predictors, meaning that findings derived from studies of trait mindfulness (continuous), for example, can be compared to those based on experimental assignment to treatment conditions (categorical). The interaction between mindfulness and phase was particularly relevant in the present study and has the possibility to inform other research in this domain, specifically in showing that trait mindfulness was related to recovery-specific indicators of HRV, but not cardiac function at earlier phases of the stress exposure process.

Although some researchers (Kemeny et al., 2012; Kunz-Ebrecht et al., 2003; Nater et al., 2006; Smeets, 2010) have begun to investigate the cardiovascular responses to social stressors such as the TSST, this work is still very preliminary. Most research studies utilizing the TSST have to date assessed

hypothalamic-pituitary-axis markers of stress response, particularly cortisol (Dickerson & Kemeny, 2004). While cortisol is a reliable indicator of stress response, it will be important to investigate other forms of psychophysiological response in social stress studies. Assessing stress-related cardiovascular function can provide unique health-relevant information, particularly given that correlations between cardiovascular outcomes and self-reported anxiety and cortisol are relatively weak, as was found here. Thus, simultaneous assessment of emotional, endocrine, and cardiovascular aspects of the stress response can provide a more complete understanding of the variability in stress resilience and vulnerability.

Conclusion

The present research seeking to uncover the role of mindfulness in stress resilience suggested that mindfulness may play an important role in cardiovascular function during and following social stress. Trait mindfulness significantly predicted decreased HR reactivity to the TSST and increased HRV particularly during recovery from the task. Those with increased mindfulness also demonstrated reduced rebound effects for HF-HRV, LF-HRV, and the LF/HF ratio. Yet while the results were significant above and beyond demographic and biological covariates (e.g., sex, age, respiration rate), mindfulness was not significantly predictive after controlling for other psychological predictors of cardiovascular response (i.e., trait rumination, depressive symptoms, and trait anxiety). Previous research has shown positive relations between mindfulness and well being (e.g., Brown & Ryan, 2003) and stress reduction interventions that utilize mindfulness, such as MBSR, have demonstrated success in ameliorating stress and related outcomes in both healthy stressed and clinical populations (e.g., Baer, 2003; Grossman et al., 2004). Additionally, trait mindfulness has been shown to be negatively correlated with rumination, depression, and anxiety (Brown & Ryan, 2003) and mindfulness based treatments have been shown to reduce these symptoms (e.g., Jain et al., 2007; Kemeny et al., 2012). The present study provides preliminary evidence for understanding the cardiovascular mechanisms by which mindfulness training may have its effects, and future research should

be undertaken to explore a buffering role for mindfulness in reducing psychological symptoms, which may then lead to more adaptive cardiovascular functioning in stressful circumstances.

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Appendix A

Informed Consent

RESEARCH SUBJECT INFORMATION AND CONSENT FORM

TITLE: Psychological Factors in Challenging Tasks

VCU IRB NO.:

This consent form may contain words that you do not understand. Please ask the study staff to explain any words that you do not clearly understand. You may take home an unsigned copy of this consent form to think about or discuss with family or friends before making your decision.

PURPOSE OF THE STUDY
This study seeks to understand the ways in which your engagement in tasks relates to a variety of psychological factors. You are being asked to participate in this study because you are an employee at Virginia Commonwealth University. The research project will be conducted in two parts, the first taking about 45-60 minutes, the second taking 90 minutes to complete. Participation is voluntary, and all responses will remain strictly confidential.

DESCRIPTION OF THE STUDY AND YOUR INVOLVEMENT
If you decide to be in this research study, you will be asked to sign this consent form after you have had all your questions answered and understand what will happen in the study. The study has two main parts: During the initial session, which will last 45-60 minutes, you will be asked to complete questionnaires asking about yourself, your thoughts, and your feelings. The second session will be held one week later and will last 90 minutes. You will be randomly assigned to participate in one of two conditions, each of which will involve engagement in two cognitive tasks and completion of a small number of additional questionnaires. Physiological measures of heart rate will be collected during the tasks through the use of electronic sensors on the skin. You may be videotaped during the tasks. As soon as certain anonymous information is coded from it, this tape will be erased or destroyed. In the second session we will also collect saliva samples and blood samples.

Saliva samples will be used to determine the effects of the study tasks on your hormone levels. The samples will be analyzed at the Virginia Commonwealth University General Clinical Research Center after completion of the study and then destroyed. There will not be a way to link these samples to your name; only an anonymous ID number generated by you will identify them.

You will be asked to provide a sample of 40 cc of blood (just over one ounce, or two tablespoons) so that we can measure certain aspects of your immune system functioning and possible genetic factors that might be associated with emotions. A small, temporary system similar to an IV drip system will be placed in one of your arm veins at the beginning of the second session and left in place until the end of that session.. This will eliminate the need for repeated needle sticks. The blood samples will be securely stored at VCU until the completion of the study, at which time they will be assayed then destroyed. As with the saliva samples, all stored blood samples will be identified by an anonymous ID number generated by you, but no other identifying information. There will not be a way to link these samples to your name.

You do not have to answer any questions, or participate in any activities, you do not wish to. You may withdraw from the study at any time, without penalty. We plan to enroll 90 adults in our study.

Significant new findings developed during the course of the research which may relate to your willingness to continue participation will be provided to you.

RISKS AND DISCOMFORTS
The physical risks involved in this study are minimal and are related to having your blood drawn. The brief pain of a needle stick when having blood drawn from an arm vein will be minimized by our use of a pain-blocking cream on your skin prior to inserting the temporary IV line. The very slight chance of a local infection at the site of the needle stick will be minimized by our use of sterile procedures to place the IV line and to draw your blood.

You may also experience feelings of distress while participating in this study. The risks are not greater than the risks associated with daily living. However, if participating in this study causes you to feel upset or you become concerned about your psychological state or your current life situation, the study staff will provide you with contact information for resources available on campus that can help you address these issues, including:

- Center for Psychological Services and Development, which offers counseling services on a sliding fee scale; phone 828-8069.

- VCU Department of Psychiatry, which offers acute care services; phone 828-2000.

Fees for treatment will be billed to you or to appropriate third party insurance.

BENEFITS TO YOU AND OTHERS
You will be paid $50 for completion of both parts of the study. Partial payment will be given to you if you decide to end your participation before the study is over. You will also have the option to receive a personalized report describing your psychological and physiological responses in the study. The study is likely to yield generalizable knowledge to further society's understanding of the processes under study.

COSTS
There are no costs for participating in this study other than the time you will spend completing the tasks and filling out questionnaires.

ALTERNATIVES
The alternative to participating in this study is to not participate.
CONFIDENTIALITY
Potentially identifiable information about you will consist of a videotape record. That is, your second study session may be videotaped, but your name will not be recorded. We will give you the option to have this tape erased at the end of the study session; at that time, please speak to the person running the study if you wish to have the tape erased. That and all other data is being collected only for research purposes. Your data will be identified only by an anonymous ID number that you generate, not by your name or other personally identifying information. The tapes and the notes on them will be stored in a locked file cabinet in a locked laboratory at VCU. After the information from the tapes is

coded, the tapes will be destroyed. Access to all data and samples will be limited to study personnel. A data and safety monitoring plan is established.

We will not tell anyone the answers you give us; however, information from the study and the consent form signed by you may be looked at or copied for research or legal purposes by Virginia Commonwealth University. Personal information about you might be shared with or copied by authorized officials of the Federal Food and Drug Administration, or the Department of Health and Human Services (if applicable).
What we find from this study may be presented at meetings or published in papers, but neither your name will not ever be used in these presentations or papers.

