Mindfulness (2018) 9:925–938
https://doi.org/10.1007/s12671-017-0832-9

ORIGINAL PAPER

Examining the Association between Trait Mindfulness and Distress in Response to a Repeated CO_2 Challenge

Philip I. Chow[1,2] · **Eugenia I. Gorlin**[3] · **Jessica R. Beadel**[3] · **Sarah Thomas**[3] · **Scott Vrana**[4] · **Roxann Roberson-Nay**[5] · **Bethany A. Teachman**[3]

Published online: 28 October 2017

Abstract The present research examined the degree to which facets of trait mindfulness were associated with level and changes in psychological distress in response to a repeated carbon dioxide (CO_2) breathing challenge. Undergraduate students (N = 93) completed a self-report measure of mindfulness and underwent two 7.5% CO_2 challenges, spaced 1 week apart. Subjective distress, physical/fear symptoms, and threat cognitions were assessed at multiple times throughout each administration. A pattern emerged such that although mindfulness facets were not reliably associated with distress at either administration separately, a low (but not high) level of mindfulness was associated with a significant decrease in distress across administrations, likely indicative of habituation, for the facets Describing ($\beta = -0.25$, $p < -0.01$), Acting with Awareness ($\beta = -0.27$, $p < .01$), and Observing ($\beta = -0.25$, $p < 0.01$). This suggests that those components of mindfulness tied to noticing/attending to the present moment may at times interfere with typical habituation processes. In contrast, those high in components of mindfulness tied to not evaluating—Non-judging ($\beta = -0.23$, $p < 0.01$) and Non-reacting ($\beta = -0.12$, $p < 0.01$)—tended to report less distress, as expected. Findings suggest that the relation between trait mindfulness and stress response is more complex and nuanced than previously thought and that focusing on both mindfulness facets and repeated exposure to stressors may help elucidate this relationship.

Keywords Mindfulness · Panic · Carbon dioxide (CO_2) breathing challenge · Subjective distress

Introduction

Mindfulness involves the capacity to purposefully attend to one's present experiences while taking a non-judgmental stance (Kabat-Zinn 1990). Research examining mindfulness-based interventions has found that practice aimed at cultivating awareness and attention to experiences in the present moment has many benefits, such as an increase in well-being (e.g., Brown and Ryan 2003; Carmody and Baer 2008) and use of adaptive coping strategies (e.g., Weinstein et al. 2009). Research has also found that mindfulness, which is typically assessed with self-report measures such as the Five Facet Mindfulness Questionnaire (Baer et al. 2006), is important to mental health outcomes. For example, a meta-analysis found medium effect sizes for mindfulness-based therapy to lower mood and anxiety symptoms (e.g., Hofmann et al. 2010) in clinical populations. Further, research has found that increasing mindfulness leads to less rumination and worry, which in turn lowers anxiety symptoms, and also that increasing mindfulness leads to less rumination and more reappraisal, which in turn lower depressive symptoms (Desrosiers et al. 2013a).

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s12671-017-0832-9) contains supplementary material, which is available to authorized users.

✉ Philip I. Chow
pic2u@virginia.edu

[1] Department of Psychiatry and Neurobehavioral Sciences, University of Virginia, Charlottesville, VA, USA

[2] Center for Behavioral Health and Technology, University of Virginia, 560 Ray C. Hunt Dr., Charlottesville, VA 22903, USA

[3] Department of Psychology, University of Virginia, Charlottesville, VA, USA

[4] Department of Psychology, Virginia Commonwealth University, Richmond, VA, USA

[5] Department of Psychiatry, Virginia Institute for Psychiatric and Behavioral Genetics, Virginia Commonwealth University, Richmond, VA, USA

However, there are unanswered questions about trait mindfulness as a protective factor in response to stressors, particularly in relation to *repeated* stressors. There are important reasons to expect trait mindfulness to aid in reducing negative responses to stressors; for instance, trait mindfulness is associated with mood states and overall well-being (Brown and Ryan 2003; Creswell et al. 2007).

Importantly, if levels of mindfulness are indeed associated with levels of, and change in, distress to repeated stressors, it could help inform clinicians as to what factors should be targeted in interventions. For example, if high (vs. low) levels of certain mindfulness facets are associated with low initial distress and decreases in distress over time, clinicians may wish to increase those facets of trait mindfulness in patients in order to increase resilience to chronic stressors. Further, knowledge of which mindfulness facets are associated with trajectories of distress may contribute to targeted interventions that increase or decrease levels of specific mindfulness facets.

Some studies have examined the role of trait mindfulness in response to stressful social tasks, generally finding that high levels of trait mindfulness are associated with more benign stress-related appraisals and use of more adaptive coping strategies (e.g., Weinstein et al. 2009), as well as attenuated subjective distress when engaging in social evaluative tasks (Brown et al. 2012). However, only a handful of studies have examined the relationship between trait mindfulness and response to tasks that are not socially evaluative. For example, Arch and Craske (2010) found that unidimensional trait mindfulness was associated with attenuated reactivity to a hyperventilation task across anxious and non-anxious individuals, but they did not examine associations of different facets or distinguish between initial reactivity versus subsequent recovery. To examine whether mindfulness interacts with active use of emotional suppression, Bullis et al. 2014 instructed participants to suppress their emotional response while inhaling CO_2-enriched air, to see whether facets of trait mindfulness predicted reactivity (Bullis et al. 2014). The authors found that a higher level of acting with awareness (a mindfulness facet) was associated with less subjective anxiety during the challenge phase, whereas a higher level of observing (another mindfulness facet) was associated with *greater* frequency and intensity of panic symptoms. These findings point to the value and complexity of studying trait mindfulness and non-social stress responding, given that one mindfulness facet was positively associated with anxiety while another mindfulness facet was negatively associated. Further, because the Bullis et al. 2014 study used suppression instructions, administered the CO_2 challenge only once, and assessed distress *after* the inhalation phase, it remains to be examined whether trait mindfulness is associated with changes in psychological distress both across and within (by examining separate phases within a task) repeated administrations of a stressor, such as the CO_2 challenge. Trait mindfulness may be differentially associated with how people respond to stressful, novel experiences versus to stressful experiences previously encountered. Further, within a stressful experience, trait mindfulness may be differentially associated with the initial level and/or trajectory of distress.

In general, we expected high (vs. low) trait mindfulness facets to be associated with less distress in response to the CO_2 task. It was expected that this would be the case even at the first administration, when individuals have no experience with the CO_2 paradigm, based on the evolutionary perspective that individual differences are adaptive, in part, because they do not require familiarity in order for them to influence behavior in the presence of stressors (Buss 1996). Indeed, cross-sectional research has found that trait mindfulness is associated with attenuated distress in the face of novel, stressful tasks (Arch and Craske 2010; Bullis et al. 2014; Brown et al. 2012). However, an exploratory question was whether trait mindfulness would be associated with distress differently at the first versus second administration. With regard to associations between trait mindfulness and change in distress across administrations, we examined competing hypotheses. On one hand, if those high (vs. low) in trait mindfulness have low distress at the first administration, it might be hard for them to experience much decline in distress due to a floor effect. On the other hand, if high (vs. low) trait mindfulness facilitates greater learning at the first administration that exposure to the CO_2 task did not result in any catastrophic outcomes, it would be reasonable to expect those high in mindfulness to evidence greater habituation across administrations. Therefore, in general, high (vs. low) mindfulness should be associated with greater decreases in distress (this greater learning would presumably occur via enhanced describing of the experience during the first administration while not judging or strongly reacting; see discussion of mindfulness facets below).

