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RESEARCH ARTICLE

Dispositional mindfulness is associated with heart rate reactivity and recovery in response to a lab stressor

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Abstract

Heightened perceived stress is consistently associated with symptoms of psychopathology. Perceived stress can be reliably linked with physiological responses, such as increased heart rate. Even though dispositional mindfulness is associated with lower self-reported stress, no studies to date have examined whether dispositional mindfulness can predict physiological responses to and recovery from stress. We recruited 142 student participants and administered a measure of dispositional mindfulness (Five Facet Mindfulness Questionnaire—Short Form/FFMQ-SF) and a modified version of the Trier Social Stress Test (TSST). Specifically, during the TSST, we instructed participants that they were about to deliver a presentation to a panel of judges, then informed them they no longer need to deliver this presentation, all while measuring their heart rate. We found that total FFMQ-SF and non-reactivity subscale scores were positively and significantly correlated with heart rate reactivity to the lab stressor. Further, we found that the FFMQ-SF facet of non-judgment was negatively and significantly correlated with the time it took for participants' heart rates to return to and stabilize at baseline. The results of this study elucidate potential mechanisms of mindfulness in stress. Specifically, mindfulness may not necessarily make people less reactive to stressors, but may operate through top-down processes to enhance recovery and resilience during stress.

KEYWORDS

dispositional mindfulness, heart rate, non-judgment, resilience, stress, Trier Social Stress Test

1 | INTRODUCTION

Stress, much like other emotional and physiological reactions, is key for survival. However, when it is prolonged in duration and/or disproportionately high, this stress may contribute to the development and maintenance of psychopathology (Dohrenwend, 2000; Haglund, Nestadt, Cooper, Southwick, & Charney, 2007). Stress is defined as tension or discomfort that is experienced when an event (stimulus or response) is perceived to tax one's coping resources, and hence perceived to be a threat to personal wellbeing (Cooper & Dewe, 2004). Elevated stress has particularly been implicated in the development and maintenance of depression (Caspi et al., 2003; Hammen, 2005) and anxiety (Sarason, 1984; Shin & Liberzon, 2010). Mindfulness-based interventions have shown tremendous promise in their ability to reduce subjective stress among healthy participants (Chiesa & Serretti, 2009; Grossman et al., 2004). However, it is not yet known whether dispositional mindfulness—the capacity to attend to present-moment experiences with acceptance—can predict autonomic responses in a laboratory stressor.

Physiological processes are important markers for the subjective experience of stress. Of these processes, heart rate and heart rate variability have received considerable attention as proxies of the stress experience (Taelman, Vandeput, Spaepen, & Van Huffel, 2009). This body of knowledge suggests that autonomic responses such as heart rate and heart rate variability are valid biological markers of subjective stress (Thayler, Åhs, Fredrikson, Sollers III, & Wager, 2012; Sack, Hopper, & Lampercht, 2004). For example, increases in heart rate have been observed in response to lab-induced stress (Knight & Rickard, 2001; Ditzen et al., 2007) but also in response to trauma (Shalev et al., 1998). In another study, researchers found that heart rate increased in reaction to work-related stress (Vrijkotte, Van Doornen, & De Geus, 2000). Accordingly, stress appears to be associated with autonomic responses, and in particular heart rate.

Although the focus in psychopathology research has been on vulnerability and reactivity during stressful situations, a new line of research is pointing to the importance of resilience factors in long-term and stable remission (Waugh & Koster, 2015). This research points to the importance of stress recovery, not only stress reactivity, in mental health. Davydov, Stewart, Ritchie, and Chaudieu (2010) argued that successful recovery from stress is a key characteristic of resilience. Central to resilience is the ability to "bounce-back" to pre-stressor or baseline levels of functioning. Tugade and Fredrickson (2004) examined heart rate recovery from stress using a modified Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). During this task, participants are made to believe they are about to present a speech that will be evaluated by a panel of judges. The researchers then measured physiological (e.g., heart rate, heart rate variability, blood pressure, etc.) and emotional (e.g., subjective ratings of mood) recovery after they removed this stressor (by informing participants that they no longer have to give the speech). Researchers found that a measure of ego-resilience predicted successful psychological and physiological (including heart rate) recovery from this stressor. Tugade and Fredrickson (2004) also found that individuals who were better able to recover from this experimentally induced stress task did so by using positive appraisal strategies to increase positive emotionality. In other words, individuals who experienced faster physiological recovery in response to the lab stress task were more likely to view the stress task as a "challenge" rather than a "threat," which increased their likelihood of experiencing emotions such as excitement, enthusiasm, and interest.