GENETIC TESTING
Background information: This research involves genetic testing. Every tissue or fluid sample contains genetic information. Recent studies have found normal genetic variations among individuals that may be linked to emotions and changes in emotions, and this study will examine these kinds of genetic variations. The genetic information we will collect cannot be used to identify diseases or to determine who is related to whom.

The genetic samples in the present study will not have any personal identifying information attached and will be coded by anonymous study identification number only. These measures will help to ensure your confidentiality. This also means that you will not be contacted in future for further genetic testing research based on the genetic test results in this study.

Future contact concerning genetic testing results: The planned genetic testing results are unlikely to have clinical implications, and therefore the results will not be made available to study participants.

Confidentiality: The genetic information collected in this study will be identified by an anonymous identification number to maintain the privacy of your genetic information. Only the study investigators will know from whom the genetic information was obtained, and the blood samples from which the genetic information was obtained will be destroyed at the end of the study.
IF AN INJURY HAPPENS
Virginia Commonwealth University and the VCU Health System (also known as MCV Hospital) do not have a plan to give long-term care or money if you are injured because you are in the study. If you are injured because of being in this study, tell the study staff right away. The study staff will arrange for short-term emergency care or referral if it is needed. Bills for treatment may be sent to you or your insurance. Your insurance may or may not pay for taking care of injuries that happen because of being in this study.

VOLUNTARY PARTICIPATION AND WITHDRAWAL
You do not have to participate in this study. If you choose to participate, you may stop at any time without any penalty. You may also choose not to answer particular questions that are asked in the study. Withdrawal from the study will not affect you present or future University relationship.

Your participation in this study may be stopped at any time by the study staff without your consent. The reasons might include:
- the study staff thinks it necessary for your health or safety;
- you have not followed study instructions;
- administrative reasons require your withdrawal.

QUESTIONS
In the future, you may have questions about your participation in this study. If you have any questions, complaints, or concerns about the research, contact:

Kirk Warren Brown, PhD
Virginia Commonwealth University
808 W. Franklin Street, Room 202
P.O. Box 982018
Richmond, VA 23284
Telephone: 804-828-6754

If you have any questions about your rights as a participant in this study, you may contact:

Office for Research
Virginia Commonwealth University
800 East Leigh Street, Suite 113
P.O. Box 980568
Richmond, VA 23298
Telephone: 804-827-2157

You may also contact this number for general questions, concerns or complaints about the research. Please call this number if you cannot reach the research team or wish to talk to someone else. Additional information about participation in research studies can be found at http://www.research.vcu.edu/irb/volunteers.htm.

CONSENT
I have been given the chance to read this consent form. I understand the information about this study. Questions that I wanted to ask about the study have been answered. My signature says that I am willing to participate in this study. I will receive a copy of the consent form once I have agreed to participate.

_____

Participant name printed Participant signature Date

_____
Name of Person Conducting Informed Consent/Witness (Printed)

_____ _____
Signature of Person Conducting Informed Consent/Witness Date

_____ _____
Investigator Signature (if different from above) Date

INFORMATION ABOUT THE STUDY RESULTS

Please indicate by checking and initialing the category below what type of information you want to receive about your psychological responses in this study. If you wish to receive this information, it is your responsibility to let the study investigator know if your address and/or telephone number changes. The study investigator's contact information is in this informed consent form under the "Questions" section.

☐ _____ I would like to receive a personalized report on my psychological responses in this study.

☐ _____ I do not want a personalized report from this study.

FUTURE RESEARCH STUDIES

Please indicate whether you would like to be contacted in the future about the possibility of participating in additional studies by initialing the appropriate line below:

____ Yes, I would like to be contacted in the future about participating in additional studies. The phone number where I can be reached is: _____

____ No, I do not want to be contacted in the future for participation in additional studies.

Appendix B

Study Advertising: Mass Email Message and Poster

Dr. Kirk Warren Brown, PhD and Dr. Nancy McCain, PhD, nationally recognized VCU researchers of stress and wellbeing, are conducting a study examining psychological
factors in challenging, interesting cognitive tasks. Participants will be asked to complete simple psychological measures and provide blood and saliva samples during two cognitive tasks in a quiet, conveniently located laboratory on the MCV campus.

You may qualify to participate if you are available for two sessions (one 60 min, one 90 min) between 2 and 7 pm and meet the following criteria:

- Are at least 18 years of age and medically healthy
- Are not a regular smoker
- Are not using oral contraceptives (birth control)
- Are not pregnant
- Are not using drugs regularly

Participants will receive $50 and a personalized research report for completing the study. For more information please contact the Study Coordinator, Ms. Melissa Glennie at 804-828-5630 or at glenniemp@vcu.edu.

Created 05.25.2008

Participants Needed

JUN 12 2008

VCU Research

Dr. Kirk Warren Brown, PhD and Dr. Nancy McCain, PhD, nationally recognized VCU researchers of stress and well-being, are conducting a study examining psychological factors in challenging, interesting cognitive tasks.

Participants will be asked to complete simple psychological measures and provide blood and saliva samples during two cognitive tasks in a quiet, conveniently located laboratory on the MCV campus.

You may qualify to participate if you can complete questionnaires at home (45 min), attend one 2 hour session at MCV in **the afternoon**, and meet the following criteria:

- Are at least 18 years of age and medically healthy
- Are not a regular smoker
- Are not using oral contraceptives (birth control)
- Are not pregnant
- Are not using drugs regularly

Participants will receive **$60 and a personalized research report** for completing the study.

For more information please contact
the Study Coordinator, Ms. Melissa Glennie
804-828-5630 or glenniemp@vcu.edu

APPROVED 6-13-08 JC / JK

VCU Cognitive Task Study • 828-5630 glenniemp@vcu.edu

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Appendix C

Questionnaires

1. Mindful Attention Awareness Scale (trait)
2. Beck Depression Inventory IA
3. Profile of Mood States (Tension-Anxiety, Anger, Vigor subscales only)
   Note. The trait version is supplied here. The state version is exactly the same except for the instructions which ask the participant to report how they are feeling in the present moment.
4. Ruminative Responses Scale
5. Demographics

DAY-TO-DAY EXPERIENCES

Instructions: Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what *really reflects* your experience rather than what you think your experience should be. Please treat each item separately from every other item.