Mindfulness has been examined as both a unidimensional and a multidimensional construct (i.e., as a general factor versus one composed of several interrelated facets, respectively). As researchers have become increasingly interested in examining how mindfulness is associated with various outcomes, this has necessitated examination of mindfulness at the facet level (e.g., Baer et al. 2008; Desrosiers et al. 2014). Mindfulness can be separated into five reliable factors, which are *describing* and labeling one's experiences, *acting with awareness* and attending to one's activities in the present moment, *non-judging* of inner experiences, *observing* and noticing one's experiences, and *non-reacting* to unpleasant stimuli, (for a review, see Baer et al. 2006).

Available evidence suggests that the facets of describing, non-judging, and non-reacting are strongly negatively associated with overall general distress and anxiety symptoms (e.g., Baer et al. 2006, 2008; Bohlmeijer et al. 2011; Cash and Whittingham 2010; Delgado et al. 2010; Desrosiers et al. 2013b). Acting with awareness, by contrast, has shown inconsistent findings concerning its association with anxiety (e.g.,

Desrosiers et al. 2013b), perhaps because attending fully to the present moment may be distressing for persons who judge many experiences as threatening. Along these lines, several studies have found that observing is *positively* associated with anxiety (e.g., Bullis et al. 2014; Curtiss and Klemanski 2014; Desrosiers et al. 2013b). High levels of observing, particularly in the absence of other mindfulness skills, may simply result in heightened attention to internal states, which can exacerbate anxiety (see literature on self-focused attention in anxiety; e.g., Makkar and Grisham 2013; Spurr and Stopa 2002). For example, whereas observing may be reflective of merely focusing and/or ruminating on unpleasant internal states, the ability to describe and label one's experiences may reflect greater capacity for introspection and ability to differentiate between different subjective states.

Importantly, examination of mindfulness at the facet level may help to clarify prior mixed findings when mindfulness has been examined as a unidimensional construct. For example, although mindfulness-based therapy has been found to be efficacious in treating anxiety symptoms (Hofmann et al. 2010), trait mindfulness has failed to show incremental validity, above and beyond positive and negative affectivity and approach-oriented coping, in associations with anxious arousal (Zvolensky et al. 2006). One reason may be that some facets of mindfulness are associated with anxiety symptoms in opposite directions (e.g., non-judging versus observing), while other facets (e.g., acting with awareness) may have little direct association with anxiety, leading to diluted effects.

The current study seeks to examine whether trait mindfulness facets are associated with level and changes in distress to a repeated stressful task. In general, we expected mindfulness facets to be negatively associated with psychological distress at both the first and second administrations of the CO_2 challenge, although an open question was whether mindfulness facets would be associated with distress more strongly at the first versus second administration. With respect to change in responding across CO_2 tasks, we examined the competing hypotheses that higher trait mindfulness would be associated with less reduction in distress or greater reduction in distress. In terms of the individual facets of trait mindfulness, our primary hypotheses were that describing, non-judging, and non-reacting would be most strongly and negatively associated with psychological distress at each time point, and would be most strongly associated with changes in distress across administrations of the CO_2 task. In terms of mindfulness' associations with distress across phases (within-session), it was hypothesized that higher (vs. lower) levels of non-judging, non-reacting, and describing would be associated with lower levels of initial distress in the anticipatory (mask) phase, less steep increase in distress (reactivity) during CO_2 inhalation, and greater decrease in distress during recovery. We did not lay out specific hypotheses for each facet at every phase and therefore these analyses were largely exploratory. All hypotheses can be seen in Table 1.

Method

Participants

Participants were 93 undergraduate students (52% female, M_{age} = 19.8, SD = 4.2) at two universities in the American Southeast, who participated in exchange for course credit or payment. The majority of participants self-identified as White (51.6%), followed by 17.2% African American, 12.9% Asian American, 11.8% Hispanic American, and 6.5% self-identified as "other," "more than 1 race," or did not respond. Participants were recruited either from a psychology participant pool (using a preselection survey) or via recruitment fliers posted on campus. To ensure equal representation of different levels of anxiety sensitivity (which is a well-known predictor of CO_2 response; Eke and McNally 1996; Rapee et al. 1992), a stratified sampling approach was taken at the university site that used the participant pool. Specifically, recruitment emails were sent to equal numbers of undergraduates scoring within each quartile of the distribution of college student scores on the Anxiety Sensitivity Index (ASI; Reiss et al. 1986). At the site using recruitment fliers, an unselected undergraduate sample was recruited. Using these recruitment methods, in total, 317 participants were recruited for session 1, and the first 150 participants were invited to return approximately 1 week later for session 2 (as part of a larger study aimed at investigating the test-retest reliability of the CO_2 challenge). Of the 150 participants invited back, 102 returned for session 2, and of those, 9 participants did not have usable mindfulness data due to random computer error. Based on attrition analyses, there were no significant differences in anxiety sensitivity or any of the CO_2 distress variables between participants who were invited back but chose not to return (n = 48) and those who did return (n = 102) (all p's > 0.10). For the 93 participants who completed the mindfulness measures, there were 25 (of 42 invited) participants with ASI scores in the lowest quartile, 28 (of 42 invited) in the lower-middle quartile, 19 (of 32 invited) in the upper-middle quartile, and 19 (of 34 invited) in the highest quartile (for ASI, M = 19.4, SD = 10.4; for more details regarding associations between anxiety sensitivity and CO_2 distress outcomes, see Gorlin et al. 2014).

Following common health-based exclusions used in past CO_2 challenge research (e.g., Garner et al. 2011; Welkowitz et al. 1999), participants were excluded from participating if they reported having asthma, a serious and unstable medical condition, lifetime history of psychotic symptoms, or if they had taken an antidepressant or psychotropic medication in the past 4 weeks (those taking benzodiazepines were eligible to participate if they had not taken their medication in the past 48 h; following Biber and Alkin 1999). Exclusion criteria were listed in recruitment emails and were assessed again at the baseline screening session.

Table 1 Hypotheses and corresponding findings for both between- and within-session mindfulness effects on distress

Between-session hypotheses and findings						
	Session 1 distress		Session 2 distress		Change in distress from sessions 1 to 2	
	Hypothesis	Finding	Hypothesis	Finding	Hypothesis	Finding
Describing	–	ns	–	ns	Competing hypotheses	Low facet had significant decrease
Non-Judging	–	–(SUDS)	–	ns	Competing hypotheses	Low and high facet had significant decreases (SUDS)
Non-Reacting	–	ns	–	ns	Competing hypotheses	ns
Acting with Awareness	–	ns	–	+	ns	Low facet had significant decrease
Observing	+	ns	+	ns	ns	Low facet had significant decrease

Within-session hypotheses and findings						
	Mask		Inhalation		Recovery	
	Hypothesis	Finding	Hypothesis	Finding	Hypothesis	Finding
Describing	–	ns	High facet/small increase	ns	High facet/large decrease	ns
Non-Judging	–	ns	High facet/small increase	ns	High facet/large decrease	ns
Non-Reacting	–	ns	High facet/small increase	Low facet/large increase[t]	High facet/large decrease	Low facet/large increase
Acting with Awareness	+	ns	High facet/large increase	ns	High facet/small decrease	ns
Observing[a]	+	ns	High facet/large increase	ns	High facet/small decrease	ns

[t] $p = 0.07$

[a] For the effect of Observing on distress within-sessions (across phases), there was no significant association between Observing and distress at any phase but there were significant trajectories across phases for those low versus high in levels of Observing

