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EXAMINING THE MINDFULNESS – STRESS RESISTANCE RELATION: THE
MEDIATIONAL ROLE OF AUTONOMY

A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science at Virginia Commonwealth University.

by

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December, 2009

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Abstract

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By Melissa P. Holt, B.S.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

Virginia Commonwealth University, 2009

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Mindfulness – a receptive attentiveness to present experience – has been shown to promote more adaptive emotion regulation (Brown, et al. 2007) and predict autonomy - motivation to behave in a self-directed manner. In turn, autonomy has been shown to predict self-regulation (Ryan & Deci, 2000). This suggests a psychological pathway from mindfulness to autonomy to emotion regulation. To better understand the regulatory potential of a mindful disposition and the possible mediating role of autonomy in healthy adult participants ($N = 69$), a laboratory social evaluative threat was used called the Trier Social Stress Task (Kirschbaum, et al., 1993). Results showed that mindfulness predicted lower self-reported anxiety but not lower negative affect or endocrine levels. State autonomy during the stressor fully mediated the inverse relation between mindfulness and anxiety. These results support the theory of the emotion regulatory potential of mindfulness, and suggest one means by which this quality may improve well-being.

Introduction

Stress, a psychological and physiological reaction to challenging or threatening stimuli, has become ubiquitous in the modern world. While stress serves the important purpose of alerting individuals to potential harm or threats in the environment (Selye, 1936) the evolved 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 challenges and threats.

There is general consensus that stress manifests both psychologically and physiologically (Chida & Hamer, 2008). There is also now widespread recognition that cognitive appraisals, or interpretations of potentially stressful events (as most basically, good, bad, or neutral), are key to determining whether stress and the consequences of it will accrue (Folkman & Moskowitz, 2004). This current understanding of the importance of cognitive appraisals is based on Lazarus and Folkman's (1984) influential research detailing the differences between primary and secondary appraisals of stressful events. Primary appraisals are defined as how individuals initially interpret a stimulus as either a threat or a challenge (or as benign). Secondary appraisals involve self-assessments concerning the adequacy of physical, social, and psychological resources at hand to cope with a primary appraised stressor. Research on coping is now well established (Folkman & Moskowitz, 2004). A currently active area of stress research seeks to uncover key factors, such as social support (Harvey, Burns, Fahy, et al, 2001) and personality (O'Brien & DeLongis, 1996), that influence whether events are

primary appraised as, most basically, positive, negative, or neutral, and to examine the stress-relevant consequences of those appraisals.

Physiological and psychological reactions to stress also have important health consequences, both physiologically and psychologically. Stress has been shown to compromise cardiovascular, hormonal, and immune functioning, which have been shown to negatively impact physical health (Gevirtz, 2000; Marsland, Bachen, Cohen, et al., 2002). For example, stress is a known predictor of cardiovascular disease, which affects millions of people in the U.S. (McCabe, Schneiderman, Field, et al., 2000). Research has also shown that increased levels of cortisol and other corticosteroids brought about by stress can lead to impaired immune functioning (Kunz-Ebrecht, Mohamed-Ali, Feldman, et al., 2003; Parrillo & Fauci, 1979). Sapolsky (1994) argues that the corticosteroid suppression of immunity may have adaptive value, in that steroidal activation of the nervous system to “fight or flee” takes precedence over immune system activation for wound healing, for example. In most animals, stress responses do not have deleterious effects because they are usually temporary. Humans though, have the unique and unfortunate ability to prolong stressors over extended periods of time, which can have detrimental effects on immune system functioning. Because of unique human capacity to extend the self into the remembered past and imagined future (the narrative or egoic self; Leary, 2004), stress can also impact individuals’ psychological health, manifest in heightened anxiety, in depression, or in post-traumatic stress disorder in extreme

circumstances (Spielberger & Saraon, 1985; Van Praag, 2004; Ehlers & Clark, 2000).

A common stressor for humans is social encounters (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 self-preservation theory suggests that people want to defend their egos to maintain their social value and standing (Gruenewald, Kemeny, Aziz, et al., 2004). When the 'social self' is threatened, people tend to show stress-related psychological and physiological responses, including elevated anxiety and levels of stress hormones, such as cortisol and alpha-amylase (Gruenewald, Kemeny, Aziz, et al., 2004, Dickerson & Kemeny, 2004; Rohleder, Natar, Wolf, et al., 2004; Granger Kivlighan, El-Sheikh, et al., 2007). Sociometer theory further argues that individuals' sense of self-worth is dependent on validation from others and therefore, social rejection can elicit stress (Leary, Tambor, & Terdel, 1995; Leary, 2004). When people are rejected by others, research has shown that they react with increased depression and aggression (Leary, Twenge, Quinlivan, 2006) as well as experience physical pain (MacDonald & Leary, 1995). Even acute social stressors have been shown to impact psychological and physiological outcomes (Kirschbaum, Pirke, & Hellhammer, 1993).

Elevated stress responses in the face of challenge or threat are not a foregone conclusion, however. Laboratory research has uncovered several predictors of the magnitude of psychological and physiological stress responses when acute social stressors are induced. For example, social support, in general and during a stressor, has been found to buffer increases in stress responses typically found in research participants (Ditzen, Schmidt, Strauss, et al., 2008; Ditzen, Neumann, Bodenmann, et al., 2007; Heinrichs, Baumgartner, Kirschbaum, et al., 2003). Trait variables, including higher dispositional positive affect, have been found to protect against acute social stress responses (Robles, Brooks, & Pressman, 2009). The nature of contextual primary appraisals made also appears to be influential. Gaab, Rohleder, Nater, et al. (2005) discovered that primary appraisal of the TSST (was it perceived as a threat or challenge) was a better predictor of salivary cortisol stress responses than were certain personality characteristics such as self-efficacy and control expectancy. This research suggests that how individuals respond to stress-relevant events can be influenced by both their demeanor and how they interpret those events.

Although many researchers have examined several resilience factors that may protect against chronic stressors (Beasley, Thompson, & Davidson, 2003; Repetti, Taylor, & Seeman, 2002, Smith & Carlson, 1997; Brewin, Andrews, & Valentine, 2000), research on predictors of variability in acute social stress responses is still at an early stage and little research has uncovered specific resilience factors that may ameliorate or even protect against the effects of acute

social stressors. Examining acute social stress responses in a controlled laboratory setting permits an analysis of how resilience factors predict stress reactivity. Establishing such predictions may offer understanding of the time course of stress reactions and responses as well as greater leverage in the ability to alter them.