1	2	3	4	5	6
Almost Always	Very Frequently	Somewhat Frequently	Somewhat Infrequently	Very Infrequently	Almost Never

I could be experiencing some emotion and not be conscious of it until some time later.	1	2	3	4	5	6
I break or spill things because of carelessness, not paying attention, or thinking of something else.	1	2	3	4	5	6
I find it difficult to stay focused on what's happening in the present.	1	2	3	4	5	6
I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	1	2	3	4	5	6
I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	1	2	3	4	5	6
I forget a person's name almost as soon as I've been told it for the first time.	1	2	3	4	5	6
It seems I am "running on automatic," without much awareness of what I'm doing.	1	2	3	4	5	6
I rush through activities without being really attentive to them.	1	2	3	4	5	6
I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.	1	2	3	4	5	6
I do jobs or tasks automatically, without being aware of what I'm doing.	1	2	3	4	5	6
I find myself listening to someone with one ear, doing something else at the same time.	1	2	3	4	5	6

1	2	3	4	5	6
Almost Always	Very Frequently	Somewhat Frequently	Somewhat Infrequently	Very Infrequently	Almost Never

I drive places on 'automatic pilot' and then wonder why I went there.	1	2	3	4	5	6
I find myself preoccupied with the future or the past.	1	2	3	4	5	6
I find myself doing things without paying attention.	1	2	3	4	5	6
I snack without being aware that I'm eating.	1	2	3	4	5	6

BDI

DIRECTIONS: On this questionnaire are groups of statements. Please read each group of statements carefully. Then choose the one statement in each group which best describes the way you have been feeling during the PAST WEEK, INCLUDING TODAY. Circle the number to indicate your choice. *Be sure to read all the statements in each group before making your choice.*

Question 1

0 I do not feel sad
1 I feel sad
2 I am sad all the time and I can't snap out of it
3 I am so sad or unhappy I can't stand it

Question 2

0 I am not particularly discouraged about the future
1 I feel discouraged about the future
2 I feel I have nothing to look forward to
3 I feel that the future is hopeless and that things cannot improve

Question 3

0 I do not feel like a failure
1 I feel I have failed more than the average person
2 As I look back on my life, all I can see is a lot of failure
3 I feel I am a complete failure as a person

Question 4

0 I get as much satisfaction out of things as I used to
1 I don't enjoy things the way I used to
2 I don't get any real satisfaction out of anything anymore
3 I am dissatisfied or bored with everything

Question 5

0 I don't feel particularly guilty
1 I feel guilty a good part of the time
2 I feel quite guilty most of the time
3 I feel guilty all of the time

Question 6

0 I don't feel I am being punished
1 I feel I may be punished
2 I expect to be punished
3 I feel I am being punished

Question 7

0 I don't feel disappointed in myself
1 I am disappointed in myself
2 I am disgusted with myself
3 I hate myself

Question 8

0 I don't feel I am any worse than anybody else
1 I am critical of myself for my weaknesses or mistakes
2 I blame myself all the time for my faults
3 I blame myself for everything bad that happens

Question 9

0 I don't have any thoughts of killing myself
1 I have thoughts of killing myself, but I would not carry them out
2 I would like to kill myself
3 I would kill myself if I had the chance

Question 10

0 I don't cry any more than usual
1 I cry more now than I used to
2 I cry all the time now
3 I used to be able to cry, but now I can't cry even though I want to

Question 11

0 I am no more irritated by things than I ever am
1 I am slightly more irritated now than usual
2 I am quite annoyed and irritated a good deal of the time
3 I feel irritated all the time now

Question 12

0 I have not lost interest in other people
1 I am less interested in other people than I used to be
2 I have lost most of my interest in other people
3 I have lost all of my interest in other people

Question 13

0 I make decisions about as well as I ever could
1 I put off making decision more than I used to
2 I have greater difficulty in making decisions than before
3 I can't make decisions at all anymore

Question 14

0 I don't feel that I look any worse than I used to
1 I am worried that I am looking old or unattractive
2 I feel that there are permanent changes in my appearance that make me look unattractive
3 I believe that I look ugly

Question 15

0 I can work about as well as before
1 It takes an extra effort to get started at doing something
2 I have to push myself very hard to do anything
3 I can't do any work at all

Question 16

0 I can sleep as well as usual
1 I don't sleep as well as I used to
2 I wake up 1-2 hours earlier than usual and find it hard to go back to sleep
3 I wake up several hours earlier than I used to and cannot get back to sleep

Question 17

0 I don't get more tired than usual
1 I get tired more easily than I used to
2 I get tired from doing almost anything
3 I am too tired to do anything

Question 18

0 My appetite is no worse than usual
1 My appetite is not as good as it used to be
2 My appetite is much worse now
3 I have no appetite at all anymore

Question 19

0 I haven't lost much weight, if any, lately
1 I have lost more than five pounds
2 I have lost more than ten pounds
3 I have lost more than fifteen pounds
Note: Circle "0" if you have been purposely trying to lose weight

Question 20

0 I am no more worried about my health than usual
1 I am worried about physical problems such as aches and pains, or upset stomach, or constipation
2 I am very worried about physical problems, and it's hard to think of much else
3 I am so worried about my physical problems that I cannot think about anything else

Question 21

0 I have not noticed any recent change in my interest in sex
1 I am less interested in sex that I used to be
2 I am much less interested in sex now
3 I have lost interest in sex completely

MOOD STATES

Instructions: Below is a list of words that describe feelings people have. Please read each one carefully. Using the 0 to 4 scale shown below, circle one number for each word that best describes **HOW YOU HAVE BEEN FEELING DURING THE PAST WEEK INCLUDING TODAY.** The numbers refer to these descriptions:

0	1	2	3	4
Not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**

1.	Spiteful	0	1	2	3	4
2.	Vigorous	0	1	2	3	4
3.	Tense	0	1	2	3	4
4.	Angry	0	1	2	3	4
5.	Active	0	1	2	3	4
6.	On edge	0	1	2	3	4
7.	Lively	0	1	2	3	4
8.	Panicky	0	1	2	3	4
9.	Energetic	0	1	2	3	4
10.	Relaxed	0	1	2	3	4
11.	Furious	0	1	2	3	4
12.	Uneasy	0	1	2	3	4
13.	Annoyed	0	1	2	3	4
14.	Cheerful	0	1	2	3	4
15.	Resentful	0	1	2	3	4
16.	Restless	0	1	2	3	4
17.	Bitter	0	1	2	3	4
18.	Nervous	0	1	2	3	4
19.	Grouchy	0	1	2	3	4
20.	Ready to fight	0	1	2	3	4
21.	Alert	0	1	2	3	4
22.	Shaky	0	1	2	3	4
23.	Rebellious	0	1	2	3	4
24.	Anxious	0	1	2	3	4
25.	Deceived	0	1	2	3	4
26.	Peeved	0	1	2	3	4
27.	Full of pep	0	1	2	3	4
28.	Carefree	0	1	2	3	4
29.	Bad-tempered	0	1	2	3	4

RESPONSE STYLES

People think and do many different things when they feel sad, blue, or depressed. Below is a list of possibilities. Please indicate whether you never, sometimes, often, or almost always think or do each one when you feel down, sad, or depressed. Please indicate what you generally do, not what you think you should do. Write a number on the line besides each item.

1----------2----------3----------4
Almost Never Rarely/Sometimes Pretty Often Almost Always

1. **Think "What am I doing to deserve this?"** _____
2. **Analyze recent events to try to understand why you are depressed.** _____
3. **Think "Why do I always react this way?"** _____
4. **Go away by yourself and think about why you feel this way.** _____
5. **Write down what you are thinking and analyze it.** _____
6. **Think about a recent situation, wishing it had gone better.** _____
7. **Think "Why do I have problems that other people don't have?"** _____
8. **Think "Why can't I handle things better?"** _____
9. **Analyze your personality to try to understand why you are depressed.** _____
10. **Go someplace alone to think about your feelings.** _____

GENERAL DEMOGRAPHIC INFORMATION

Note. This information is being collected *only* to help us describe the study sample. It will remain strictly confidential and no information will be used to identify you personally, nor will it be shared with any other party.