Procedure

Study procedures were approved by Institutional Review Boards at both sites. All participants provided informed consent and were told that the study was composed of a series of computer tasks (assessing mood and thinking patterns), self-report measures, as well as a breathing task that may produce some anxiety. Because it was important to not prime participants with panic expectancies, they were told that they would receive more information about the breathing task later in the study. Participants began by completing a baseline SUDS rating and DSQ, followed by a battery of measures administered in randomized order. They were then provided with a full description of the CO_2 challenge procedure, including the steps involved, and the possibility of anxiogenic effects, such as dizziness, rapid heart rate, and other symptoms similar to those listed on the DSQ. After participants signed a second informed consent form specific to the breathing task, the experimenter put the facemask on the participant, along with a belt and electrodes, and re-administered the SUDS and DSQ (as measures of anxious responding before the CO_2 breathing phase). SUDS ratings were then collected every 2 min throughout the CO_2 challenge. DSQ scores were collected after 5 min of CO_2 inhalation and again following the 5-min recovery period (after CO_2 inhalation had stopped), after which the facemask was removed. Participants whose final SUDS rating was more than 20 points above their baseline had the option of being led through a diaphragmatic breathing relaxation exercise to ensure that they did not leave the study distressed. Participants were invited to return approximately 1 week later for another administration of the CO_2 challenge (session 2), which followed the same procedure as session 1, and to complete additional measures, including the trait mindfulness measure. The trait mindfulness measure was completed before the CO_2 administration at session 2. This was largely due to convenience and because there was little reason to expect trait mindfulness scores to change over 1 week, as previous research has found strong 2-week test-retest reliability for non-English versions of the FFMQ (e.g., Veehof et al. 2011), as well as the Kentucky Inventory of Mindfulness Skills (KIMS; Baer et al. 2004), which has considerable overlap with the FFMQ and assesses four out of the five mindfulness facets in the FFMQ.

Measures

Trait Mindfulness Mindfulness was assessed using the 39-item Five Facet Mindfulness Questionnaire (FFMQ; Baer et al. 2006). Participants rated the degree to which various statements (e.g., When I am walking, I deliberately notice the sensations of my body moving; I watch my feelings without getting lost in them) were *generally true* of themselves (1 = never or very rarely true; 5 = very often or always true). Internal consistencies were good for subscales assessing observing (M = 25.5, SD = 5.3), describing (M = 25.9, SD = 5.7), acting with awareness (M = 25.5, SD = 5.0), non-judging (M = 26.2, SD = 6.3), and non-reacting (M = 21.9, SD = 3.8; α = 0.79, 0.89, 0.84, 0.91, and 0.76, respectively).

Anxiety Sensitivity The 16-item Anxiety Sensitivity Index (ASI; Reiss et al. 1986) assesses the tendency to fear symptoms associated with anxiety. Participants rated (0 = very little; 4 = very much) their agreement with various statements (e.g., It scares me when I become short of breath). This measure was administered at the first study session only (M = 19.2, SD = 10.3). The ASI is a well-validated measure that previous research has found to be a robust predictor of CO_2 responding (e.g., Eke and McNally 1996; Rapee et al. 1992). Internal consistency in the current sample was good (α = 0.88).

CO_2 Challenge Task Participants were told ahead of time that the task would take 18 min to complete, and that they would begin by breathing ambient air through a facemask before inhaling CO_2-enriched air (which would begin and end at unspecified times during the task). Participants sat in a comfortable chair and breathed through a silicone mask that covered their nose and mouth. The mask was connected to a multi-liter bag containing 7.5% CO_2-enriched air via a gas impermeable tube. A two-way stopcock allowed the experimenter to manually switch between ambient air and the CO_2 mixture (participants were not informed when CO_2-enriched air was being turned on and off). The stopcock valve and the bag containing the CO_2 mixture were hidden behind a partition. After putting on the facemask, participants breathed ambient air for 5 min, followed by 8 min of 7.5% CO_2-enriched air, followed by 5 min of ambient air (which served as a recovery phase before the mask was removed).

On at least two occasions, participants were told that they were allowed to stop the procedure at any time without penalty. In total, 18 participants out of the 93 chose to prematurely stop the procedure in session 1, and 13 participants chose to prematurely stop the procedure in session 2. Available data for participants who opted out of the procedure (e.g., distress ratings for the first part of the task) were still included in analyses.

Subjective Distress The Subjective Units of Distress Scale (SUDS; Wolpe 1969) is a widely used, verbally administered scale that provides an index of self-reported anxiety ranging from 0 (no anxiety) to 100 (extreme anxiety). SUDS ratings were collected 11 times throughout the experiment (see the "Procedure" section).

Physical- and Fear-Related Symptoms of Panic and Threat Cognitions A modified 26-item Diagnostic Symptom Questionnaire (DSQ; Sanderson et al. 1989) was used to assess current panic response. The questionnaire is composed of two scales. One 16-item scale assessed the

presence and severity of physical symptoms (e.g., trembling or shaking; pounding or racing heart; according to the Diagnostic and Statistical Manual of Mental Disorders, 4th ed.; American Psychiatric Association 2000) and accompanying fear-related responses (e.g., fear of going crazy) on a nine-point Likert scale (0 = Not at all noticed; 8 = Very strongly felt). Another scale assessed threat cognitions (10 items; e.g., I feel like I might be dying; I need help) on a four-point Likert scale (1 = Not at all true; 4 = Very true). Because the original DSQ measure only allows for dichotomous yes/no responses for threat cognitions, the response scale was modified to allow for dimensional scores. DSQ scores were collected at four times throughout the experiment (see the "Procedure" section).

Note, the materials reported here are part of a larger, two-session study that examined correlates of distress to a repeated CO_2 challenge. The present research is the first using this dataset to examine how mindfulness variables are associated with subjective distress to a repeated CO_2 task, and no mindfulness variables or subjective distress variables were excluded from this report (i.e., no additional correlates of mindfulness were examined but not reported). A full list of materials is available by contacting the first author.

Data Analyses

DSQ scores were log-transformed to reduce positive skew. Zero-order correlations between all mindfulness and distress variables can be found in Table S1, and correlations among mindfulness variables as well as with anxiety sensitivity can be found in Table S2 in the Online Resource. We conducted linear mixed-effects model analyses using the "lme4" package in R (Bates et al. 2014) to test the role of each of the five individual mindfulness facets in associations with distress over the two CO_2 tasks. All mindfulness variables were mean-centered. The advantages of linear mixed modeling over more traditional repeated-measures analysis of variance (ANOVA) approaches—such as improved flexibility in modeling time effects and more inclusive, unbiased handling of missing data—have been extensively documented elsewhere (e.g., Nich and Carroll 1997; Wilksch and Wade 2014). Thus, all available values of a repeated measure, including those from participants who dropped out, were included in our mixed model analyses.

The five individual mindfulness facets were examined in separate models examining the incremental validity of each individual facet, with the other four facets included as covariates. All continuous variables were standardized prior to analyses. Further, to ensure that our outcome measures specifically captured participants' distress in response to the laboratory stressor, baseline levels of each distress measure at sessions 1 and 2 were entered as covariates in all regression models. Phase of stressor was coded as an ordered within-subject factor with three levels (Room Air/Mask, CO_2 Inhalation, and Recovery), allowing for the estimation of both linear and quadratic trends for phase. Session was coded as a categorical within-subject factor with two levels (session 1, session 2), and distress type was coded as a categorical within-subject factor with three levels (SUDS, DSQ-Phys/Fear, and DSQ-Cognitive scores were standardized). Random effects of Intercept and Distress type by Subject were included in each model to control for individual differences in mean distress levels and in response variability across measures.

For the initial omnibus model, Distress was regressed onto the fixed effects of Mindfulness, Session, Linear and Quadratic phase, Distress type, and their 2-, 3-, and 4-way interaction terms. An F test was first conducted on this full model to determine whether the effects of mindfulness differed by distress type (i.e., if any interactions involving Mindfulness and Distress type were significant). If not, these interaction terms were removed from the simplified follow-up regression model; otherwise, separate follow-up regression models were conducted within each Distress type. Regression statistics for each mixed-effects model, including regression weights for associations between mindfulness and distress at each session, are shown in Table 2. Slopes across sessions and phases (as indicated) for a given mindfulness facet reflect standardized b's, which represent the model-predicted change in standard-deviation units of Distress from session 1 to session 2 or across consecutive phases, respectively. Only those interactions involving mindfulness are reported here given the focus of the present research (full statistical results are available from the lead author). There were significant negative main effects of Session (with distress decreasing from session 1 to session 2) as well as Quadratic Phase for every model, except where otherwise noted. The Variance Inflation Factor (VIF; a widely used metric to assess multicollinearity) in the current analyses were all less than 5 (and all except one were less than 4), well below the widely recommended cutoff of 10 (e.g., Hair et al. 1998; O'brien 2007).