Framed as resilience terms, this line of inquiry asks, “What characteristics allow people to circumvent deleterious outcomes that acute social stressors frequently invoke? One factor that accumulating research suggests may support resilience to social stress is mindfulness. In the sections to follow, I will first describe the nature of mindfulness and its potential stress resistance benefits, and then offer a testable explanation for these benefits by discussing a motivational factor called autonomy.

Mindfulness

Mindfulness is defined as being aware of and attentive to one’s present internal state and circumstances (Brown & Ryan, 2003). Research has shown that the attention spans of people are generally limited and most processing happens at a nonconscious level; that is, below conscious awareness (Bargh, 1999). Further, awareness of internal and external stimuli tends to be biased in ways that protect, maintain, or enhance the egoic self (Baumeister, Heatherton, & Tice, 1994; Leary, 2004). More mindful people though, tend to be less defensive when processing ego threatening situations (Baer, 2003; Brown, Ryan, Creswell, & Niemiec, 2008) allowing for a more open and receptive attention to

thoughts, emotions, and external events. When people are more mindful, and by implication, freer from egoic demands, people may then be free to make more objective choices (Brown, Ryan, & Creswell, 2007).

Research on dispositional mindfulness and mindfulness training has suggested several benefits to being more mindful. Dispositional or trait mindfulness refers to individuals' natural (untrained) tendency to be more attentive in the present moment. People who are more dispositionally mindful tend to be physically healthier, show more adaptive behavior, and have better overall psychological well-being (Brown & Ryan, 2003). They also show more self-control (Barnes, Brown, Krusemark, et al., 2007) and appear to be better able to monitor their emotions (Amodio & Frith, 2006). A functional magnetic resonance imaging (fMRI) study has also shown that more dispositionally mindful people show less distress in a social stress situation (social exclusion), and this relation was partially explained by less dorsal anterior cingulate cortex (dACC) activation – a neural marker of emotional reactivity – and greater prefrontal cortical activation in regions associated with emotion regulation (Creswell, Eisenberger, & Lieberman, 2008). In addition, a study conducted by Weinstein, Brown, and Ryan (2009) found that individuals higher in dispositional mindfulness made more benign appraisals of stressful events and also demonstrated more adaptive coping strategies under stress. Taken together, these research findings suggest that more mindful people may be less reactive to

stressful situations and better able to regulate their emotions during social and other stress-relevant situations.

Research on mindfulness training, using the Mindfulness-Based Stress Reduction program (MBSR, Kabat-Zinn, 1982) has been shown to reduce stress symptoms (Carlson, Speca, Patel, et al., 2003), increase perception of control (Astin, 1997), and enhance affect regulation (Tacon, McComb, Caldera, & Randolph, 2003). Together with the findings on dispositional mindfulness, this training-related mindfulness research suggests that more mindful people tend to be better resistant to stress. This project will attempt to explain why mindfulness may have its beneficial effects on stress resistance by looking at autonomy as a mediating factor.

Autonomy

Although discussed by philosophers throughout the centuries (e.g., Aristotle's notion that man has an inherent desire to learn), the concept of autonomy was probably first described in modern scientific circles by Heider (1958) and DeCharms (1968) through discussions of intrinsic versus extrinsic motivation and internal and external loci of causality. These authors argued that some motivations derive from a person wishing to do something (internal locus/acting as an Origin), while other motivations come from being forced to do something by someone else (external locus/acting as a Pawn). DeCharms (1968, p320) stated that, "freedom of choice implies commitment and self-involvement whereas constraint implies external influence."

Extending this early theorizing, Self-determination theory (SDT; Deci & Ryan, 1985; Ryan & Deci, 2000) has argued that to feel autonomous is to feel that one is the agent of their own decisions and behavior, which can be found in both intrinsic and extrinsic forms of motivation. Autonomous behavior is that which is chosen willingly, that is *self*-determined. SDT posits that the perceived causal origin of behavior varies unidimensionally along a spectrum ranging from highly autonomous to highly controlled. The highest level of autonomy is intrinsic motivation, wherein a person feels free not only to choose their behaviors, but finds inherent interest and enjoyment in them. Autonomy can also be seen when behavior is extrinsically motivated. Although there may be external constraints on a behavior, people can still perceive a sense of choice in the form or expression of the behavior. The most autonomous form of extrinsic motivation is identified regulation. A person that identifies with their behavior perceives that the behavior is personally important or valuable to perform, even though it is not inherently interesting or enjoyable (i.e., fully self-determined). Introjected regulation is a less autonomous form of extrinsic motivation than identified regulation. In introjected regulation, a person is motivated to behave because of internal rewards and punishments, such as trying to avoid guilt or embarrassment. The least autonomous form of motivation is external regulation. This form of motivation is based on compliance, external demands or requests, or external rewards or punishment. An externally motivated person does not feel at all like the agent of their own decisions.

When people act autonomously, either through intrinsic motivation or more autonomous forms of extrinsic motivation, there are numerous benefits in both adaptive behavior regulation and overall psychological well-being (Ryan & Deci, 2000). Although there has been much research showing that feelings of autonomy lead to better psychological well-being in general (Csikszentmihalyi & Rathunde, 1993; Ryan, Deci, & Grolnick, 1995), no research to date has focused on the impact of autonomous motivation on emotion regulation during a stressful event.

However, there is indication that autonomy can be facilitated by mindfulness. Research has shown a positive relation between mindfulness and both dispositional autonomy and day-to-day state levels of autonomous motivation for behavior (Brown & Ryan, 2003). (see also Levesque and Brown, 2007). This research shows that a person's level of dispositional mindfulness may predict how autonomous one feels in a variety of life situations. Therefore, if mindfulness leads to autonomous functioning (at a trait and state level) and both mindfulness and autonomy lead to improved well-being outcomes, it is possible that autonomous motivation may be acting as a mediator between the mindfulness – well-being relationship.

Whether mindfulness predicts heightened autonomy and the positive psychological outcomes that may come from such motivation have not been demonstrated in a social stress-relevant context. Dispositional mindfulness, or the capacity to be more open and receptive to present realities, may help to

foster autonomous motivation in certain stressful situations. Theoretical support for this proposition comes from Deci and Ryan (2000), who stated that people are more effective at self-regulation when their awareness of current experiences is heightened. Hodgins and Knee (2002) stated that people who tend to be more autonomously motivated are more open to reality, and therefore less directed by ego-investing information. Perhaps a more mindful disposition may increase perceived autonomy, which then reduces the threatening nature of stress-relevant events and leads to increased stress resistance.