1. What is your age? _____ years

2. What is your gender? (circle one) M F

3. What is your racial/ethnic origin? (check one)
_____ White or Caucasian
_____ Black or African American
_____ Hispanic or Latino(a)
_____ Asian
_____ Native American
_____ Other

4. What is your marital status? (check one)
_____ Single, not in a committed relationship
_____ Single and in a committed relationship
_____ Married
_____ Separated/Divorced, not in a committed relationship
_____ Separated/Divorced and in a committed relationship
_____ Widowed, not in a committed relationship
_____ Widowed and in a committed relationship

5. What is your job title? _____

Appendix D

Health Screen Phone Interview Script

Date ___ /____ /_____

Phone Screening Health Questionnaire

Interviewer Instructions: This study will include measurements of heart rate, three blood samples, and periodic saliva samples, and therefore we want to identify factors which may affect these responses during the investigation. I'd like you to please answer the following questions. Before beginning, I want to emphasize that all information that you provide will remain confidential, and feel free not to answer any questions that you feel uncomfortable in answering. If you have any questions as you go along, please ask me to clarify. Ok, ready?

1. I will read a list of medical conditions, and when I come to the end I'd like you to answer yes if you have any of them. You do not need to indicate which of these conditions you have, just answer yes if anything on the list applies to you. If you do not have any of these conditions, please answer no.

Yes **No**

_____ An endocrine disorder, such as Cushing's Syndrome or Addison's Disease.
_____ An autoimmune disease, such as lupus, rheumatoid arthritis, or multiple sclerosis.
_____ A severe immune disease, such as HIV infection or AIDS.
_____ A metabolic disease, such as adult diabetes, hypoglycemia or hyperglycemia.
_____ Chronic Fatigue Syndrome.
_____ A diagnosed anxiety or depressive disorder (within last 6 months).
_____ A chronic infectious disease, such as hepatitis, tuberculosis, mononucleosis, etc.
_____ Any form of cancer or tumor
_____ A blood disease such as hemophilia or leukemia
_____ Serious allergies or asthma as an adult
_____ A cardiovascular condition, such as hypertension
_____ If you have been pregnant or have breastfed in the last six months

2. **Over the past 7 days**, how many cigarettes have you smoked per day on average?

_____ cigarettes

3. Now I'd like you to tell me if you have taken any of the following types of prescription and recreational drugs **in the past seven days.** I will read a list of drugs and when I come to the end, I'd like to answer yes if you have taken any of them. You do not need to indicate which of these drugs you have taken, just answer yes if anything on the list applies to you. If you have not taken any of these drugs, please answer no.

Yes **No**

_____ Birth Control Pill
_____ Aspirin
_____ Marijuana
_____ Cocaine
_____ Ecstacy

_____ Speed

4. How tall are you?

_____ feet _____ inches

5. How much do you weigh?

_____ lbs

[BMI = _____]

Exclude if ANY of the following questions are marked with the answers below:

1. = YES
2. = > 0 cigarettes
3. = YES

BMI = > 32

Interviewer recruitment action taken:

_____ Prospective participant matches one or more of the exclusion criteria. Informed that,

"Unfortunately, the exclusion criterion/criteria (to be named here) prevent us from enrolling you in the study. However, I want to thank you for your interest in this project."

_____ No exclusion criteria met. Proceeded to schedule Part 1 appointment with the following:

"The purpose of this study is to investigate the effects of various psychological factors on engagement with, and psychological and physiological reactions to, two challenging cognitive tasks we will ask you to complete. In the first part of the study, you will be asked to complete a packet of psychological questionnaires at home. It will take about 45 minutes. I will mail this packet to you, along with a consent form that we ask you to read first. After you read the consent form, please call me if you have any questions about any aspect of the study. My phone number will be on the consent form. You will not have to sign the consent form after you read it; your completion and return of the packet will be taken as your agreement to complete the first part of the study. I ask that you bring the completed packet with you when you come for the laboratory portion of the study. That second part will involve two effortful cognitive tasks, the completion of several additional questionnaires, and the collection of saliva samples and blood samples to assess physiological responses to the tasks. You may be videotaped during the tasks. You will be able to let the experimenter know if you do not wish to be videotaped."

"It is important to note that because of certain biological rhythms we need to account for, participants have to attend the second, or laboratory part of the study at either 12:30 pm or 2:30 pm. Will either one of those times be ok for you?"
[If male] "Due to the fact that we will be assessing heart and respiration rate through electronic sensors that rest on your skin, it may be necessary to shave small areas on your chest to get a good connection. Will that be alright?"

[If yes] “Do you have any questions at this point?”

[Once those are addressed]

[If there are any questions you cannot answer, inform them that the Study Coordinator will get back to them soon with a response.]

“Can we go ahead and arrange to have the questionnaire packet mailed to you?”

“Ok, I’ll ask you to give me your name and a US Mail address that is certain to come to you personally. And by the way, your name and mailing address will be used only for this purpose; we will not share this information with anyone and it will not be attached to the study data you provide.”

Name: _____

Address: _____
_____

“Can we go ahead and set up an appointment for you for the second part of the study?”

Date and time of Part 2 appointment: ___ /____ /_____ @ _____ pm

“Thank you very much for your participation.”

Appendix E

Exclusion Criteria Checklist

Today, have you …

Engaged in strenuous exercise?	Y	N
Drank alcohol?	Y	N
Smoked any cigarettes?	Y	N

Within the past hour, have you …

Consumed any dairy products?	Y	N
Consumed any caffeine?	Y	N
Eaten anything?	Y	N

Appendix F

Trier Instructions Script

This tape contains instructions for the cognitive and performance activities portion of today's session. Please listen carefully to the following instructions.

In approximately **ten minutes** the cognitive and performance activities portion of the session will begin. During this portion of today's session, you will be asked to participate in **two activities**. For the first activity, you will be asked to give a **5-minute speech** and for the second activity you will be asked to **do a number counting exercise**. Instructions for the counting exercise will be given directly following your speech. You will be given the instructions for the speech portion of the activity now.

In ten minutes, you will be asked to deliver a speech in which you will talk freely for 5 minutes. During your 5 minute speech, please pretend that you are applying for a job and explain why you believe you would be a good candidate for the job. The job for which you are applying is for a position in which you would have to work effectively with other VCU employees to come up with solutions to problems typically faced by other employees in your department or unit. During your 5 minute speech please talk about why you believe you would be a good candidate for this job. You can talk about the skills, abilities, attributes, traits, or experience that you possess that you believe makes you a good candidate. *Please assume that you are actually applying for this job and describe qualities and qualifications that you believe you actually possess that would make you a good candidate for this job.* As previously stated, the speech should be for a position in which you would have to work effectively with other VCU employees to come up with solutions to problems typically faced by other employees in your department or unit.

In ten minutes, a panel of evaluators will enter the room. You will then be asked to deliver your 5 minute speech to this panel of evaluators. The evaluators will listen to your speech and **will evaluate your performance and the content of your speech**, including the quality of your presentation and your ability to communicate your points effectively to the panel. You will also be videotaped so that your speech and non-verbal behavior can be analyzed later by the panel. The videotape will be evaluated for poise, articulation, style, and your communication abilities.

You now have 5 minutes **to mentally prepare your speech**. During this time please think about what you will say during your speech. As you will not be able to use any notes during your speech, please mentally prepare for your speech without the assistance of any notes.

It is important that you try your hardest to give an articulate and well-planned speech. In addition, it is critical that you speak for the entire five minutes.