We computed power analyses for a mixed-effects model using the "lmmpower" package in R (Donohue and Edland 2016), and found that a sample size of 73 would provide 85% power to detect a modest effect (i.e., a change in the outcome corresponding .25 SD units) in a model with a continuous predictor (i.e., mindfulness), a three-level within-subject "timepoint" factor (with linear and quadratic trends), and a two-level within-subject "session" factor.

Results

Describing

The omnibus F test revealed no significant interactions involving Describing and Distress type (all $F < 3$, all $p > 0.05$); thus, subsequent regression analyses were collapsed across Distress type. As seen in Table 2, there was no significant main effect of Describing, suggesting that higher

Table 2 Mixed-effects regression results for associations between mindfulness variables and distress across sessions and phases of the CO_2 task (standardized β coefficients are shown)

Outcome	Predictors	β	SE	t	p
Overall distress					
	Describing	0.03	0.05	0.64	0.53
	Session 2 vs. session 1 Distress	− 0.17	0.04	− 4.52	< 0.01
	Linear effect of CO_2 phase	0.01	0.03	0.44	0.66
	Quadratic effect of CO_2 phase	− 0.83	0.03	− 26.07	< 0.01
	Describing x Session	**0.08**	**0.04**	**2.18**	**0.03**
	Session 1 Describing	− 0.01	0.05	− 0.17	0.86
	Session 2 Describing	0.07	0.05	1.37	0.18
	High Describing session 1 to 2 Slope in Distress	− 0.09	0.05	− 1.58	0.11
	Low Describing session 1 to 2 Slope in Distress	− **0.25**	**0.05**	− **4.87**	< **0.01**
SUDS					
	Non-judging	− 0.18	0.09	− 1.98	0.05
	Session 2 vs. session 1 SUDS	− 0.35	0.06	− 5.94	< 0.01
	Linear effect of CO_2 phase	− 0.01	0.05	− 0.16	0.88
	Quadratic effect of CO_2 phase	− 0.80	0.05	− 16.04	< 0.01
	Non-judging x session	**0.12**	**0.06**	**2.06**	**0.04**
	Session 1 Non-judging	− **0.24**	**0.09**	− **2.52**	**0.01**
	Session 2 Non-judging	− 0.12	0.09	− 1.26	0.21
	High Non-judging session 1 to 2 Slope in SUDS	− **0.23**	**0.08**	− **2.79**	< **0.01**
	Low Non-judging session 1 to 2 Slope in SUDS	− **0.46**	**0.08**	− **5.79**	< **0.01**
DSQ physical/fear					
	Non-judging	− **0.22**	**0.08**	− **2.79**	**0.01**
	Session 2 vs. session 1 DSQ physical/fear	− 0.14	0.06	− 2.18	0.03
	Linear effect of CO_2 phase	0.20	0.05	3.69	< 0.01
	Quadratic effect of CO_2 phase	− 0.98	0.05	− 18.20	< 0.01
DSQ cognitive					
	Non-judging	− 0.03	0.06	− 0.55	0.58
	Session 2 vs. session 1 DSQ cognitive	− 0.02	0.07	− 0.23	0.82
	Linear effect of CO_2 phase	− 0.16	0.06	− 2.77	0.01
	Quadratic effect of CO_2 phase	− 0.73	0.06	− 12.30	< 0.01
Overall distress					
	Non-reacting	− **0.10**	**0.05**	− **2.05**	**0.04**
	Session 2 vs. session 1 Distress	− 0.17	0.04	− 4.67	< 0.01
	Linear effect of CO_2 phase	0.01	0.03	0.25	0.81
	Quadratic effect of CO_2 phase	− 0.83	0.03	− 26.18	< 0.01
	Non-reacting x Linear phase	− **0.12**	**0.03**	− **3.75**	< **0.01**
	High Non-reacting Linear Slope across phases	− 0.12	0.08	− 1.53	0.13
	Low Non-reacting Linear Slope across phases	0.10	0.07	1.29	0.20
	Main effect of Non-reacting at Mask phase	− 0.01	0.06	− 0.12	0.90
	Main effect of Non-reacting at CO2 phase	− 0.09	0.05	− 1.87	0.07
	Main effect of Non-reacting at Recovery phase	− **0.18**	**0.06**	− **3.02**	< **0.01**
Overall distress					
	Acting with awareness	0.09	0.05	1.72	0.09
	Session 2 vs. Session 1 Distress	−0.16	0.04	−4.20	< 0.01
	Linear effect of CO_2 phase	0.01	0.03	0.23	0.82
	Quadratic effect of CO_2 phase	−0.84	0.03	−26.26	< 0.01
	Awareness x Session	**0.11**	**0.04**	**3.13**	< **0.01**
	Session 1 Awareness	0.03	0.05	0.55	0.58
	Session 2 Awareness	**0.14**	**0.05**	**2.69**	< **0.01**

Table 2 (continued)

Outcome	Predictors	β	SE	t	p
	High Awareness session 1 to 2 Slope in Distress	− 0.04	0.05	− 0.80	0.42
	Low Awareness session 1 to 2 Slope in Distress	− 0.**27**	0.**05**	− **5.49**	< 0.**01**
Overall distress					
	Observing	0.04	0.05	0.90	0.37
	Session 2 vs. session 1 Distress	− 0.17	0.04	− 4.49	< 0.01
	Linear effect of CO_2 phase	0.02	1.42	0.57	0.57
	Quadratic effect of CO_2 phase	− 0.83	1.42	− 26.12	< 0.01
	Observing x Session	0.**08**	0.**04**	**2.13**	0.**03**
	Session 1 Observing	0.00	0.05	0.07	0.94
	Session 2 Observing	0.08	0.05	1.50	0.14
	High Observing session 1 to 2 Slope in Distress	− 0.09	0.05	− 1.62	0.10
	Low Observing session 1 to 2 Slope in Distress	− 0.**25**	0.**05**	− **4.74**	< 0.**01**
	Observing x Linear Effect of phase	0.**07**	**1.45**	**2.05**	0.**04**
	High Observing Linear Slope in Distress across phases	0.09	0.05	1.84	0.07
	Low Observing Linear Slope in Distress across phases	− 0.05	0.05	− 1.08	0.28
	Observing x Quadratic Effect of phase	0.**09**	**1.44**	**2.72**	< 0.**01**
	High Observing Quadratic Slope in Distress across phases	− 0.**74**	0.**05**	− **16.18**	< 0.**01**
	Low Observing Quadratic Slope in Distress across phases	− 0.**92**	0.**04**	**−20.56**	< 0.**01**

Baseline SUDS, DSQ Physical/Fear, and DSQ Cognitive at each session were included as continuous covariates in each model. Main effects and interactions of FFMQ facets are in bold. Low and High Describing, Non-judging, Acting with awareness, and Observing reflect model-predicted values at − 1 and + 1 SD from the mean of their respective facets of the Five Facet Mindfulness Questionnaire

SUDS subjective units of distress, *DSQ Physical/Fear* Diagnostic Symptom Questionnaire physical and fear symptoms, *DSQ Cognitive* Diagnostic Symptom Questionnaire threat cognitions

$^{**}p < 0.01$, $^{*}p < 0.05$

describing was not uniquely associated with lower overall distress after taking into account all other facets. There was a significant Describing x Session interaction (see Fig. 1, top left), such that those low in describing had a significant decrease in distress across sessions while distress did not significantly change across sessions for those high in describing. Describing was not significantly associated with distress at either time point alone.