The term mindfulness has many uses in contemporary psychology. It has been conceptualized as a state (of being aware of present moment experiences non-judgementally), a disposition (overall capacity to be mindfully aware of present moment experiences non-judgmentally), and as a set of interventions sharing common elements (Crane et al., 2017; Feldman & Kuyken, 2019). There is evidence that dispositional mindfulness increases with increased engagement with and cultivation of states of mindfulness (Hölzel et al., 2011; Kiken, Garland, Bluth, Palsson, & Gaylord, 2015). Evidence demonstrates that mindfulness interventions, which are designed to heighten states of mindfulness through structured protocols, increase trainees' dispositional capacity to be mindful, which in turn has many health benefits (Goleman & Davidson, 2017; Kiken et al., 2015; Shapiro, Brown, Thoresen, & Plante, 2011).

Heightened dispositional mindfulness is associated with lower self-reported stress (Bao, Xue, & Kong, 2015). Mindfulness may modulate stress through two hypothesized neural mechanisms: bottom-up, or top-down regulation strategies (Chiesa, Serretti, & Jakobsen, 2013). Each such pathways corresponds to a particular pattern of neural activation. For instance, top-down regulation strategies involve activation of prefrontal regions in the brain, and hence such strategies tap into higher-order processes (e.g., cognitive reappraisal and cognitive defusion). By contrast, bottom-up regulation strategies alter neural activation in the emotional centers of the brain, without necessarily tapping into higher-order processes. Although reliance on top-down strategies may not reduce the magnitude of initial activation in the emotional regions of the brain, such processes may expedite recovery mechanisms (Chiesa et al., 2013).

In support of the bottom-up regulation hypothesis, researchers found that patients with substance use disorder randomized to a mindfulness training condition showed less stress reactivity post-intervention than those assigned to the control condition (Brewer et al., 2009). Acceptance training also appears to be related to lower physiological indices of stress (Lindsay, Young, Smyth, Brown, & Creswell, 2018). Mindfulness training also appears to lower subjective stress reactivity in response to the TSST among generalized anxiety disorder patients (Hoge et al., 2013). There have also been a few neuroimaging studies that suggest reduced neural activation of emotional brain regions among seasoned meditators (see Goleman & Davidson, 2017, for review). Interestingly, however, Beshai, Prentice, and Huang (2018) found that dispositional mindfulness was positively and significantly associated with subjective decreases in mood (i.e., higher mood reactivity) immediately after a negative mood induction. That is, individuals higher on dispositional mindfulness experienced an increased drop in their mood in response to the sad induction. The researchers also found that depressive symptoms and other correlates of depression (e.g., negative cognitive reactivity) were associated with a smaller drop in mood in response to the negative induction. In other words, it appears that dispositional mindfulness is associated with heightened emotional flexibility (appropriate emotionality given shifting contexts), which is further associated with a more resilient profile. Accordingly, this particular finding is not consistent with a bottom-up emotion regulation hypothesis in mindfulness. That is, it appears that more resilient profiles are also more emotionally flexible, experiencing the full gamut of emotion when contextually appropriate.

There is also robust support for the top-down regulation hypothesis in mindfulness (Chiesa et al., 2013). As mentioned, several lines of evidence suggest that mindfulness interventions also work through increases in mindfulness-specific skills (Alsubaie et al., 2017). These skills are driven by the theoretical components of mindfulness related to attention regulation (describe, observe and act with awareness), decentring (non-react), and acceptance (non-judge). Researchers found that dispositional mindfulness longitudinally predicted more benign appraisals of stressors and higher use of adaptive coping strategies (Weinstein, Brown, & Ryan, 2009).