Goals of the present study

The purpose of this study is to explain why being more mindful has benefits for resistance to social stress by examining the role of autonomy as a mediating factor. This overarching goal was tested in three steps. The first step was to replicate and extend research showing a predictive relation between mindfulness and stress resistance. I hypothesized that higher levels of dispositional mindfulness predicted lower stress responses in the form of reduced reactivity to and faster recovery from an acute social stressor, measured using both psychological (emotional) and physiological (endocrine) indicators. The second step of this study was to replicate and extend research showing a positive relation between mindfulness and autonomous functioning. I expected to find that higher levels of dispositional mindfulness predicted more autonomous forms of motivation in the social stress context. The second step also included the goal of extending research on autonomy and well-being by showing whether

perceived autonomy predicted better stress regulation. I hypothesized that higher levels of autonomy during the social stress task would predict less stress reactivity and faster recovery. The final step examined whether these state levels of autonomy during the social stress task mediated the relationship between dispositional mindfulness and stress resilience (reactivity and recovery). I hypothesized that autonomous motivation would fully or partially mediate the relation between dispositional mindfulness and stress regulation.

This study sought to test these hypotheses by using the Trier Social Stress Task (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), which has been shown to reliably induce social evaluative acute stress in the laboratory as measured by both emotional (self-reported) responses and endocrine responses in the form of increased levels of both salivary cortisol and alpha-amylase (Dickerson & Kemeny, 2004; Gruenewald, Kemeny, Aziz, et al., 2004; Gordis, 2006; Nater, Rohleder, Gaab, et al, 2005; Nater, La Marca, Florin, et al., 2006). Participants' dispositional mindfulness was assessed before the beginning of the session. Perceived autonomy during the TSST was assessed immediately after task completion. Stress reactivity and recovery, measured via self-reported emotional state and endocrine responses, were assessed at baseline and at multiple points following the TSST.

Method

Participants

Participants were 69 healthy adults, mostly female (72.7%), sampled from the population of employees at Virginia Commonwealth University (VCU). Three participants' scores were excluded from analyses due to improper procedure execution or the participant's acquaintance with a confederate, leaving a sample of 66 participants (48 women, 18 men). The diversity in age, race/ethnicity, occupation, and civil status of employees at VCU, being that it is one of the largest universities in the state of Virginia, was sufficient to support the strength of generalizability to the general population of working, healthy adults in the U.S. Specifically, participant ages ranged from 19 to 61 years old ($M = 38.3$ yrs; $SD = 11.5$ yrs). The majority of participants (68.2%) identified their race/ethnicity as White or Caucasian and others self-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 titles, ranging from security guard to 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%).

Participant recruitment was conducted through advertisements distributed throughout VCU's campus in the form of brochures, posters, and mass e-mails. 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' study responses. To compensate for time and energy devoted, participants received \$60 and a personalized report of their responses to the study measures.

The experimenter phoned interested participants to introduce the study and check all exclusion criteria (see below). Although participants were informed that they would be completing "challenging tasks" and that they would be videotaped, they were not directly told that a stress induction was involved. This was to ensure a natural reaction to the TSST without any preconceived biases and time to prepare for handling a stressful encounter. A consent form and an initial packet of questionnaires containing demographic and trait psychological measures were mailed to the participant's home. Included in this packet were measures of dispositional mindfulness and a variety of other trait psychological constructs not of direct interest to this study.

Exclusion Criteria

Participants were excluded from the study if they had any existing health conditions (e.g., autoimmune disorders, Cushing's disease, high blood pressure, psychiatric illness) or used certain prescription (e.g., oral contraceptives) and nonprescription (e.g., marijuana, regular tobacco use) drugs, which could affect their stress responsiveness, put them at risk during the stress procedure, or affect the biological measures assessed in this study (Gruenewald, Kemeny, Aziz, et al., 2004). Participants were asked not to engage in behaviors on the day of their appointment known to influence endocrine responses, such as

performing strenuous exercise, drinking alcohol, or smoking, as well as consuming dairy products, caffeine, or food one hour before the session (Dickerson & Kemeny; 2004). These exclusion criteria were included in the study advertising and checked before the protocol began.

Procedure

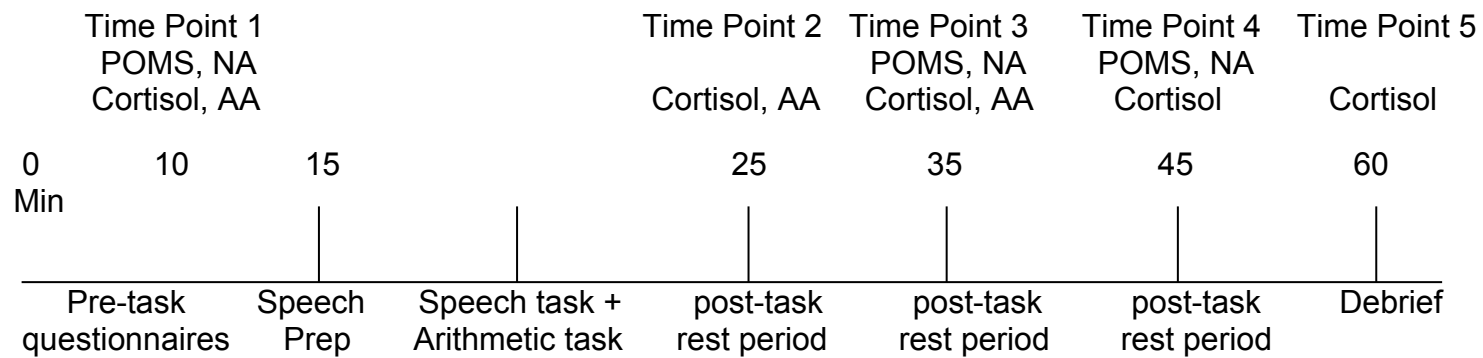
The laboratory part of the study took place within one to two weeks after the phone interview and receipt of the questionnaires by mail. Due to the diurnal rhythm of cortisol and alpha-amylase, sessions were run only in the afternoons with sessions either starting at 12:30pm or 2:30pm. The lab session involved the laboratory induction of social evaluative stress by using the well-validated and commonly used Trier Social Stress Task (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). The TSST has been shown in a number of studies to reliably elicit social stress responses (Dickerson & Kemeny, 2004). See Figure 1 for an illustration of the timeline for the procedure.

In the lab session, the participants were first re-introduced to the study and asked to complete a second, laboratory session-specific informed consent form. Exclusion criteria were checked once again and the session was rescheduled if the participant hadn't met the criteria for that day (e.g., had eaten within the hour of the appointment). Several procedures took place not in direct relation to this study, such as blood draws and heart rate monitoring. The experimenter then administered the psychological stress questionnaires and

collected the first saliva sample at Time Point 1 (see Figure 1) to assess baseline subjective states and psychobiological stress levels.

In order to elicit stress, participants were first told to listen 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 job title was intentionally chosen for its relevance to a sample of VCU employees.