Non-judging

The omnibus F test revealed a significant two-way Non-judging x Distress Type interaction ($F_{(2.74)} = 4.48$, $p = 0.02$); thus, separate follow-up regression analyses were conducted for each of the three distress measures. As seen in Table 2, there was a negative effect (at $p = 0.05$) of non-judging for SUDS and a significant negative effect for DSQ Physical/Fear, suggesting that a higher level of non-judging was associated with lower distress of those types. There was also a significant Non-judging x Session interaction for SUDS. In line with hypotheses, higher non-judging was significantly associated with lower subjective distress at session 1 (see Fig. 1, bottom left), though not at session 2. Both those low and high in non-judging had significant decreases in distress across sessions.

Non-reacting

The omnibus F test revealed no significant interactions involving Non-reacting and Distress type (all $F < 2$, all $p > 0.10$); thus, subsequent regression analyses were collapsed across Distress type. As shown in Table 2, similar to non-judging for DSQ Physical/Fear, there was a significant negative main effect of Non-reacting, indicating that participants higher in non-reacting reported less overall distress. Unlike other mindfulness facets, there was no significant Non-reacting x Session interaction, suggesting that non-reacting had similar associations with distress at each session. There was a significant Non-reacting x Linear Phase interaction, although individual slopes for those high and low in non-reacting were not significant. As seen in Fig. 2 (top panels), participants low in non-reacting had a slight overall increase in distress over the course of the CO_2 challenge, whereas those high in non-reacting had little change. To further clarify this interaction, follow-up regression analyses were run to examine the main effect of non-reacting at each phase of the

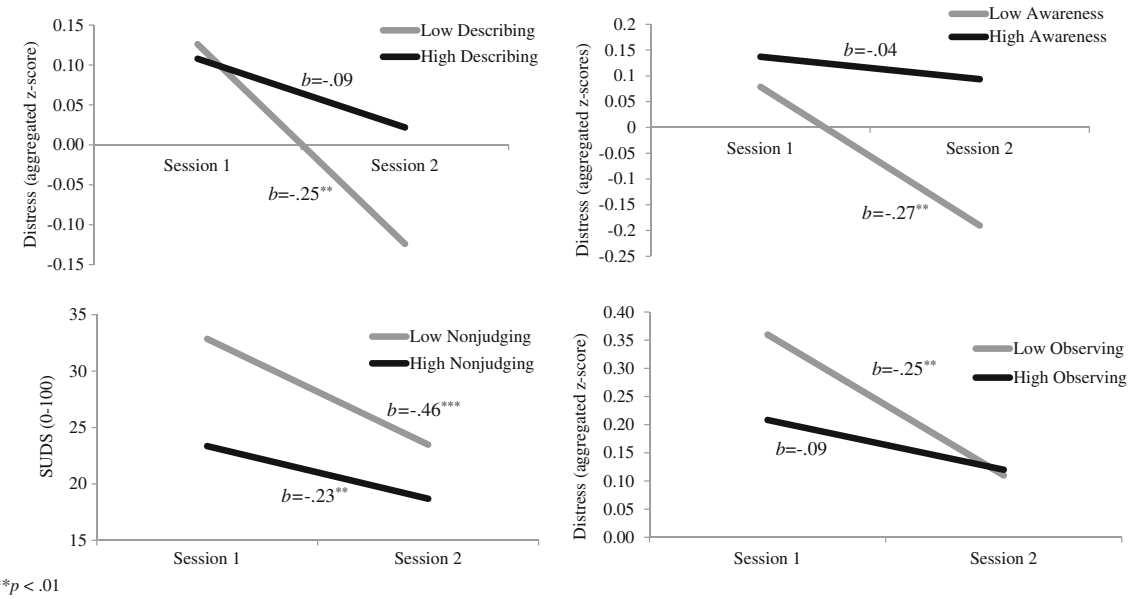

Fig. 1 Simple slopes for the Session x Describing (top left), Session x Awareness (top right), and Session x Observing (bottom right) interactions for Overall Distress, as well as the Session x Non-judging (bottom left) interaction for SUDS. $^{**}p < 0.01$. *SUDS* subjective units of distress. Low and High Describing, Awareness, Non-judging, and Observing reflect model-predicted values at − 1 and + 1 SD from the mean of their respective facets of the Five Facet Mindfulness Questionnaire. Standardized *b*'s reflect the model-predicted change in standard-deviation units of Distress from session 1 to session 2

challenge (Mask, CO_2 Inhalation, and Recovery). As seen in Table 2, these analyses revealed no significant main effect of non-reacting during the Mask phase, a marginally significant ($p = 0.07$) negative effect of non-reacting during CO_2 inhalation, and a significant negative effect of non-reacting during the Recovery phase, such that a higher level of non-reacting was associated with a lower level of distress. Taken together, these results indicate that the effects of non-reacting became more pronounced at the later phases of the challenge.

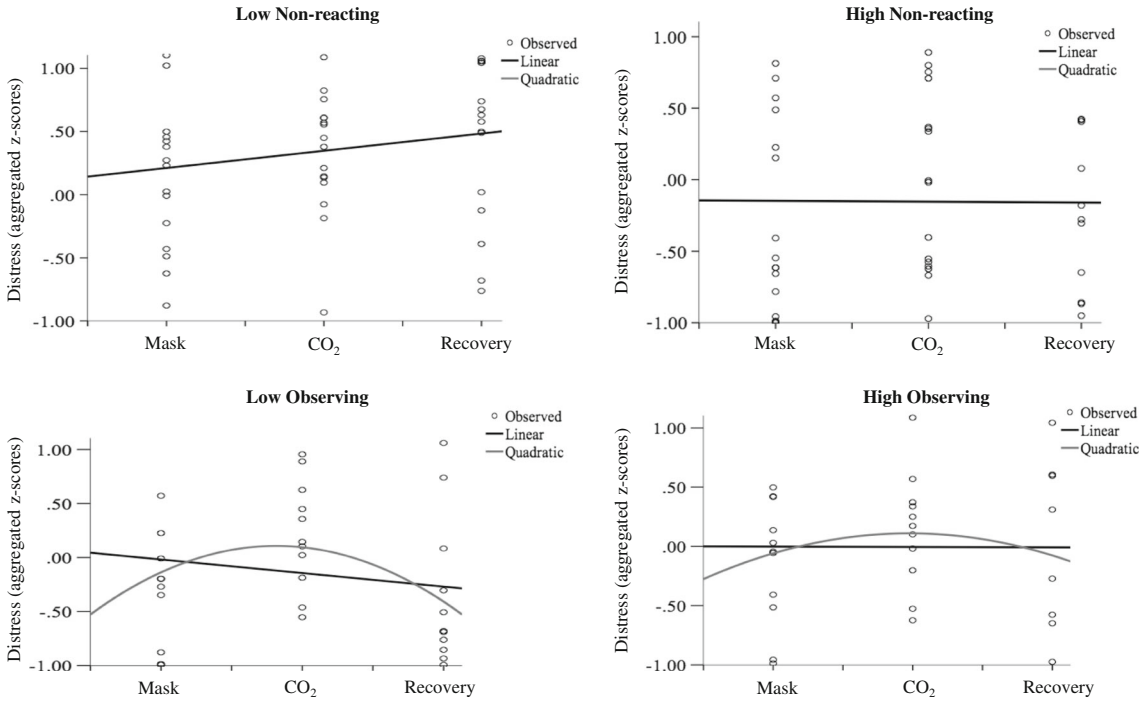

Fig. 2 Brest fit lines and scatterplots for the Linear Phase x Non-reacting (top) interaction and the Linear and Quadratic Phase x Observing interactions (bottom) for Overall Distress. Low and High Non-reacting, as well as Low and High Observing represent participant groups that are − 1 and + 1 SD (respectively) from the mean of their respective facets of the Five Facet Mindfulness Questionnaire

Acting with Awareness

The omnibus *F* test revealed no significant interactions involving Acting with awareness and Distress type (all $F < 2.5$, all $p > 0.10$); thus, subsequent regression analyses were collapsed across Distress type. As seen in Table 2, similar to describing, there was no significant main effect of Awareness but there was a significant Awareness x Session interaction that was again characterized by those low in awareness showing a significant decrease in distress across sessions, whereas those high in awareness showed little change. Unlike results for describing, in this case higher awareness was significantly associated with *greater* distress at session 2 (see Fig. 1, top right).