2 | CURRENT STUDY

Taken together, the summarized evidence suggests that the experience of subjective stress is reliably associated with certain physiological proxies, such as heart rate. Next, the summarized evidence also suggests that mindfulness may work to mitigate stress by (a) enhancing top-down regulation, hence helping novice trainees return to baseline more quickly, and then (b) reducing reactivity, or the magnitude of initial distressing emotions from the outset among seasoned trainees. However, results from Beshai et al. (2018) cast doubts on the second said point. Specifically, increases in dispositional mindfulness appear to be associated with increased (not decreased) reactivity, given the possible role of mindfulness in emotional flexibility.

No studies to date have examined whether dispositional levels of mindfulness and its facets are associated with physiological proxies of stress. Studies of this nature are important, as they help researchers unpack the mechanisms of action of this versatile approach to wellbeing. Accordingly, if mindfulness works to thwart stress through bottom-up mechanisms, we would expect relatively mitigated heart rate responses to stressors. By contrast, if mindfulness works to mitigate stress by enhancing top-down inhibitory mechanisms, we would expect initial heart rate spikes in reaction to stressors, with a relatively shorter time to heart rate recovery for those exhibiting high levels of mindfulness. To test these hypotheses, we recruited 142 students and exposed them to a modified laboratory stressor and then assessed their levels of dispositional mindfulness. Given the inverse effects of mindfulness on experiential avoidance (Thompson & Waltz, 2010), as well as evidence suggesting a relationship between dispositional mindfulness and enhanced emotional flexibility (Beshai et al., 2018), we hypothesized that dispositional mindfulness would be associated with a higher heart rate in response to a laboratory stressor. We also hypothesized that dispositional mindfulness would be associated with faster recovery after removal of the laboratory stressor.

3 | METHODS

3.1 | Participants

Prior to data collection, this study was approved by the [redacted] Research Ethics Board. Participants were all 18 years of age and over and were recruited through the [redacted] Psychology Research Participant Pool. Participants received one course credit as compensation for their participation. As a safety precaution, anyone who self-identified as having a heart condition or blood pressure higher than 140/90 was not eligible to participate.

A total of 142 participants completed study tasks and were included in the final analyses. The final sample consisted of people of varying ages, ethnicities, and socioeconomic backgrounds. The pertinent demographic information is summarized in Table 1.

3.2 | Measures

Five Facet Mindfulness Questionnaire–Short-Form (FFMQ-SF; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2008). The FFMQ-SF assesses dispositional mindfulness. FFMQ-SF was developed to assess five facets of mindfulness: observing (e.g., "I pay attention to physical experiences, such as the wind in my hair or sun on my face"), describing (e.g., "I'm good at finding the words to describe my feelings"), acting-with-awareness (e.g., "I rush through activities without really being attentive to them"), non-judging of inner experience (e.g., "I tell myself I shouldn't be thinking the way that I'm thinking") and non-reactivity to inner experience (e.g., "I watch my feelings without getting carried away by them"). The 24 items are rated on a 5-point Likert scale, ranging from 1 (*never or very rarely true*) to 5 (*very often or always true*). After reverse-scoring negatively worded items, higher scores on the FFMQ-SF are indicative of higher mindfulness skills. This questionnaire encompasses the multidimensional-nature of the mindfulness construct (Rau & Williams, 2016). One study examining the measure's factor structure, internal consistency, and construct validity concluded that the short form has similar psychometric properties as the original 39-item FFMQ (Bohlmeijer, Klooster, Fledderus, Veehof, & Baer, 2011; Baer et al., 2008).

3.3 | Procedure

The study was conducted in a designated room in the Depression, Cognition, and Culture Lab at the [redacted]. A modified TSST was used to measure stress reactivity and recovery. Participants were directed to a private room by a trained researcher, where they were informed what the project would entail and asked to provide their written consent. After consent was obtained, and after an acclimation period of 5 min (adaptation phase), participants were asked to secure a chest-band HR monitor around their chests, sitting approximately one half-inch below the rib cage. The chest-band measured participants heart rates in real time and these HR readings were projected simultaneously to a smart mobile phone connected to the band wirelessly.