The instructions also informed participants that their performance, as well as the content of their speech, would be evaluated. The experimenter then exited the room and after a five-minute speech preparation period, two “evaluators” (confederates) entered the room and sat at a desk directly in front of participants. One of the evaluators started a five-minute timer and said “Please begin your speech; you have five minutes.” If participants inquired about the time remaining or stopped their speech before their time was up, the evaluators said “You still have time remaining, please continue” along with other similar responses. The evaluators maintained stony faces, constantly stared at the participant, and refrained from any non-verbal affirmatory cues such as “mmm hmm” or head nodding; this procedure was followed to foster stress responses.



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Figure 1. Procedure timeline. Psychological measures and alpha-amylase were assessed at three time points (baseline and twice post-TSST); cortisol was assessed at all five time points.

At the end of the five-minute speech, participants were instructed to perform a mental arithmetic task by counting aloud backwards from 2,083 by 13's for five minutes. Participants were 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 evaluators said, "Please go faster!" The evaluators also took notes during the tasks to enhance the experimental realism.

The evaluators then left and the experimenter reentered at Time Point 2 to collect a second saliva sample to assess endocrine reactivity to the TSST. To measure stress recovery, saliva was collected at three more time points: 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*). In addition to collecting another saliva sample at Time Point 3 (10 minutes post-task), the experimenter also administered the PLOC to assess autonomous motivation during the TSST and re-administered the POMS and PANAS to assess the participant's psychological state during the tasks. As these measures reflected retrospective feelings of stress at Time Point 2, the psychological stress measures assessed at Time Point 3 should be compared to the endocrine measures of stress at Time Point 2. Saliva and current psychological states were assessed again at Time Point 4 (20 minutes post-task). A final saliva collection was performed at Time Point 5 to assess cortisol recovery and then participants were fully debriefed.

Measures

Dispositional mindfulness. Mindfulness was assessed at a trait level using the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003). Past research (e.g., Brown & Ryan, 2003) has shown that mindfulness, as assessed via the MAAS, is related to a variety of self-reported indicators of psychological well-being. It 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, $\alpha = .82$ (Brown & Ryan, 2003; MacKillop & Anderson, 2007), as well as a very good internal consistency for this particular sample, $\alpha = .91$.

An additional measure of dispositional mindfulness, the acting with awareness subscale of the Five Factor Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, et al., 2006) was included to give additional support to examining role of mindfulness in stress resistance. It includes eight statements, calculated as a mean, each scored on a 5-point Likert scale ranging from “never or very rarely true” to “very often or always true”. The acting with awareness subscale of the FFMQ has shown excellent reliability in other samples, $\alpha = .87$ (Baer, Smith, Hopkins, et al., 2006) as well as in this sample, $\alpha = .91$.

State autonomy. Motivational orientation during the TSST was measured with an adapted version of the Perceived Locus of Causality Scale, (PLOC; Ryan & Connell, 1989). The PLOC is an 26-item scale that measures whether one

tends to be more intrinsically or extrinsically motivated by focusing on different levels of autonomous motivation that rest on a continuum: external (“Because I was just doing what I was told to do”), introjected (“Because I didn’t want to look bad to the experimenters or judges”), identified (“Because I thought acting in this way was important”), and intrinsic (“Because acting that way was fun and enjoyable”). Participants determine how much each motivational item fit with their self-perception on a 7-point Likert scale ranging from “Not at all” to “Very much”. A final motivation score is calculated by taking the mean of each subscale and weighting it based on its level in the continuum of intrinsic and extrinsic motivation. The PLOC has shown good utility in several studies of self-regulated behavior (Reis, Sheldon, Gable, et al., 2000) and mindfulness (Brown & Ryan, 2003; Levesque & Brown, 2007).

Stress responses. Stress responses were assessed in four ways. It was measured by two self report and two objective measures both before and after the stress inducing tasks. There is argument for using a combination of self-report and objective measures when operationalizing stress responses (Weinstein, Averill, Opton, et al., 1968; Vassend, Halvorsen, & Norman, 1987). With only self-report, participants could just be answering what they think is right or what they should feel in corroboration with their expectations of the experimenter’s hypotheses of the study (Orne, 1962). They may not even be fully aware of what their actual experiences are. Objective measures, on the other hand, can complement the description of a participant’s experience

because they eliminate the need for self-awareness and any potential response biases. Such measures also offer a window into neurobiological responses to stress. When both kinds of measures are used, a more complete depiction of the participant's stress responses is obtained.

State anxiety. The first self-report measure of stress was the tension-anxiety subscale of the Profile of Mood States (POMS; McNair & Lorr, 1964). The POMS is intended to measure how participants are feeling at the present moment (emotional state). 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, average $\alpha = .79$ (McNair, Lorr, & Droppleman 1971; Albrecht & Ewing, 1989). The tension anxiety subscale was also found to be reliable in this sample at all time points (α scores $> .83$).

State negative affect. The second measure of stress was the negative affect subscale of the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988). The PANAS measures negative affect using 10 descriptors. Some examples of descriptor words are "distressed" and "hostile". It is measured on a 7-point Likert scale ranging from "Not at all" to "Extremely" in accord with how the participants are feeling at the present moment. The PANAS scale has shown high internal consistency reliabilities ranging from .84 to .87 for

negative affect (Watson, Clark & Tellegen, 1988). The negative affect subscale was also found to be reliable in this sample at all time points ($\alpha > .72$).

Salivary cortisol. The first objective measure of stress was salivary cortisol. Salivary cortisol was measured at five times (once at baseline and four times post-TSST) to assess immediate reactions to the stressful event as well as recovery from it. Cortisol is a product of the hypothalamic-pituitary-adrenal (HPA) axis, which is a neuroendocrine pathway known to be centrally involved in how people react to stress (Lovallo & Thomas, 2000). When stress occurs, the hypothalamus releases corticotrophin releasing hormone (CRH), which then stimulates the pituitary gland to secrete adrenocorticotropin hormone (ACTH), which then stimulates the adrenal cortex to release cortisol into the bloodstream. Since this is a process that occurs over some minutes, saliva samples were taken at five time points during the study to assess cortisol reactivity and recovery, in accordance with other studies that induce stress within a laboratory setting (Dickerson & Kemeny, 2004; Gruenewald, Kemeny, Aziz, et al., 2004). Other studies using the same procedure and also measuring cortisol outcomes (see Dickerson & Kemeny, 2004 for review) were used as a benchmark to compare patterns of salivary cortisol reactivity and recovery from the TSST.