Please put all other reading materials away and concentrate on preparing your speech now. The panelists will enter in ten minutes to evaluate your speech on why you would be a good candidate to work effectively with other VCU employees to come up with solutions to problems typically faced by other employees in your department or unit. Please begin to mentally prepare for your speech now. You have 5 minutes to prepare.

Appendix G

Experimental Protocol

TSST Study Protocol SON 2008

***Before Participant Arrives*:**

1. Prepare study materials as follows:
    a. Put on lab coat and have a pen in lab coat pocket w/ stopwatch
    b. put p's ID on all 6 packets & label DVD's & CD, & study set up sheet
    c. ready CD instructions & metronome DVD
    d. camera system ready with 3 blank DVDs in DVR's 1 (cam 2), 2 (cam 4), and 4 (cam 3). Check presets for couch, blood, closeup, fullbody, & evaluators
    e. microphone system ready (set volumes in control & viewing room to max; mute observation rm until paced breath, CD instructions or answering questions)
    f. put supplies in view room: magazines, tissues, 5 salivettes displayed and labeled with ID number, marker, bio baggy, bottled water, disposable razor
    g. have blank CD & envelope aside and labeled to burn afterwards
    h. have extra pens/pencils ready in control & view room
    i. ready evaluator scripts & surveys on clipboards w/ pens & labcoats & stopwatch
    j. put p's consent forms & 6 packets on table w/ a clipboard & pen in view room.
    k. Have protocol on clipboard ready w/ set up sheet on bottom.

2. Prepare LifeShirt materials:
    a. Ready supplies in view room: Tape measure, sizing chart, clean garments in all sizes, 3 ECG electrodes
    b. 1 labeled cases, each with: 2 batteries,1 recorder,1 data card,1 data cable,1 fanny pack, 1 wireless card, yellow cord, wireless box.
    c. Plug the wireless box into the computer with the yellow cord, plug power adapter into the wall. Insert wireless card into the right side of the recorder.
    d. Place the dongle into the USB port of the computer.
    e. Turn on recorder to check that the time stamp is accurate
    f. Plug card reader into computer. Insert the data card into the reader. Make sure the only files on the card are the programming files (including a wireless OPT file). If there are any data files, save them to a file on the computer and delete them from the card. Place the data card into the recorder.
    g. Record case letter being used on the set up sheet.
    h. Check the charge of both batteries.
    i. If the light is green, the battery is charged. If one of the batteries is not fully charged, place it in the charger and let it charge during the experiment. The Battery Charger will recharge batteries in a few hours. Place charged battery into the recorder. **(use right/ charge left**)

Unlock viewing room door

1. Greeting

"Hello, I'm xx. I'll be the experimenter for the study today."

Record the participants' ID & time in on the log-in sheet.

2. Show both rooms
"This is the room that I will be in when I am not with you. And this is the room that you will be in today. Please have a seat on sofa facing the window."

3. Intro
"Did you bring a cell phone today?" If so, *"Please turn it off now so that we may begin."*
"Let me begin by telling you a bit about this study. This study seeks to understand the ways in which your engagement in tasks relates to a variety of psychological factors. If you agree to participate in the study, you will be asked to complete the study today. The entire session is expected to take 2 hours. You will be asked to complete questionnaires asking about your characteristic ways of thinking, feeling, and acting. You'll also be asked to engage in two cognitive tasks here in the lab. As part of this, we will also collect saliva and blood samples to examine physiological responses to the tasks, as well as ask you to complete a small set of additional questionnaires at several points during our time here today. Do you have any questions about the study at this point?"

4. Informed Consent
"Before we get started, we'd like you to read the informed consent form for the study. If you agree to participate in the study after having read the consent form, we ask that you print and sign your name and date in the appropriate place on the last page [show them the line]. *There are two copies so you can keep one for yourself. And just so you know, it is pretty much the same information you received in the form that was mailed in the packet you got at home. When you're finished or if you have any questions, please just speak into the microphone right here* [show them the line]."

If there are questions, answer them **but without saying anything about the purpose of the study except to repeat what you've already said. Do not say that the "real" purpose of the study, or even that "more" about the study will be discussed later**. Simply repeat what you've already said above.

5. Exclusion criteria
"So first of all, I just want to make sure that we check that you've met the study criteria for today."
Go to exclusion criteria checklist
If they qualify say, *"Great, now we can continue."*

If they don't qualify say, *"Unfortunately, the exclusion criterion/criteria (name it/them here) for this study prevent us from continuing today. You may recall that we asked you to refrain from _____ on the day of (or 1 hr before) this session. That is just a requirement of the study, unfortunately. However, we would like to reschedule another appointment with you."*

Set up another appointment with a date that is as close as possible to the current date.

5. Lifeshirt fitting
"Now, I would like to fit you for a LifeShirt. The LifeShirt is like a t-shirt that will measure basic physiological measures like heart rate and respiration through electronic sensors that rest on the skin. Let's head over to the other side of the room so that we can get your shirt."
If necessary, *"Please remove any baggy outer layers of clothing."*

Using the tape measure, measure the chest underneath the armpits and the abdomen at the belly button. **Record measurements**

Refer to the sizing chart. Select the correct sized LifeShirt, **record shirt number**.
Before you leave show them how to put it on.
"Now, I will escort you to the bathroom to put on your Lifeshirt. Please put it on underneath your shirt, it should rest directly on your skin. Tell women, "It is OK to wear a bra underneath."
Unzip the black zipper only. Show them the white zipper and say,
"When you put this shirt on, only zip up the white zipper – leave the black zipper unzipped. When you are finished, I will escort you back to the room. You will not be able to use the restroom once we continue with the rest of the study. So. if you would like to use the restroom now, this is a good time."

If a man has excessive chest hair, you need to shave it. *"As mentioned in the phone interview, I am going to have to shave a small portion where I will place the electrodes for two reasons. 1 - In order to get a good connection between this electrode and your skin, there cannot be any hair AND 2 – It will hurt taking the electrode off at the end of the session if it is pulling hair."* Use a disposable razor and gently shave the necessary regions.

Adjust side straps to ensure a good fit.
Attach data cable to Velcro. Black and white wires go on top, Red wires go on the bottom
Connect 4 black wires into data cable
Thread the ECG leads through the slits
Snap leads to electrode & put on skin through slits
Put on fanny pack
Connect data cable to the recorder
Power on the recorder & make sure it is working. Check data and time. Click yes through configurations. Confirm that the recorder is now collecting data.
Record time for putting on Lifeshirt.
Put the recorder into the fanny pack
"You may now put your clothing on over the LifeShirt."

6. Blood catheter placement
"*Now, we'd like to place a small, temporary blood collection system in one of your arms and that will be left in place until the end of this session. This will eliminate the need for repeated needle sticks. The system we'll use involves minimal pain if any at all. The blood samples will allow us to measure immune responses and possible genetic factors that might be associated with your responses to the tasks today.*
I want to introduce you to ?? who is a Nursing graduate student here at VCU. She is trained in the collection of blood samples and will set you up for that right now."
Record time for Blood placement. Record time for Baseline start

7. Check Lifeshirt equipment
Return to sofa with back straight & feet flat on floor.
"Now I'd like you to please sit up straight with your feet flat on the floor like I am sitting right now. Please just breathe normally for a few moments. I will check to make sure that the Lifeshirt data is recording properly." Then leave the room.
Check for even respiration waves and clear heart beat spikes.