Observing

The omnibus *F* test revealed no significant interactions involving Observing and Distress type (all $F < 2$, all $p > 0.10$); thus, subsequent regression analyses were collapsed across Distress type. As seen in Table 2, there was no significant main effect of Observing, suggesting that higher observing was not associated with lower overall distress. Similar to describing and acting with awareness, there was a significant Observing x Session interaction, such that those low in observing reported a significant decrease in overall distress while those high in observing did not significantly change across sessions (see Fig. 1, bottom right). Following the results for describing, observing was not significantly associated with distress at either time point alone. Similar to non-reacting, there was a significant Observing x Linear Phase interaction for overall distress, although individual slopes for those high and low in observing were not significant. Follow-up regression analyses examining the main effect of observing at each phase of the challenge revealed no significant main effects of observing at any phase, though there was a marginally significant trend ($p = 0.07$) for High Observing being associated with increases in distress across phases. In addition, there was a significant Observing x Quadratic Phase interaction and individual quadratic *trajectories* across phases were significant for those low and high in observing, though follow-up regression analyses revealed no significant main effects of associations between observing and distress at any phase of the challenge. As seen in Fig. 2, the quadratic trend resembled an upside down "U" for both groups over the course of the CO_2 task, with those low in observing showing relatively more curvature in distress across phases than those high in observing. Descriptively, there was a pattern for those low (vs. high) in observing to have a relatively greater increase in overall distress from the mask to CO_2 inhalation phases, followed by a greater decrease in distress from the CO_2 inhalation to recovery phases, suggesting more intense changes across phases in response to the CO2 challenge compared to those high in observing.

Examining Incremental Validity of Mindfulness in CO_2 Responding

Research has found that anxiety sensitivity, which reflects a fear of anxiety-related symptoms, is the strongest and most robust predictor of CO_2 reactivity (Eke and McNally 1996; Rapee et al. 1992). Thus, to establish the incremental value of mindfulness measures beyond already-established predictors, the models were rerun while controlling for anxiety sensitivity using the ASI (i.e., ASI was included as a main effect covariate), which allowed for testing the predictive validity of trait mindfulness facets above and beyond ASI. Importantly, even after reanalyzing the data controlling for the ASI, virtually all of the original significant findings (in Table 2) remained significant at $p < 0.05$, with two exceptions. Specifically, the Describing x Session and Observing x Session interactions became marginally significant after controlling for anxiety sensitivity (β's = 0.07, p's = 0.07). The consistency of the results points to the incremental value of mindfulness as a unique correlate of CO_2 responding, even after taking into account anxiety sensitivity.

Discussion

The aim of the current study was to examine associations between trait mindfulness facets and level and changes in distress in response to a repeated CO_2 challenge, both between and within sessions. Unexpectedly, a pattern emerged such that lower levels of describing, acting with awareness, and observing (facets linked to noticing/attending to the present moment) were each associated with a significant *decrease* in overall distress across administrations, whereas higher levels of those facets were not associated with significant change in overall distress. In contrast, higher levels of non-judging and non-reacting (facets linked to non-evaluation of the present moment) each tended to be associated with lower distress, with results varying based on specific distress measure and time point (i.e., session and phase). Finally, some interesting patterns emerged for non-reacting and observing in relation to distress across phases (within a CO_2 administration). Specifically, a higher level of non-reacting was associated with a greater decrease in distress over phases, resulting in less distress during the recovery phase for those high (vs. low) in non-reacting. Further, descriptively, it appeared that those high in observing reported less change in distress in response to the CO_2 challenge across phases, relative to those low in observing.

As past research has found some mixed findings with respect to unidimensional mindfulness, we believe our findings highlight some of the potential pitfalls of solely focusing on associations between a general mindfulness variable and stress responses, and also highlight the limits of examining reactivity at a single time point. However, because the current study

does not examine unidimensional mindfulness, an interesting direction for future work is to examine how unidimensional trait mindfulness (e.g., using the MAAS; Brown and Ryan 2003) is associated with changes in distress. For example, given that we found evidence in the current study of facets predicting distress in different directions, this may dilute the effect of unidimensional mindfulness as a predictor of change in distress. A better understanding of the relations between unidimensional mindfulness and distress, as well as between mindfulness facets and distress, may help researchers and clinicians to identify which specific variables to target in therapy. For example, although research has found that mindfulness-based therapies (MBTs) are overall effective in treating anxiety and mood problems, there is great variation among MBT studies in the degree to which they have been found to reduce symptom severity (see Hofmann et al. 2010), and it is possible that MBTs targeting a general mindfulness variable are influenced by nuances at the facet level; that is, by facets predicting distress in different directions. For example, a major component of self-compassion, which some research has found to be more strongly associated with depression/anxiety symptom severity than is general mindfulness, involves adopting a calming stance towards distressing thoughts (rather than over-identifying with them; Van Dam et al. 2011) and aligns closely with operational definitions of non-judging and non-reacting (i.e., non-evaluation of internal experiences), both of which were negatively associated with distress in the current study.

Somewhat surprisingly, a pattern emerged across multiple facets such that lower mindfulness was associated with greater decreases in distress across sessions, while higher mindfulness was not significantly associated with change across sessions. Though one might have expected the null effect for the high mindful participants to be due to a floor effect (i.e., being so low in distress at the first session that there was little room to observe change in distress to subsequent stressors), this is unlikely given that higher describing, acting with awareness, and observing were not significantly associated with lower distress at either session. Indeed, increased attention and exposure to a feared stimulus (as afforded by higher describing, acting with awareness, and observing) would typically be expected to lead to greater habituation versus those who avoid exposure to a feared stimulus (e.g., Tang et al. 2015). Thus, we offer alternative explanations that future work could also consider. Paradoxically, it may be that a higher level of mindfulness is associated with attenuated learning and less habituation to previously encountered stressors. One way to understand this finding follows from Treanor's (2011) proposal that mindfulness may at times enhance, but at other times negatively influence, extinction learning. For example, a common consequence of a high level of mindfulness is increased relaxation, which may result in avoidance of distress and decreased opportunities for learning, similar to the impediments to successful extinction learning caused by safety behaviors (e.g., drug use, distraction; Treanor 2011), although our data were not able to test this speculation. Alternatively, it may be that those who scored high on describing, acting with awareness, and observing more generally attend to all present moment experiences, and this balanced focus actually decreases the amount of attention paid to a feared stimulus (e.g., CO_2 challenge). If this were the case, it may not necessarily be that greater attention to the present moment interferes with habituation, as increasing these facets may actually lead to more balanced focus on one's experiences and not just the feared stimuli. Clearly, future research is needed to evaluate moderators that determine when mindfulness will enhance versus interfere with learning given the clear clinical implications (e.g., whether mindfulness should be encouraged during exposure therapy).