Salivary alpha-amylase. The second objective measure of stress was alpha-amylase, measured at three times (once at baseline and twice post-TSST) to assess immediate reactions to the stressful event as well as recovery from it. Unlike cortisol, alpha-amylase is a product of the sympathetic nervous system

(SNS) as opposed to the HPA axis. Also, it is an enzyme that is produced directly in the salivary glands instead of being passively diffused through the blood system (Granger, Kivlighan, El-Sheikh, et al., 2007). This means that it generates a quicker reaction time to stress and has a more sensitive threshold compared to salivary cortisol. However, levels of alpha-amylase also quickly return to normal after the stressor making a fourth and fifth saliva assay unnecessary in this study. Salivary alpha-amylase is generally seen as a measure of stress reactivity because it has been correlated with increases in norepinephrine (Rohleder, Natar, Wolf, et al., 2004) and has reliably shown increased levels after induced psychological stress (Gordis, 2006; Nater, Rohleder, Gaab, et al, 2005; Nater, La Marca, Florin, et al., 2006).

Statistical Analysis

The key predictor variable in this study was dispositional mindfulness. There were four dependent measures of stress response: two psychological questionnaire responses (anxiety and negative affect) and two endocrine responses (salivary cortisol and salivary alpha-amylase). Autonomy was analyzed as the mediating variable between mindfulness and the four stress response indicators. The main purpose of this research was to discover whether state levels of autonomy during a social stress task mediated the relation between dispositional mindfulness and stress reactivity and recovery.

All primary analyses were conducted using restricted maximum likelihood (REML) repeated measures multilevel linear models (MLM) by way of the PROC

MIXED procedure in SAS (Singer, 1998). By using MLM, both between and within-subjects differences can be analyzed in the same procedure using continuous variables. For the purposes of the present study, that means that repeated dependent stress measures can be compared simultaneously to continuous between-subjects variables, such as mindfulness and autonomy. Another advantage of using the MLM approach is the ability to retain cases for which there is missing data. MLM-based planned contrasts were conducted where appropriate to examine changes in response across time points.

Denominator degrees of freedom were calculated in all models using the between/within method. The most appropriate within-person error covariance structure (unstructured or compound symmetry) was chosen based on chi-square tests comparing the -2 restricted log likelihood model fit indices for each outcome in unconditional means models (Singer, 1998). A compound symmetry covariance structure was most appropriate for self-reported anxiety models while unstructured covariance was used for negative affect models. A compound symmetry structure was most appropriate for the cortisol and alpha-amylase data. All predictor variables, including possible covariates, were centered around zero in order to increase the interpretability of the MLM intercept parameters (Bryk & Raudenbush, 1992; Schwartz & Stone, 1998). Several demographic variables (age, gender, ethnicity, and civil status) and other possible covariates, such as the gender mix of the two confederates and session

time of day, were thought to possibly affect the results and were therefore tested in preliminary models.

Model assumption checks. The data were checked for univariate normality before analyses. Two data points on POMS anxiety subscale were identified as outliers (due mainly to floor effects in baseline and recovery stress levels) and were winsorized (Dixon, 1960; Tabachnick & Fidell, 2007) to normalize the relevant distributions. A square root transformation was also performed on baseline negative affect scores to reduce skewness. As is typical when collecting salivary samples in a TSST study (Keene, 1995; Kirschbaum, Pirke, & Hellhammer, 1993), the cortisol and alpha-amylase data were natural log transformed to achieve normality.

Data reduction. The four post-TSST cortisol levels were reduced using area under the curve (AUC) equations as a compliment to the MLM procedure and because it is a common method for analyzing cortisol responses (Fekedulegn, Andrew, Burchfiel, et al, 2007). Two equations were used to address two AUC questions: Were there changes over time in cortisol levels (Area under the curve with respect to ground – AUC_G)? And what was the change in intensity of cortisol levels at the different time points (Area under the curve with respect to increase – AUC_I)? See Pruessner, Kirschbaum, Meinlschmid, et al, (2003) for equations.

Mediation model. The model for testing whether autonomy was a mediator of the mindfulness – stress resistance relationship followed Baron and

Kenny's (1986) three-step procedure for analyzing mediation. The first step was to test the direct predictive relation between mindfulness and the four stress responses, using separate repeated measures multilevel linear models. Next, the predictive relation between mindfulness and autonomy was assessed using a simple regression. Lastly, the relation between mindfulness and post-TSST stress responses was assessed while including the purported autonomy mediator in MLM. If autonomy significantly predicted stress responses, and the relationship between mindfulness and stress response did not significantly differ from zero when autonomy was taken into account, then autonomy could be said to be a full mediator of the relation between mindfulness and stress response. If the mindfulness – autonomy relation dropped to a non-zero level, partial mediation would then be observed. The statistical significance of both full and partial mediation was tested using MacKinnon et al.'s (2002) recommended $\alpha\beta$ /standard error test. Four separate models were analyzed to assess the mediation effects on all four dependent measures of stress. See Figure 2 for a graphical representation of the models.

As the pattern of stress responses over time may in fact reflect a curve rather than a straight line, both the linear effect and the quadratic effect of time were assessed for post-TSST stress responses. Quadratic effects of time have been shown to be useful in predicting salivary cortisol results in previous studies (Zoccola, Dickerson, & Zaldivar, 2008; Vedhara, Miles, Bennett, et al., 2003).

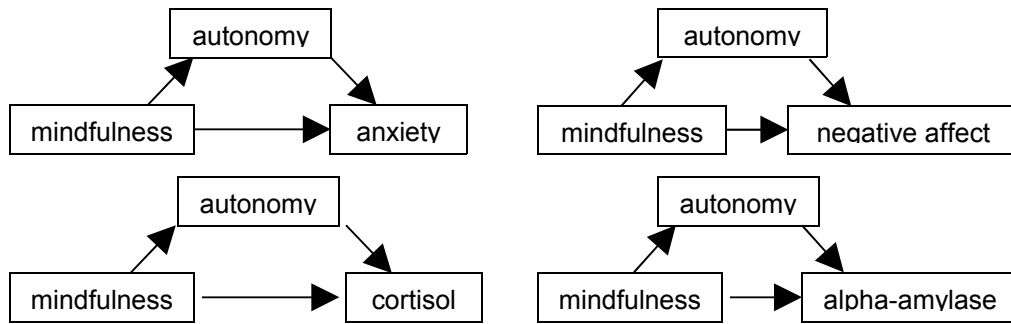


Figure 2. Models proposed for four different stress outcomes. According to Baron and Kenny's (1986) procedure, each path was tested for significance at the $p < .05$ level. If autonomy is a full mediator of the relation between mindfulness and stress, the once significant relationship between mindfulness and the respective dependant variable will no longer be significant. In each model the reduction in p value was tested for significance using MacKinnon et al.'s (2002) distribution of $\alpha\beta$ /standard error test.