8. Paced breathing (over the mic)
"Now, I'm going to continue to check the Lifeshirt equipment and I'd like you to do what's called "paced breathing". This means breathing in for 2 beats of a metronome that I will play over the intercom, and then out for

2 beats. Let me demonstrate what I mean…Breathe in for 2 beats [clap clap] then out for 2 beats [clap clap]. [Simultaneously clap] In…Out…In…Out… We do this for 2 minutes. Do you have any questions about this breathing task? I'll start the metronome now. Please follow the instructions when the metronome stops."
Start Metronome DVD. Record start time for paced breathing. Record stop time for paced breathing.

9. Resting breathing
Record start time for resting. Stop Metronome DVD after instructions. Record stop time for resting.

10. Packet 1
"Ok, here's our first brief packet of questionnaires about how you're doing right now. Please just speak into the microphone when you're finished or if you have any questions."

11. Check the time. Go no further until 1pm. If necessary, just wait, no magazines.
(over the mic) *"We have a short rest period until we continue with the next stage of the study. I'll be back when the time is up."*

12. Saliva 1 Mark time on tube If before 1pm, then wait!
"This is the first point that I'd like to ask you to provide a saliva sample… First, let me explain how the salivette works. As you can see, there is a big tube with a little tube inside it [take it apart to demonstrate]. *I'll ask you to place this cotton salivette in your mouth for about a minute. I need to make sure that it's in your mouth long enough to get an adequate sample. You can chew on it, suck on it, do whatever it takes to create enough saliva. I'll tell you when the time is up and you can put it in this little tube and then place the little tube back into the larger tube and put everything is this baggy."*
Record time for 1st saliva collection.

13. Blood 1
"*Now, we'd like to collect a first blood sample which will allow us to measure immune responses and possible genetic factors that might be associated with your responses to the tasks today.*
Record time for 1st Blood. Record time for baseline stop

14. Speech Prep
"Ok, now we're ready for the two cognitive tasks. I'll play the instructions for these tasks over the intercom. Again, just speak into the microphone if you have questions about the tasks."
unmute the observation room mic
Start CD instructions
mute the observation room mic **Record start time for TSST Speech Prep**
Wait outside door at 4:30. Go in at 5 mins.
Record stop time for TSST Speech Prep

15. Packet 2
"Before you begin the first task, we would like you to please complete this brief packet of questionnaires about your perceptions of the upcoming tasks. Again, let me know when you're done."
Double check camera settings.

16. TSST
When P is done, pick up Packet 3, and introduce TSST **Move microphone**

"You will now complete your speech and math task. Please stand on this spot right here [Point to spot on floor]. *It is important that you not move from this spot during both tasks."*
Start Camera DVD Record. Send in Evaluators
Record TSST start time. **Record TSST stop time**.
Stop Camera DVD Record before you reenter
Record start Recovery 1 **Move microphone**

17. Saliva 2 **Mark time on tube**
"We'd now like to collect a second saliva sample just like before. Take the cotton salivette out of the little tube and keep it in your mouth for a minute. Then, put it back in the little tube, put the little tube into the big one, and put everything in the baggy." **Record time 2nd Saliva**.

18. Rest 1
"Here's some magazines you can look through until we're ready to start the next part of the study." Then leave the room until **10 mins** has passed since TSST stop time.
Record stop time recovery 1. **Record start Recovery 2**

19. Saliva 3 **Mark time on tube**
"Ok, we'd now like to collect a third saliva sample just like before." **Record time 3rd Saliva.**

20. Packet 3
"Ok, here's our third brief packet of questionnaires about how you're doing right now. Again, just speak into the microphone when you're finished or if you have any questions." **Record stop time recovery 2**. **Record start Recovery 3**

21. Rest 2
(over the mic)
"We have another rest period, you can read the magazines until we're ready to start the next part of the study. I'll be back when the time is up." Wait until **20 mins (+10)** has passed since TSST ended **Record stop time recovery 3**. **Record start Recovery 4**

22. Saliva 4 **Mark time on tube**
Pick up Packet 4 *"Ok, we'd now like to collect a fourth saliva sample just like before."* **Record time 4th Saliva.**

23. Packet 4
"Here's our fourth brief packet of questionnaires about how you're doing right now and your thoughts. Again, just speak into the microphone when you're finished or if you have any questions." **Record stop recovery 4**
Record start Recovery 5

24. Rest 3
(over the mic) *"We now have another rest period, you can read the magazines until we're ready to start the next part of the study. I'll be back when the time is up."*
Wait until **35 mins (+15)** has passed since TSST stop time. **Record stop recovery 5 Record start Recovery 6**

25. Saliva 5 (Reenter with nurse) **Mark time on tube**
*"Ok, we'd now like to collect a fifth saliva sample just like before."***Record time 5th Saliva.**

26. Blood 2
"?? will now collect the 2nd blood sample." **Record time 2nd Blood.**

27. Packet 5
"Here's our fifth and final brief packet of questionnaires about how you're doing right now and your thoughts. Again, just speak into the microphone when you're finished or if you have any questions."

28. Check the time. Record stop Recovery 6 at 20mins total. If not done with Packet 6, inform them that there is approximately 10 minutes left (over the mic) & let them continue until the 30 min rest is up and collect 3rd blood. Do debrief & payment after blood.

29. Debriefing

"Now, most of our session is done. First, I would like to thank you for participating in all of the activities we have asked you to do in this study. We realize it can be quite a challenging study and we really appreciate your effort. So, how are you feeling?
We have a little bit left but while we're waiting I want to tell you a bit more about the study. Before I discuss the study with you in a little more detail, do you have any questions about the experiment? Before I tell you about the goals of this study, I want to explain why it is necessary in some kinds of psychological studies not to tell participants all about the purpose of the study, or even about how challenging it will be, at the very beginning. The reason is that doing so might affect the person's behavior in such a way that how they act or react in the study would no longer be a good indication of how that person reacts spontaneously in everyday situations. Discovering how people naturally react is what we are really trying to find out here. So, we are really trying to mimic what people's experience would be like in the real world, where things come at us unexpectedly or we don't know exactly how to respond to challenging situations. To see people's natural or spontaneous responses, we have to wait until after the study (that is, right now) to fill in the details on the study goals.

I should mention that this is not a problem in all psychological studies. For example, in a study on learning, if you wanted to have people learn something and then test them, you might want them to know exactly what they were going to be tested on. That way they could do their best to learn what you wanted them to. But in studies like this one, we need to see people's natural responses for the study findings to say something meaningful about what might happen in stressful everyday life situations. Can you see why it's important to hold off on revealing the whole purpose of the study at the beginning, because if we did it might influence your behavior and make the data invalid?

Now, I would like to explain exactly what we were trying to study in this experiment. Remember when you called, I told you we were interested in studying your psychological and physiological responses to demanding cognitive performance activities? Ok, this is all true. But it is important to say that the procedure today was <u>designed</u> to induce a challenging, even stressful experience. Everyone participating in the study receives the same treatment so that we can better understand how different people cope with the same kind of stress. So the goal in being evaluated by the panel was not to judge you as a person, or to judge your performance but only to induce a stress response. Do you see what I'm saying?