The modified TSST commenced in three phases: (a) The researcher would ask the participant to sit quietly and then left the room for timing of the adaptation phase (0–3 min). Measurements during this adaptation phase were used as baseline. Accordingly, the researcher recorded participants baseline heart rate every 30 s of every phase, during intervals of 0 s, 30 s, 1 min, 1 min, and 30 s, and at 2 min. An average of the five recorded HRs was calculated; (b) during the preparation phase, the experimenter informed the participant that they would have 3 min to prepare and deliver a presentation on "why they were a good friend" via web-camera to a panel of judges for evaluation. The experimenter recorded the participant's HR at the same five 30-s intervals during this preparation phase, and an average HR during this phase was also calculated; (c) In the final phase, the researcher informed participants that they no longer had to present and they were asked to sit quietly in the room (recovery phase). During this recovery phase, the researcher recorded the time (in seconds) it took for participant's HR to return to their average baseline level or lower and remain there for five consecutive seconds (Fredrickson & Levenson, 1998). The third phase had a maximum recording time of 10 min.

After the physiological measures were obtained and recorded, participants were asked to complete the FFMQ-SF and a demographics survey. This was done on a computer using the web-based program, Qualtrics, an online, secure surveying software. All participants were

TABLE 1 Demographic characteristics

	Frequency (*n*)	Percentage	Mean	Standard deviation	Cronbach's α
Age			21.73	5.28	
Sex					
Female	112	78.8			
Marital Status					
Single/Never Married	126	88.7			
Married	6	4.2			
Other	10	7.0			
Ethnicity					
White/Caucasian	86	60.5			
Asian	27	18.9			
Black	14	9.8			
Middle Eastern	9	6.3			
Indigenous	6	4.2			
Year of Study					
1	36	25.2			
2	46	32.3			
3	36	25.2			
4	16	11.2			
5+	8	5.6			
Employment Status					
Employed Part-Time	79	55.6			
Unemployed	49	34.3			
Other	14	9.8			
History of Psychiatric Condition					
Yes	23	16.1			
FFMQ-SF			75.92	11.95	.81
Observing			13.2	3.9	.78
Describing			16.7	4.1	.83
Acting-with-awareness			17.0	4.3	.84
Non-judging of inner experience			15.2	4.3	.77
Non-reactivity of inner experience			13.8	3.9	.77

Abbreviation: FFMQ-SF, Five Facet Mindfulness Questionnaire-Short Form.

thoroughly debriefed at the end of the protocol and feedback was gathered.

3.4 | Data preparation and analyses

All data were checked for accuracy and completeness. The proportion of missing values within each scale for each participant was calculated. We used a threshold of 80% for completeness. Accordingly, if this proportion exceeded 20%, a total score was not computed and was treated as a missing value; if the missing proportion was <20%, mean imputation was used (Downey & King, 1998; Shrive, Stuart, Quan, & Ghali, 2006).

We conducted a paired samples *t* test comparing average heart rates during the adaptation and preparation phases to examine the success of the manipulation. Upon establishing the success of the manipulation, we calculated heart rate reactivity by subtracting average heart rates during the adaptation (baseline) phase from average heart rates during the preparation stage. Finally, we conducted a product–moment Pearson correlation analysis to examine correlations between heart rate reactivity, time to heart rate recovery, and dispositional mindfulness (total and subscale) scores to test our primary hypotheses.

4 | RESULTS

4.1 | Manipulation check

Participant heart rate was a mean of 83.46 (*SD* = 13.83) during the adaptation (baseline) phase, and a mean of 93.39 (*SD* = 15.44) during the preparation phase, an increase of 9.94 (*SD* = 9.42) heart beats. A paired-samples *t* test revealed a significant increase in heart rate from baseline to preparation phase, $t(141) = -12.55$, $p < .001$, $d = 1.14$ (95% CI: 0.89–1.39).

4.2 | Zero-order correlations

Zero-order correlation coefficients of the relationships of reactivity, recovery, and mindfulness are summarized in Table 2. As can be observed, total scores on the FFMQ-SF were positively and significantly correlated with reactivity scores, $r = .17$, $p = .04$. In addition, there was a significant positive relationship between scores on the non-react facet of the FFMQ-SF and heart rate reactivity, $r = .17$, $p < .05$. Finally, there was a negative and significant relationship between scores on the non-judgment facet of the FFMQ-SF and time to heart rate recovery, $r = -.20$, $p = .019$.