Cross-dependent variable relationships were also assessed to see how self-reported measures of stress correlated with endocrine measures. To determine the significance of all relations between variables, regression and MLM coefficients were analyzed at the $p < .05$ level (Baron & Kenny, 1986).

Results

Preliminary analyses

Initial testing using unconditional means models showed that there was a significant amount of variance to be accounted for in both self-reported dependent variables: anxiety and negative affect ($ps < .0001$), as well as in both psychobiological dependent variables: cortisol and alpha-amylase ($ps < .0001$), giving support for further investigation.

In preliminary multilevel models, none of the demographic variables showed a significant relation to the self-reported stress outcomes of anxiety and negative affect: age ($ps > .29$), gender ($ps > .36$), ethnicity ($ps > .54$), and civil status ($ps > .83$). Gender has been found to influence cortisol levels in some studies using the TSST (Kudielka, Buske-Kirschbaum, Hellhammer, et al., 2004) and a relation was found in this sample, ($p < .05$) with males showing higher cortisol levels compared to females at both baseline (males, $M = .338$, $SD = .025$; females, $M = .334$, $SD = .017$) and immediately post-TSST (males, $M = .358$, $SD = .040$; females, $M = .345$, $SD = .027$). However there were no significant relations of gender to alpha-amylase ($p > .52$, nor were there relations of age ($ps > .66$), ethnicity ($ps > .21$) or civil status ($ps > .23$) on either endocrine measure.

One variable considered as a covariate was the time that the session started (12:30pm or 2:30pm) with the majority of participants attending the earlier 12:30pm session (65.2%). Self-reported anxiety was the only dependent

variable to which time of day had a significant relation ($ps < .05$), showing that participants attending the early afternoon session ($M = .641, SD = .424$) compared to those in the later afternoon ($M = .451, SD = .343$) showed increased anxiety even at baseline. Therefore, it was included as a covariate in all primary models focused on POMS anxiety. Time of day had no significant relation to negative affect or to the two endocrine measures (all $ps > .13$).

Gender mix of the two confederates performing as evaluators during the TSST (male/male, female/female, male/female) was tested as another possible predictor of stress responses. The most common configuration of confederates was a mixture of male and female (69.7%), followed by two males (18.2%) and two females (12.1%). Using dummy coded predictors, no significant relations were found for gender mix of confederates on either self-reported or physiological measures of stress ($ps > .05$) and so, like other non-significant demographic and procedural predictors tested, were not included in the primary models to preserve statistical power.

Cross-dependent variable relationships. Cross-dependent variable relationship analyses revealed some significant correlations between the four measures of stress response: anxiety, negative affect, cortisol, and alpha-amylase. Although at Time Point 1 self-reported stress measures were significantly correlated with cortisol ($ps < .05$), as would be expected at baseline, neither self-report measure significantly correlated with either endocrine measure post-TSST ($ps > .05$) (see Table 1). After the TSST, there is a clear distinction

between self-report measures that only correlate with each other ($ps < .0001$) and endocrine measures that only correlate with each other ($ps < .05$).

Table 1

Cross-dependent variable correlations

	Baseline			Reactivity			Recovery		
	NA	AA	cortisol	NA	AA	cortisol	NA	AA	cortisol
Anxiety	.71****	.09	.28*	.81****	.03	.23	.80****	.03	.24
NA	-	.23	.31**	-	.05	.21	-	-.07	.20
AA	-	-	.22	-	-	.38**	-	-	.28*

Note. Baseline = Time Point 1 for all dependent variables; reactivity = Time Point 3 for self-report variables and Time Point 2 for endocrine variables; recovery = Time Point 4 for self-report variables, Time Point 3 for alpha-amylase, and Time Point 5 for cortisol. NA = negative affect; AA = alpha-amylase.

* $p < .05$, ** $p < .01$, *** $p < .001$, **** $p < .0001$

Other variable relationships. Although both measures of mindfulness, the MAAS and FFMQ-AA, are highly correlated ($r = .90, p < .0001$), this was to be expected given that five of the eight FFMQ-AA items were taken from items on the MAAS. In addition, both mindfulness measures were negatively correlated with trait levels of negative affect (MAAS, $r = -.49, p < .0001$; FFMQ, $r = -.42, p < .001$) and trait levels of tension or anxiety (MAAS, $r = -.46, p < .0001$; FFMQ, $r = -.37, p < .01$). The only variable to significantly correlate with the PLOC, state levels of autonomous motivation, was the MAAS ($r = .31, p = .01$).

Primary analyses

TSST responses. Multilevel models were first used to determine whether the TSST reliably induced stress in terms of all four outcomes. There was a significant quadratic effect of time in each of the four dependant variables,

namely anxiety [$t(128) = -16.61, p < .0001$], negative affect [$t(128) = -15.34, p < .0001$], cortisol [$t(262) = -7.50, p < .0001$], and alpha-amylase [$t(130) = -6.56, p < .0001$] (see Figure 3).

Planned contrasts showed that scores immediately post-TSST (reflecting Time Point 2 for endocrine responses and Time Point 3 for retrospective self-reported responses during TSST) were significantly different from baseline on self-reported anxiety, self-reported negative affect, alpha-amylase, and cortisol, ($p < .01$) (see Table 2). Scores during recovery periods (Time Point 4 for self-report measures, Time Point 3 for alpha-amylase, and Time Point 5 for cortisol) were not significantly different from baseline ($p > .08$).

Table 2

Dependent variable means (SD) at each TSST time point.

	Anxiety	negative affect	alpha amylase	cortisol
Time Point 1	0.57 (0.40)	1.21 (0.23)	55.54 (47.13)	0.34 (0.02)
Time Point 2	-	-	108.19 (113.79)****	0.35 (0.03)**
Time Point 3	2.09 (0.97)****	2.86 (1.27)****	60.23 (51.67)	0.36 (0.04)****
Time Point 4	0.87 (0.63)	1.42 (0.49)	-	0.36 (0.04)****
Time Point 5	-	-	-	0.35 (0.03)

** $p < .01, p < .0001$

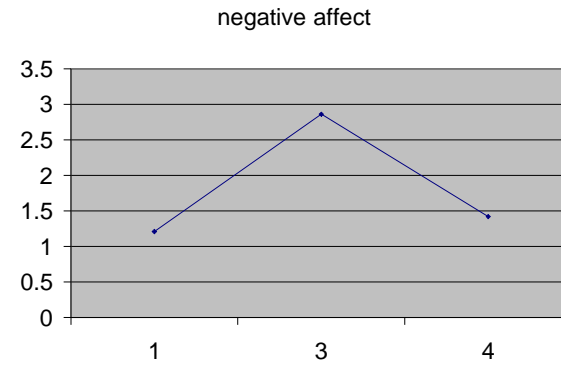
Prediction of subjective TSST responses.