Now, in more detail, this study is part of a program of research designed to assess the importance of a number of psychological factors for handling the kinds of stressors that we all experience - such as taking an important test, having to give a presentation before an audience, or having a stressful interaction or conflict with someone. We're

particularly interested in how several indicators of psychological resilience that you completed in the first session of this study – like how tuned in people are to their emotions, and certain personality traits – help to determine how well people regulate their emotions when confronted with challenging situations.
The measures of emotional state you completed today, the heart rate and respiration measures, the saliva and blood samples you provided, and even the video record, are all important indicators of the various ways that people respond under such stressful circumstances. For example, everyone's saliva has different levels of hormones and everyone's blood has immune markers that reflect responses to stressful situations. We are also interested in people's thoughts and emotions both before and after the speech and math activities. That is why we asked you to fill out the questionnaires asking you how you currently felt and your thoughts about the tasks and your performance.

Did you find the tasks stressful? [If so] That is completely normal. Most everyone finds both of the tasks challenging, even stressful. And we realize the study can also make people feel annoyed about having to do some of the activities. Unfortunately, there is no way to study in detail people's psychological and physiological responses to demanding social and other situations without exposing them to such situations in a laboratory. However, we feel that it is very important to try to understand how people respond to challenging or stressful experiences. The reason why we're examining whether psychological resilience predicts responses to challenge or stress on all of the psychological and physiological measures you provided is to help us to design better programs for boosting resilience to stress that people commonly experience at work, at home, and in their lives generally. This is important because how people respond to real-life stressors can have consequences for their mental and even physical health. For example, some people might show heightened psychological and physiological responses to our laboratory activities and these same people might show similar heightened responses to real-life situations. So if we can identify those factors that help people to regulate their reactions to stress situations, that may have important benefits for their health and well-being.

Ok, so how do you feel now? Based on what I've said so far, do you understand why we asked you to do the activities and why we believe they are important to the study?

(Note to debriefer: Be sure to spend some time here monitoring the participant's mood state. If they still seem upset be sure to keep talking to them about their thoughts and feelings. Be sure to emphasize that we realize the procedures might have upset them and that we want to understand how they are feeling about their experience and to make sure that we have them feeling ok/good about their participation before they leave. Building rapport is very important here. Asking them their opinions about the study or any of the procedures also gives them an outlet to vent their frustration and then you can try to reassure them that you understand why they might be upset, etc.)

I want to emphasize how important your participation was in this study. The study is quite involved, and your data is an important contribution to our research goals. Now, the data of other participant's will also be very important. Thus, it is very important that we make sure that other people who will participate in the experiment enter the same way you did. So, for example, when you came here you did not know that you might perform speech and math tasks in front of other people. And you didn't know the specific purpose of the at-home questionnaires that I told you about today? Well it is important that other participants also ***don't know*** *about these details beforehand, as it could easily bias their natural responses to the questionnaires and to the tasks. If that happened the data that we got from you and other people in the past would be useless and the time spent in doing this experiment, including the time you spent participating today, would be wasted. So that is why we have to ask you not to tell others about the goals of the study or to share the information we just discussed. This is hard, I realize, especially when we go through a demanding situation, we want to tell people about it!*
For some people, it's easy to think, what difference does it make if I talk to one of my co-workers, because there are so many VCU employees, it's not likely they will be in the study. That may be true, but they might say something to

someone else who will be. Do you see what I mean? Ok, so are you willing to refrain from talking to anyone at VCU about this study?

Now, if you want an easy thing to tell people if they ask you about the experiment is that is was about people's psychological and physiological responses to challenging tasks.
I do hope that this study will feel worthwhile to you. It makes me feel better to let you in on what we are trying to achieve. We feel that both experimenters and participants are working together to make important discoveries and contributions to people's well-being.
Do you have any other questions or comments about anything you did today or anything we've talked about? I want to sincerely thank you again for your participation and I've enjoyed the opportunity to do research with you.

If there are ?'s you cannot answer, say to contact Kirk using the contact info on the consent form.

30. Prepare Payment

"Ok, we have to wait just a bit longer to collect the final blood sample. In the meantime, we can prepare your payment for participating in the study. This is the form we will use. Please check to make sure the information is correct, enter your SSN and sign at the bottom.

31. Rest 4

We still have a little more time, so you can just sit and relax for a bit until the nurse is ready for the final blood sample.
Then leave the room until **65 mins (+30)** has passed since TSST stop time.

32. Blood 3

" ?? will now collect the final blood sample." **Record time 3rd Blood**

33. Remove Lifeshirt

"Now we can begin to remove the LifeShirt system."

Remove recorder from fanny pack, stop session & power off. **Record time Lifeshirt off.**
Disconnect the Recorder from the Data Cable and set the fanny pack & recorder aside
Unzip the black zipper.
Gently unsnap the ECG leads from the electrodes on their chest. Pull the leads out through the slits
disconnect the 4 LifeShirt wires & gently remove the Data Cable from the LifeShirt & set aside
Loosen the straps on both sides of the LifeShirt.

"Now, I'll escort you to the restroom so you can remove the Lifeshirt and put on your regular clothes. Here is the white zipper. Just unzip that completely and you can take the shirt off. Gently pull the electrodes off your chest and abdomen and throw them in the trash. When you're finished and dressed, please bring the shirt back to this room and we will continue."

34. *"How are you doing?"*
In the event of any undue distress arising from the procedure, refer to the resources listed on the consent form.

35. Thank the P for coming. Make sure they have a copy of the consent form. Then say,

"If you indicated on your consent form that you wanted a personalized report of your responses to the study, we'll be sending it to you later this year."

36. Escort the P out of the office and to the elevator. **Record study ending time.**

Part F: After Participant leaves.

1. Give salivettes to whomever the hand off person is. Make sure they are correctly labeled.
2. Label new salivettes and place them in the participant salivette rack (for the next participant)
3. Lifeshirt maintenance & data download.
   a. If it is necessary, wipe down any hardware with a damp cloth to dislodge any organic material. Take care not to allow fluids into contact with the electronic components.
   b. Log shirt into cleaning list & put LifeShirt in section to be cleaned
   c. If a battery was being charged during the session, place the battery back in the case.
   d. Remove the data card from the recorder and insert into the data card reader. Click green button on reader. Window will appear for Sandisk TransferMate. Click Browse. Desktop > VivoData. Click OK. DO NOT Check erase files from card. Click Transfer. Click Quit
   e. Confirm that the file is in the VivoData folder on Desktop and be sure to rename it with the participants ID #.
   f. Convert the file. Open up VivoLogic software. Go to File>Import Raw Data. Browse to the saved file in the VivoData folder for input. Browse to the location you want to save the converted file (same folder). Click OK
   g. Burn a CD. Put a blank CD into the drive. Open the window for the CD – click on My Computer and double click on D drive. Drag the subject's files (both the raw data & converted viv file) from the VivoData folder to the D: window. Click "Write files to CD" on the left
   h. Make sure to write P's #, date, & TSST start time on the CD and store with the rest of their materials.
   i. Open the F Drive on the computer while the card is in the reader. Delete the 2 participant's files only. Leave the programming files for the next participant
   j. Put all the hardware back in the case and store on the shelf

4. Finalize DVDs. Label 3 TSST DVD with ID, date/time, and camera position (closeup, full body, evaluators)
5. Put all participant materials together (informed consent, questionnaires, panelist evaluations, time log, DVD, CD) and place them in storage. **Make sure ID is correctly labeled on all materials. Bring all participants completed materials back to 806 lab once a week.**

6. Put away all study materials. Or if there is another participant, get new study materials ready.

Appendix H

Evaluator Script

Panelist Roles and Behavior

There will be two panelists at a time for each session. One panelist (Panelist A) will be in charge of giving the instructions and making sure things run smoothly in the speech portion of the experiment. The other panelist (Panelist B) will give the instructions for the counting backwards task. Before greeting the participant, decide who will Panelist A and who will be Panelist B.