Previous research has primarily examined mindfulness facets in relation to distress to a single administration of a stressful task. The present research was able to examine the incremental validity of each facet in relation to distress across two administrations of the CO_2 challenge. A fascinating pattern emerged such that *lower* (and not higher) levels of facets related to noticing and attending to negative internal experiences (i.e., describing, acting with awareness, observing) were associated with significant decreases in distress across sessions. In addition, a higher level of acting with awareness was significantly associated with a higher level of distress at the second session. In contrast, a high level of non-judging, a facet tied to non-evaluation of internal experiences, was associated with lower subjective distress at the first session. Similarly, being high in non-reacting was associated with less overall distress. Taken together, our findings are consistent with a small yet growing body of literature suggesting that the effects of Observing, Acting with Awareness, and Describing may depend on levels of Non-judging or Non-reactivity (Eisenlohr-Moul et al. 2012; Desrosiers et al. 2014; Peters et al. 2013; Tomfohr et al. 2015). Future research (that is better powered than the current study to test for interactive effects) could examine whether the tendency to notice and attend to negative internal experiences *without* accompanying non-judgment may actually impede normal habituation processes, perhaps because the enhanced observation makes those experiences more overwhelming, resulting in difficulties recognizing safety cues and making non-threatening appraisals. In addition, future work should also examine whether a propensity to withhold evaluation of internal experiences, such as not labeling them as "good" or "bad," may be associated with less distress over time, especially to a novel stressor.

Taken together, these findings highlight the importance in future work of focusing on individuals with low levels of mindfulness, as well as looking at interactions among facets, either by examining samples who systematically vary in levels of noticing/attending and non-evaluating facets or by manipulating these facets, with the aim of developing targeted

interventions. For example, by recruiting individuals high and low in various mindfulness facets, future work may test the hypothesis that individuals high in describing, acting with awareness, and observing, and yet low in non-judging, may continue to have elevated levels of distress each time they are confronted with a stressor because of their hypersensitivity to negative internal experiences and difficulty withholding judgment of those experiences as intolerable. Such work could inform clinicians who wish to teach strategies that help patients decrease the degree to which they attend to many details for certain experiences while also encouraging a non-judgmental response to those experiences that are noticed. This line of research may be particularly important for efforts aimed at attenuating distress to novel stimuli by allowing unpleasant experiences to naturally occur without examining all aspects in intensive detail and evaluating them as good or bad.

The present research allowed us to examine the incremental validity of each facet in relation to phase of stressor, by separating out Mask (anticipation), CO_2 inhalation (reactivity), and Recovery phases. The finding that high (vs. low) observing was associated with a trend for an increase in distress across phases is somewhat consistent with previous research finding that higher observing can be a positive predictor of distress (e.g., Bullis et al. 2014, though the finding of a flatter trajectory of distress for those high in observing fits this pattern less clearly). Once again, as a facet associated with noticing negative internal experiences, future work should continue to examine whether a higher level of observing, in the absence of other mindfulness facets, is associated with hyperawareness and relatively high and stable levels of distress before, in response to, and after, an active stressor. In contrast, a higher level of non-reacting, a facet associated with non-evaluation and accepting one's reality, was associated with lower distress during the latter phases of the challenge and especially after the CO_2 inhalation had passed. Thus, future work should examine whether increasing levels of non-reacting is particularly useful for attenuating distress when faced with a prolonged stressor, such as sitting in traffic, and when quickly regaining composure to manage multiple stressors is crucial, such as when managing multiple deadlines.

Limitations and Future Directions

There are several suggestions for future research in light of limitations of the present study. Given that some of the findings were exploratory and others were somewhat inconsistent with hypotheses, more work is needed to increase confidence in our findings. It is important to note that our findings were based on a single study with 93 participants, and we advise caution in making any claims until these results are replicated. We are, however, encouraged that our findings support and contribute to emerging literature finding differential associations between mindfulness facets and distress. Although attrition analyses revealed that those who returned for the second session did not differ from those who did not return in terms of anxiety sensitivity or CO_2 distress variables, the reasons for declining to return are unknown. Thus, it is possible that those who opted out were more avoidant, leading to a slightly biased sample, though it seems unlikely this would have had a large effect given the absence of other differences in CO_2 responding. Because data were collected from an undiagnosed sample of undergraduate students, future research is needed to examine the link between mindfulness and response to repeated stressors in clinical samples. For example, future research may examine the potential relationship between mindfulness and comorbid psychiatric conditions on stress responses.

Although the FFMQ is a popular and informative measure used in mindfulness research, there is some concern that facets may be more accurately conceptualized as mindfulness-related skills rather than mindfulness per se (see Brown et al. 2007), which is supported by the finding of differential item functioning based on meditation experience (Van Dam et al. 2009). Future work may wish to examine the relations between mindfulness traits and mindfulness skills. For example, research in personality suggests that mindfulness skills may be more malleable and thus evidence faster change than mindfulness traits. Another suggestion for future research is to assess state mindfulness and/or obtain qualitative descriptions of attention during the CO_2 challenge. For example, one might expect those high in the observing facet to use highly negative descriptive language to describe their subjective experience at each phase of the CO_2 challenge. Additionally, despite a lack of association between several mindfulness variables (describing, acting with awareness, observing) and overall subjective distress at session 1, there is a possibility that other approaches to examining distress, such as examining peak distress or physiological indicators of arousal, would reveal that those low in mindfulness had a greater potential for habituation/regression to the mean.

As mindfulness questionnaire data were collected at session 2, it cannot be ruled out that experience from session 1 influenced mindfulness scores. Although trait mindfulness is theorized to demonstrate the same relative stability over time as other personality traits (so is unlikely to meaningfully change over the course of a week without any direct intervention), future research may examine whether trait mindfulness changes as a function of time and/or experience with stressors and examine mindfulness as a longitudinal predictor. Further, future research may include more than two CO_2 challenge administrations to better understand how mindfulness is associated with responses to repeated stressors. Additionally, future research may examine whether mindfulness is more strongly associated with self-reported versus physiological measures of distress, which may elucidate mechanisms linking mindfulness to anxiety. For example, a stronger association with self-reported (vs. physiological) distress could suggest that the mechanisms connecting mindfulness to stress/anxiety are

primarily cognitive in nature (e.g., mindfulness influencing perceptions of negative stimuli and/or threat appraisals). Finally, by randomly assigning participants to different conditions aimed at increasing or decreasing specific mindfulness facets, future research may examine the causal effects of noticing/attending facets and non-evaluative facets on distress.

Despite these limitations, the present research extends existing research by demonstrating that the relation between trait mindfulness and distress to a repeated stressful task is largely dependent on the mindfulness facet in question. Findings for isolated individual facets varied at both the between-and within-session level, suggesting valuable directions for future research to determine whether variable interventions (e.g., different types of observing or thought defusion exercises) may be needed to address different facets of mindfulness.

Acknowledgement This study was funded by a National Institute of Mental Health grant (K01MH080953) to Roberson-Nay and a National Institute on Aging (R01AG033033) and National Institute of Mental Health (R34MH106770) grants to Teachman.

Author Contributions PC: Assisted with the data analyses and wrote the paper. EG: Assisted with designing and executing the study, as well as the data analyses and editing of the final manuscript. JB: Assisted with designing and executing the study, and editing of the final manuscript. ST: Assisted with the data analyses and editing of the final manuscript. SV: Assisted with designing the study and editing the final manuscript. RR: Assisted with designing and executing the study, as well as editing the final manuscript. BT: Assisted with designing and executing the study, as well as writing and editing the final manuscript.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethics Approval and Consent to Participate All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of Virginia Review Board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

References

American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders: DSM-IV-TR. Washington, DC: American Psychiatric Association

Arch, J. J., & Craske, M. G. (2010). Laboratory stressors in clinically anxious and non-anxious individuals: the moderating role of mindfulness. *Behaviour Research and Therapy, 48*, 495–505.

Baer, R. A., Smith, G. T., & Allen, K. B. (2004). Assessment of mindfulness by self-report: the Kentucky inventory of mindfulness skills. *Assessment, 11*, 191–206.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13*, 27–45.