In examining the hypothesized path from mindfulness to autonomy to subjective (self-reported) stress responses, the first step (Baron & Kenny, 1986) was to examine the direct relation of mindfulness to the two dependent variables. Both dispositional measures of mindfulness, MAAS [$t(63) = -2.49, p < .05$] and

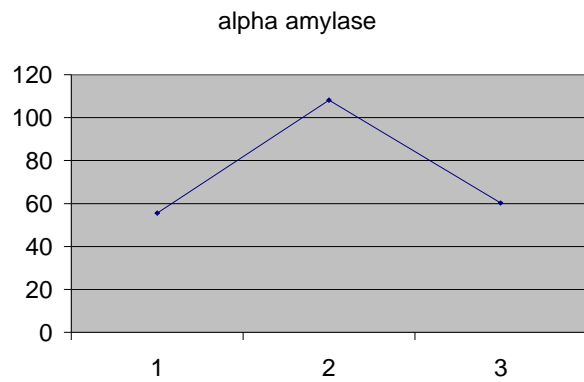
A



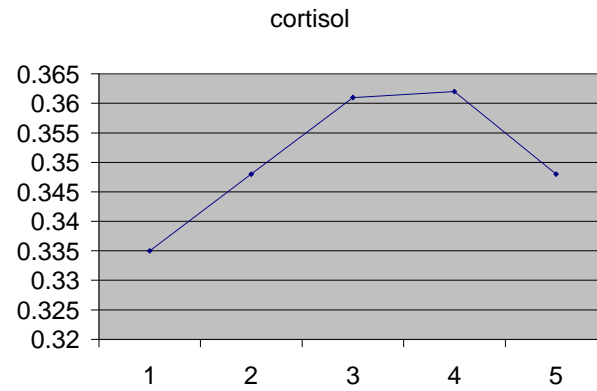
B



C



D



31

Figure 3A-D. Mean stress responses at multiple time points (A = anxiety; B = negative affect; C = alpha amylase; D = cortisol). X axes designate time point; Y axes designate response score.

FFMQ [$t(63) = -2.79, p < .01$] were found to significantly predict post-TSST anxiety as measured by the POMS, above and beyond the effect of time of day. This relation was not moderated by linear time ($p > .32$) or quadratic time ($ps > .48$). Thus the relation of mindfulness to lower anxiety was found across all time points. Neither mindfulness measure, MAAS [$t(64) = -.67, p = .50$] nor FFMQ [$t(64) = -.31, p = .76$] significantly predicted changes in PANAS negative affect scores. As mindfulness did not significantly predict negative affect, no further mediation testing of that model was necessary.

Step two of the model involved analyzing the predictive relations between the two measures of mindfulness and perceived autonomous motivation during the TSST. Scores on the MAAS were found to significantly predict autonomous motivation during the TSST [$t(64) = 2.59, p < .05$] but FFMQ mindfulness did not [$t(64) = 1.65, p = .10$]. As scores on the FFMQ did not predict state autonomy levels, further tests were not performed on any models using FFMQ as the predictor. It is also noteworthy to mention in step two that autonomy predicted one of the dependent measures. Autonomous motivation during the stressor was not predictive of negative affect [$t(64) = -1.10, p = .27$], but it did significantly predict self-reported anxiety, [$t(63) = -4.09, p < .0001$].

The third step in mediation testing was to assess whether scores on the PLOC mediated the relationship between MAAS mindfulness and self-reported anxiety. Although the predictive relation of the MAAS to anxiety was previously significant ($p < .05$), when autonomous motivation was entered into the model

with the MAAS, autonomy fully mediated the relation between mindfulness and anxiety as evidenced by a now non-significant relation between mindfulness and self-reported anxiety ($p = .12$). MacKinnon et al.'s (2002) $\alpha\beta/s$ method to calculate z' was used to measure the significance of the indirect path from mindfulness to autonomy to anxiety and the mediation was found to be significant [$z' = -2.19, p < .01$]. See Figure 4 for a representation of the mediation model for anxiety.

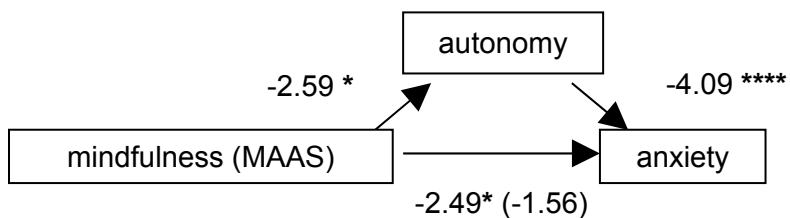


Figure 4. Autonomy as a mediator between mindfulness and self-reported anxiety
 * $p < .05$, **** $p < .0001$

Prediction of TSST physiological responses. Mindfulness, measured by the MAAS, did not significantly predict TSST stress levels on either endocrine measure: cortisol, $t(64) = 1.14, p = .25$, or alpha-amylase, $t(64) = 1.51, p = .13$. FFMQ scores did not significantly predict either cortisol [$t(64) = 1.65, p = .10$] or alpha-amylase [$t(64) = 1.68, p = .10$]. Similarly, least squares linear regression models using AUC values were not significant. Neither mindfulness measure, the MAAS [$t(1) = 1.12, p = .27$] nor FFMQ [$t(1) = 1.75, p = .08$] were significantly predictive of cortisol levels represented by AUC_G . AUC_I values were also not significantly predicted by either the MAAS [$t(1) = 1.61, p = .11$] or the FFMQ [$t(1) = 1.45, p = .15$]. As both predictors failed to show significant relations to the

endocrine dependent variables, further investigation into mediation was unnecessary. Table 3 displays the model statistics for each of the four dependant variable models.

Table 3

Multilevel model results for each mediation model

Outcome	t	df	p
Autonomy			
MAAS	2.59	64	.012
FFMQ	1.65	64	.10
Anxiety			
MAAS	-2.49	63	.015
FFMQ	-2.79	63	.008
Autonomy	-4.09	63	< .0001
MAAS (with autonomy)	-1.56	62	.12
Negative affect			
MAAS	-.67	64	.50
FFMQ	-.31	64	.76
Autonomy	-1.10	64	.27
Alpha-amylase			
MAAS	1.51	64	.13
FFMQ	1.68	64	.10
Autonomy	.14	64	.89
Cortisol			
MAAS	1.14	64	.25
FFMQ	1.65	64	.10
Autonomy	-.49	64	.62

Discussion

The purpose of this study was to assess the mediating role of autonomous motivation on the mindfulness-stress resistance relationship in a social stress context, in which stress was measured by both psychological (subjective, or self-reported) stress indicators and two endocrine markers of stress, cortisol and alpha-amylase. 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). In this study, the TSST was found to elicit social stress responses as indicated by elevated levels of anxiety, negative affect, cortisol, and alpha-amylase following the TSST, and all of which returned to baseline levels during post-task recovery. These results indicate that the TSST procedure was successful in inducing social stress in this study.