4.3 | Discussion

In this study, we sought to examine the relationships between facets of the FFMQ and heart rate reactivity and recovery during stress. We found a positive association between mindfulness and heart rate reactivity. Further, we found a negative association between the facet of non-judgment and time to heart rate recovery. The effect sizes of these associations were small; however, results of this study demonstrate the systematic relationship between indices of psychological resilience and physiological reactivity and recovery from stress.

Replicating and extending laboratory stress and reactivity procedures (Kirschbaum et al., 1993; Tugade & Fredrickson, 2004; Tugade, Fredrickson, & Feldman Barrett, 2004), we found that participants' heart rate increased significantly by approximately 10 beats in reaction to the stressful situation. Accordingly, the manipulation was successful in eliciting the stress response (Kirschbaum et al., 1993). This is an important finding, as it validates the use of this protocol in eliciting laboratory stress. Further, we replicated and extended previously published stress procedures (e.g., Fredrickson & Levenson, 1998; Tugade & Fredrickson, 2004) by operationally defining recovery as the time (in seconds) it took for participants' heart rate to return to baseline and remain there for five consecutive seconds. This procedure was partially validated by the association of this construct with the mindfulness facet of non-judgment.

TABLE 2 Zero-order correlations between heart rate reactivity and recovery and the facets of the FFMQ-SF

	Reactivity	Recovery
FFMQ-SF-Total	0.17*	−0.14
a. Observe	0.05	0.02
b. Describe	0.07	−0.13
c. Act Aware	0.08	−0.12
d. Non-react	0.17*	0.04
e. Non-judge	0.13	−0.20*

Abbreviations: FFMQ-SF, Five Facet Mindfulness Questionnaire-Short Form; reactivity, average heart beats per minute during preparation phase minus average heart beats per minute during adaptation phase; recovery, seconds elapsed for heart rate to return to average during adaptation phase and stay there for five consecutive sections.
*Significance at the .05 level.

We found that total mindfulness scores were positively correlated with heart rate reactivity in response to stress. That is, and in support of the first hypothesis, mindfulness skills appear to be associated with emotional flexibility even in response to unpleasant experiences (Beshai et al., 2018; Roemer & Orsillo, 2003). This heightened reactivity is consistent with theories suggesting mindfulness should theoretically be associated with low experiential avoidance, and hence acceptance of distress (Kabat-Zinn, 2009; Roemer & Orsillo, 2003). Further, researchers have found that psychopathology, and in particular depression, is associated with dampened emotional responses in response to both positive and negative stimuli (Bylsma, Morris, & Rottenberg, 2008). The finding that mindfulness is associated with increased heart rate reactivity in response to the modified TSST suggests that mindfulness may function to facilitate flexible, context-specific emotional responding (Silberstein, Tirch, Leahy, & McGinn, 2012). Researchers have argued that emotional flexibility in response to congruent environmental cues may be an index of resilience (Beshai et al., 2018; Coifman & Bonanno, 2010; Waugh, Thompson, & Gotlib, 2011). This result also casts doubts on the dichotomy of the hypothesized mechanisms (top-down vs. bottom-up) of mindfulness (Chiesa et al., 2013). That is, heightened dispositional mindfulness may be associated with an increased capacity to choose flexibly between emotion regulation strategies that are most appropriate for a given context (Beshai et al., 2018).

In addition, we found that the mindfulness facet of non-reactivity to inner experiences was significantly and positively associated with increased heart rate reactivity. Brown and Ryan (2004) defined the construct of non-reactivity to inner experiences as the capacity to be able to have thoughts of varying emotional valence without being swept by them. Accordingly, researchers found that scores on the non-react facet of the FFMQ to be strongly and positively associated with measures of emotional flexibility (Curtiss & Klemanski, 2014). That is, it is possible that the capacity to be non-reactive to internal experiences allowed for greater acceptance of the stressful nature of the lab stress task, which then was associated with higher reactivity to such task. This finding also supports a more nuanced picture of how dispositional mindfulness and its facets regulate stress.