The purpose of being a confederate is to make the subject feel uncomfortable. Your job as an evaluator is to present **a** serious and stoic, but not hostile, demeanor towards the participant. This means that you shouldn't smile, nod your head, or provide affirmative verbal responses, such as "mm-hmm." You should keep frequent eye contact with the participant and pretend to be evaluating their speech. Note that this is a very difficult task. It is especially difficult not to smile or nod your head. Generally, this is done by giving a cold and impersonal evaluative impression.

Panelists should try and:

-maintain a stony face
-no head nodding or signs of speech support "mm-hmm"
-no smiling
-maintain direct eye contact
-keep emotional distance
-be objective
-write comments down on a clipboard (as noted below)

It is important that we standardize how many times you look down at your clipboard and how many times you write things. So, to do that, there are 14 checkboxes down below, for you to use during the speech task. Our goal is to look down at the clipboard and **mark off a box approximately every 20 seconds or so – so that by the end of the 5 minutes we have marked off all 14 boxes.** I also want you to pretend to write a few comments about the subject, so I have put down 3 lines for you to do that – so **make 3 written comments throughout the 5 minutes**.

Be sure not to necessarily always write or check boxes when your partner does.

Participant ID# _____

Panelist B: Point to the cameras and say
"You can see the cameras there and there. We will now begin recording your performance. It is important that you look at us during your entire performance"

Panelist A: *"Please begin with your speech, you have five minutes."* **Panelist A is timekeeper**
(Check off these boxes every 20-30 seconds, and write three comments during the speech)

☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐

Speech job title: an administrative assistant in the psychology department. As part of this position, you would be asked to perform activities such as filing, organizing, contacting participants, coordinating research projects, writing up research reports, and working with other professors and graduate students.

- Interrupt sentences with a comment or question. Do not make a comment or ask a question at the end of a sentence.

Questions and comments you can make:

Panelist A:

- If they pause >15 s before time is up say, ***"You still have time remaining, please continue."***

-*"What qualifies you in particular for this position?"*

-*"I don't think you have made a good case, please elaborate on _____."*

-*"So you do not have any experience in _____?"*

Panelist B:

-*"What makes you better than all the other candidates?"*

-*"What you are saying is irrelevant to this position, please stay on topic."*

-*"I don't see how _____ is beneficial for this position. Can you please explain."*

- In response to odd or humorous behavior take notes on the behavior and say, *"Professionalism is important in this speech."*

- If they look away say, *"Please look at us."*

(After completing the speech task)

Panelist A: *"Okay, your 5 minutes are up, please stop. We will now move on to the counting task."*
Counting task instructions

Panelist B: *"We will now give you the instructions for the counting task. We want you to solve a calculation task. Please count aloud backwards from 2,083 to zero in 13-step sequences. Please calculate as quickly and correctly as possible. Should you miscalculate, we will point out your mistake and you have to start all over again."*

"We now ask you to count backwards from 2,083 by 13's. Please do this as quickly and as accurately as possible. Also, keep your eyes open and face forward at all times. Please begin."

Panelist A is timekeeper and holds the watch in hand. There is no need for Panelist A to ever look at the sheet. Just stare at the subject and occasionally glance at the time.

Arithmetic Check:

2083	1992	1901	1810	1719	1628	1537	1446
2070	1979	1888	1797	1706	1615	1524	1433
2057	1966	1875	1784	1693	1602	1511	1420
2044	1953	1862	1771	1680	1589	1498	1407
2031	1940	1849	1758	1667	1576	1485	1394
2018	1927	1836	1745	1654	1563	1472	1381
2005	1914	1823	1732	1641	1550	1459	1368

Things to say during the counting task

Panelist B:

-If they make a mistake say, *"That is incorrect, please start over beginning at 2,083 and count backwards by 13's."*
-If they keep on making mistakes say, *"It is very important to be accurate and to not make any mistakes. Please start over."*
-If they lean their head back or close their eyes say, *"Please keep your eyes open and/or your head level."*
-If they look away say, *"It is important that you look at us."*

Panelist A: (At one minute intervals, say): *"Please go faster."* **Wait a few seconds if panelist B is making a comment, but stick to the same one-minute interval for the next comment.**

After counting task

Panelist B: *"Thank you for completing the calculation exercise. This completes the performance portion of this study. The experimenter will return to the room shortly."*

Do not answer any questions the participant may ask. Just quietly leave the room.

(Both panelists leave the room.)

Subject ID # _____

Date:_____

YOUR IMPRESSIONS OF THE PARTICIPANT

DURING THE SPEECH:

How **nervous** would you say the participant was?

1	2	3	4	5	6	7
not at all nervous						very nervous

How **anxious** would you say the participant was?

1	2	3	4	5	6	7
not at all anxious						very anxious

How **embarrassed** would you say the participant was?

1	2	3	4	5	6	7
not at all				embarrassed		very embarrassed

How **confident** would you say the participant was?

1	2	3	4	5	6	7
not at all confident						very confident

How **apologetic** (i.e., did they say there were 'sorry' often) would you say the participant was?

1	2	3	4	5	6	7
not at all apologetic						very apologetic

Did the subject **maintain eye contact** during the speech?

1	2	3	4	5	6	7
not at all			half of the time			most/all of the time

What was the subject's **voice like**?

1	2	3	4	5	6	7
very shaky						very strong

1 2 3 4 5 6 7
very quiet very loud

Was the subject **'fidgety' or did they perform odd body movements (e.g., wringing hands)?**
1 2 3 4 5 6 7
never/not at all definitely/ all the time

Overall, please rate the subject's performance on the speech task:
1 2 3 4 5 6 7
very poor excellent

DURING THE MATH TASK:

How **nervous** would you say the participant was?
1 2 3 4 5 6 7
not at all nervous very nervous

How **anxious** would you say the participant was?
1 2 3 4 5 6 7
not at all anxious very anxious

How **embarrassed** would you say the participant was?
1 2 3 4 5 6 7
not at all embarrassed very embarrassed

How **confident** would you say the participant was?
1 2 3 4 5 6 7
not at all confident very confident

How **apologetic** (i.e., did they say there were 'sorry' often) would you say the participant was?
1 2 3 4 5 6 7
not at all apologetic very apologetic

Did the subject **attempt to make eye contact**, look back at you to see if you were watching, etc.?
1 2 3 4 5 6 7
not at all half of the time most/all of the time

Did the subject make **any comments out loud or directly to you**?

1	2	3	4	5	6	7
never/not at all						very often

Any notable remarks that the subject made? Please list: _____

_____

Was the subject **'fidgety' or did they perform odd body movements (e.g., squirm in chair)?**

1	2	3	4	5	6	7
never/not at all						definitely/ all the time

Overall, please rate the subject's performance on the math task:

1	2	3	4	5	6	7
very poor						excellent

Vita

Melissa Page Holt was born on January 6, 1982 in Fairfax County, Virginia, and is an American citizen. She graduated from Osbourn Park High School, Manassas, Virginia in 2000. She received her Bachelor of Science in Psychology from University of Mary Washington, Fredericksburg, VA in 2004 and subsequently worked as a research assistant for Georgetown University's Department of Psychiatry in Washington, DC for three years. She received her Master of Science in Experimental Psychology from Virginia Commonwealth University, Richmond, VA in 2009.