I first hypothesized that higher levels of dispositional mindfulness would predict lower stress responses. Although mindfulness, as measured by both the MAAS and FFMQ, did not predict reactivity to or recovery from the TSST on negative affect, alpha-amylase, or cortisol, higher scores on both measures did significantly predict reduced self-reported anxiety levels after controlling for relevant demographic and procedural covariates. The second hypothesis was that higher levels of dispositional mindfulness would predict more autonomous forms of motivation during the TSST. Scores on the MAAS significantly predicted increased autonomous motivation during the TSST, but scores on the FFMQ did

not. Thirdly, I hypothesized that higher levels of autonomy during the TSST would predict less stress reactivity and faster recovery. Similarly to mindfulness, state autonomous motivation significantly predicted reduced self-reported anxiety levels but not negative affect, alpha-amylase, or cortisol. The main hypothesis in this study was that state levels of autonomy during the TSST would mediate the relation between dispositional mindfulness and stress resilience. Although there was no evidence for a direct or indirect relation between mindfulness and negative affect or the endocrine outcomes, autonomy fully mediated the mindfulness – anxiety relationship.

Other findings. In line with previous research using the TSST (Kudielka, Buske-Kirschbaum, Hellhammer, et al., 2004), there was a significant effect of gender on cortisol levels, with men showing higher post-TSST levels than females. Time of day did not affect endocrine measures, but those participants participating in the early afternoon showed increased anxiety to the TSST than those in the later afternoon. This may be an important addition to Dickerson & Kemeny's (2004) suggestion that any afternoon saliva sample will be adequate to assess endocrine stress response to the TSST. When measuring psychological responses, it may be that differences can appear even within afternoon sessions. This finding is novel and requires replication before recommendations can be made.

Measuring psychological and psychobiological stress

Most research studies utilizing the TSST tend to only assess the psychobiological responses to social stressors, such as cortisol and alpha-amylase (Dickerson & Kemeny, 2004). While these measures are reliable indicators of stress response, it is important to not disregard the assessment of emotional state in social stress studies. Assessing stress-related psychological states such as affect can provide unique information, particularly given that the affect measures assessed here were not significantly correlated with endocrine measures at any time point during the procedure. Thus, assessment of both emotional and biological aspects of the stress response can provide a more complete understanding of the variability in stress resilience.

However it was contrary to prediction that mindfulness did not significantly predict endocrine responses. Previous research on mindfulness has indicated that mindfulness is associated with lower stress and stress-relevant responses (e.g., Barnes et al., 2007; Weinstein et al., 2009), although the present study is the first to test this relation with endocrine outcomes. However, these null findings are unexpected in light of the fact that dispositional mindfulness has repeatedly predicted stress outcomes (see review by Brown, Ryan, & Creswell, 2007), and has been shown to predict reduced brain activity in areas pertaining to emotional reactivity and increased activity in areas related to emotion regulation (Creswell Eisenberger, & Lieberman, 2008), which recent research indicates has a direct downstream relation to HPA axis activation (Herman,

Ostrander, Mueller, et al., 2005). Thus the role of mindfulness in stress-relevant endocrine responses deserves further investigation.

The fact that mindfulness significantly predicted lower anxiety across all time points in a social stress context suggests a possible buffering effect on the primary appraisal of and secondary responses to stress.

The mediating role of motivation

The present study is also the first to show that more mindful people, by way of higher autonomous motivation, tend to be less anxious when confronted with social evaluative threat. This finding builds on previous research that has shown that mindfulness predicts higher perceived choicefulness and volition in the execution of action (i.e., higher autonomous motivation) (Brown & Ryan, 2003; Levesque & Brown, 2007). Self-determination theorists such as Deci and Ryan (2000) and Hodgins and Knee (2002) have claimed that those who are more autonomous tend to also be more open to reality and less directed by ego-investing information. This research suggests that dispositional mindfulness, or the capacity to be more open and receptive to present realities, may help to foster autonomous motivation in stressful situations, which can thereby help reduce anxiety when confronted with stressors. Further research on this topic is warranted, particularly of an experimental nature, to understand the stress reduction pathway explored correlationally here.

Both constructs, autonomy and mindfulness, imply a similar ability of cognitive flexibility; having the ability to control ones thoughts and emotions

without the interference of egoic thoughts and external pressures. As did those who were more mindful, participants who performed the TSST with more autonomous motivation showed less anxiety compared to those who were less autonomous (that is, more ego-involved). Although previous research has shown autonomy to lead to numerous benefits, such as adaptive behavior regulation and psychological well-being (Ryan & Deci, 2000; Csikszentmihalyi & Rathunde, 1993; Ryan, Deci, & Grolnick, 1995), at present, this study is the first to examine the role of autonomous motivation in stress resilience. Along with mindfulness, a better understanding of autonomy may be important in helping to buffer stress reactions as well as to understand the mechanisms by which successful stress-reduction techniques can work.

Limitations and future directions

There are several limitations to this study. First, the study was correlational, and therefore causal explanations cannot be inferred. Without randomization of participants, one cannot know if mindfulness caused the decrease in self-reported anxiety. Future, experimental research is needed to better examine the causal role of mindfulness on autonomous motivation and stress resilience. Such research will help to offer direction to interventionists seeking to enhance the effectiveness of mindfulness-based training and therapies, such as Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982).

This study also had novel hypotheses, and further research is needed to replicate these findings and to further explore the relations of mindfulness and autonomy to stress-relevant endocrine response.

In general, the present line of research seeking to explain the role of mindfulness in stress resilience and reduction is important, and the preliminary findings reported here suggest that autonomous motivation may play an important role in explaining why more mindful people respond more adaptively to social and other stressors. Previous research has shown positive relationships between mindfulness and well being (Brown & Ryan, 2003) and stress reduction therapies that utilize mindfulness, such as Mindfulness-Based Stress Reduction (Kabat-Zinn, 1982) have been shown to be successful in ameliorating stress and related outcomes in a both healthy and a variety of mental health populations (see Baer, 2003, and Grossman, Niemann, Schmidt, et al., 2004, for meta-analytic reviews). Further basic research may shed more light on those processes, such as autonomy, that help to explain the success of mindfulness interventions. Such research can also foster the adaptation of mindfulness interventions to ameliorating deficits in emotion regulation and stress management in vulnerable populations.

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