Further, we also found the mindfulness facet of non-judgment to be negatively associated with time to heart rate recovery. This finding is consistent with that of Baer et al. (2008) who found that the facet of non-judgment in particular was strongly and negatively associated with neuroticism, thought suppression, difficulties with emotional regulation, and experiential avoidance. Researchers have found heart rate to be a marker for resilience (Oldehinkel, Verhulst, & Ormel, 2008). Accordingly, mindfulness, and non-judgment in particular, may be associated with physiological markers of resilience. That is, results indicate some facets of dispositional mindfulness (e.g., non-react) are associated with emotional flexibility, hence making it likely for people to accept internal experiences, and in turn react appropriately (reactivity). Results also indicate that other facets (non-judgment), may then allow people to better process and regulate such emotional and physiological experiences when environmental inputs change (recovery). This finding is important, as mindfulness-based interventions for resilience may focus on cultivating the facet of non-judgment and its correlates to enhance indices of resilience to stress.

This study contributed to the literature in several ways. First, we used a large sample of undergraduates to examine the link between mindfulness and physiological reactivity to stress. Indeed, the employed sample size was larger than that in the majority of other studies examining the relationships of mindfulness and stress responses. Second, this study replicated findings from other studies showing that scores on self-report psychological measures are reliably associated with the more "objective" physiological indices of stress. Third, our finding that the mindfulness facet of non-judgment is associated with shorter time to physiological recovery after stress is important, as it sheds light on the mechanisms of mindfulness during stress.

This study suffered from several limitations that pave the way for future research. First, as we used an undergraduate and primarily female sample, the results obtained may not generalized to other populations. Second, we used a modified version of the TSST, hence deviating from the body of research on the original version of the task. With this said, the modified version functioned as a successful manipulation of heart rate reactivity in the present study. Third, we used only one measure of dispositional mindfulness, despite the existence of other measures of this construct (e.g., the Mindfulness Awareness and Attention Scale). Finally, we did not examine heart rate responses in relation to other indices of resilience. Relatedly, we did not measure how mindfulness may moderate other indices of psychopathology (e.g., rumination; negative emotions) and their relationship with stress reactivity. This is important, as recent studies suggest high dispositional mindfulness may buffer to protect individuals who are at heightened risk for psychopathology (Beshai & Parmar, 2018; Mishra, Beshai, Wuth, & Refaie, 2019). Another limitation of the current study relates to the ordering of study tasks. We administered the scale of dispositional mindfulness after completion of the laboratory stress induction task. Given that the FFMQ is sensitive to change (Gu et al., 2016), it is possible that how participants responded to and completed the FFMQ may be partially explained by their appraisal of the experimental task itself. That is, results obtained here may be a function of ordering effect. However, reversing the order to administer the FFMQ prior to administering the social stress task may have functioned instead to inoculate participants from the effects of the experimental manipulation. Bergeron, Almgren-Doré, and Dandeneau (2016) found that priming mindfulness words through a scrambled sentence task had the effect of lowering psychological and self-reported physiological markers of stress. Finally, there is evidence that states of mindfulness introduced during mindfulness-based interventions increase dispositional mindfulness overtime; however, researchers have demonstrated there is heterogeneity in the operational definitions and usage of the term "mindfulness" (Van Dam et al., 2018). Accordingly, it is unknown whether a different operational definition or assessment of dispositional mindfulness may impact the results obtained or their interpretation.

Future studies should replicate our findings with non-student populations and using other measures of dispositional mindfulness. Moreover, future studies should examine whether strong correlates of the facet of non-judgment (e.g., difficulties in emotion regulation; thought suppression; neuroticism) also predict response and recovery from stressors. Further, future studies should examine whether non-judgment-focused mindfulness interventions can enhance resiliency over the long term. If the link between non-judgment and resilience is supported in future projects, this would have important implications on the treatment of depression and anxiety.

In the current investigation, we found that total scores on the measure of dispositional mindfulness were positively correlated to increases in heart rate following exposure to a lab stressor. Further, we also found that the facet of non-judgment was negatively correlated with the time it took for participants' heart rate to return to and stabilize at baseline. Accordingly, dispositional mindfulness appears to be implicated in even physiological processes related to stress reactivity and recovery. This finding is important in our understanding of mindfulness, as well as in developing interventions that are designed to cultivate resilience to stress.

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