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., Walsh, E., Duggan, D., & Williams, J. M. G. (2008). Construct validity of the five facet mindfulness questionnaire in meditating and nonmeditating samples. *Assessment, 15*(3), 329–342.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2014). lme4: linear mixed-effects models using Eigen and S4. *R package version 1.0–6*.

Biber, B., & Alkin, T. (1999). Panic disorder subtypes: differential responses to CO2 challenge. *The American Journal of Psychiatry, 156*, 739–744.

Bohlmeijer, E., Peter, M., Fledderus, M., Veehof, M., & Baer, R. (2011). Psychometric properties of the five facet mindfulness questionnaire in depressed adults and development of a short form. *Assessment, 18*, 308–320.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822–848.

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*, 211–237.

Brown, K. W., Weinstein, N., & Creswell, J. D. (2012). Trait mindfulness modulates neuroendocrine and affective responses to social evaluative threat. *Psychoneuroendocrinology, 37*, 2037–2041.

Bullis, J. R., Bøe, H. J., Asnaani, A., & Hofmann, S. G. (2014). The benefits of being mindful: trait mindfulness predicts less stress reactivity to suppression. *Journal of Behavior Therapy and Experimental Psychiatry, 45*, 57–66.

Buss, D. M. (1996). Social adaptation and five major factors of personality. In J. S. Wiggins (Ed.), *The five-factor model of personality: theoretical perspectives* (pp. 180–207). New York: Guilford Press.

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine, 31*, 23–33.

Cash, M., & Whittingham, K. (2010). What facets of mindfulness contribute to psychological well-being and depressive, anxious, and stress-related symptomatology? *Mindfulness, 1*, 177–182.

Creswell, J. D., Way, B. M., Eisenberger, N. I., & Lieberman, M. D. (2007). Neural correlates of dispositional mindfulness during affect labeling. *Psychosomatic Medicine, 69*, 560–565.

Curtiss, J., & Klemanski, D. H. (2014). Factor analysis of the five facet mindfulness questionnaire in a heterogeneous clinical sample. *Journal of Psychopathology and Behavioral Assessment, 36*, 683–694.

Delgado, L. C., Guerra, P., Perakakis, P., Vera, M. N., del Paso, G. R., & Vila, J. (2010). Treating chronic worry: psychological and physiological effects of a training programme based on mindfulness. *Behaviour Research and Therapy, 48*, 873–882.

Desrosiers, A., Vine, V., Klemanski, D. H., & Nolen-Hoeksema, S. (2013a). Mindfulness and emotion regulation in depression and anxiety: common and distinct mechanisms of action. *Depression and Anxiety, 30*(7), 654–661.

Desrosiers, A., Klemanski, D. H., & Nolen-Hoeksema, S. (2013b). Mapping mindfulness facets onto dimensions of anxiety and depression. *Behavior Therapy, 44*, 373–384.

Desrosiers, A., Vine, V., Curtiss, J., & Klemanski, D. H. (2014). Observing nonreactively: a conditional process model linking mindfulness facets, cognitive emotion regulation strategies, and depression and anxiety symptoms. *Journal of Affective Disorders, 165*, 31–37.

Donohue, M. C., & Edland, S. D. (2016). longpower: power and sample size calculators for longitudinal data. *R package version 1.0–16*.

Eisenlohr-Moul, T. A., Walsh, E. C., Charnigo Jr, R. J., Lynam, D. R., & Baer, R. A. (2012). The "what" and the "how" of dispositional mindfulness: Using interactions among subscales of the Five-Facet Mindfulness Questionnaire to understand its relation to substance use. *Assessment, 19*, 276–286.

Eke, M., & McNally, R. J. (1996). Anxiety sensitivity, suffocation fear, trait anxiety, and breath-holding duration as predictors of response to carbon dioxide challenge. *Behaviour Research and Therapy, 34*, 603–607.

Garner, M., Attwood, A., Baldwin, D. S., James, A., & Munafo, M. (2011). Inhalation of 7.5% carbon dioxide increases threat processing in humans. *Neuropsychopharmacology, 36*, 1557–1562.

Gorlin, E. I., Beadel, J. R., Roberson-Nay, R., & Teachman, B. A. (2014). The self-fulfilling panic prophecy: anxiety-related control attributions uniquely predict reactivity to a 7.5% CO2 challenge. *Cognitive Therapy and Research, 38*, 585–599.

Hair, J., Anderson, R., Tatham, R., & Black, W. (1998). *Multivariate data analysis*. Upper Saddle River: Prentice Hall.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: a meta-analytic review. *Journal of Consulting and Clinical Psychology, 78*, 169–183.

Kabat-Zinn, J. (1990). *Full catastrophe living: using the wisdom of your body and mind to face stress, pain, and illness*. New York: Delta.

Makkar, S. R., & Grisham, J. R. (2013). Effects of false feedback on affect, cognition, behavior, and postevent processing: the mediating role of self-focused attention. *Behavior Therapy, 44*, 111–124.

Nich, C., & Carroll, K. (1997). Now you see it, now you don't: a comparison of traditional versus random-effects regression models in the analysis of longitudinal follow-up data from a clinical trial. *Journal of Consulting and Clinical Psychology, 65*, 252–261.

O'brien, R. M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality & Quantity, 41*, 673–690.

Peters, J. R., Eisenlohr-Moul, T. A., Upton, B. T., & Baer, R. A. (2013). Nonjudgment as a moderator of the relationship between present-centered awareness and borderline features: Synergistic interactions in mindfulness assessment. *Personality and Individual Differences, 55*, 24–28.

Rapee, R. M., Brown, T. A., Antony, M. M., & Barlow, D. H. (1992). Response to hyperventilation and inhalation of 5.5% carbon dioxide-enriched air across the DSM-III-R anxiety disorders. *Journal of Abnormal Psychology, 101*, 538–552.

Reiss, S., Peterson, R. A., Gursky, D. M., & McNally, R. J. (1986). Anxiety sensitivity, anxiety frequency and the prediction of fearfulness. *Behaviour Research and Therapy, 24*, 1–8.

Sanderson, W. C., Rapee, R. M., & Barlow, D. H. (1989). The influence of an illusion of control on panic attacks induced via inhalation of 5.5% carbon dioxide-enriched air. *Archives of General Psychiatry, 46*, 157–162.

Spurr, J. M., & Stopa, L. (2002). Self-focused attention in social phobia and social anxiety. *Clinical Psychology Review, 22*, 947–975.

Tang, Y. Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. Nature Reviews. *Neuroscience, 16*, 213–225.

Tomfohr, L. M., Pung, M. A., Mills, P. J., & Edwards, K. (2015). Trait mindfulness is associated with blood pressure and interleukin-6: exploring interactions among subscales of the Five Facet Mindfulness Questionnaire to better understand relationships between mindfulness and health. *Journal of Behavioral Medicine*, 38, 28–38.

Treanor, M. (2011). The potential impact of mindfulness on exposure and extinction learning in anxiety disorders. *Clinical Psychology Review, 31*, 617–625.

Van Dam, N. T., Earleywine, M., & Danoff-Burg, S. (2009). Differential item function across meditators and non-meditators on the Five Facet Mindfulness Questionnaire. *Personality and Individual Differences, 47*, 516–521.

Van Dam, N. T., Sheppard, S. C., Forsyth, J. P., & Earleywine, M. (2011). Self-compassion is a better predictor than mindfulness of symptom severity and quality of life in mixed anxiety and depression. *Journal of Anxiety Disorders, 25*, 123–130.

Veehof, M. M., Peter, M., Taal, E., Westerhof, G. J., & Bohlmeijer, E. T. (2011). Psychometric properties of the Dutch Five Facet Mindfulness Questionnaire (FFMQ) in patients with fibromyalgia. *Clinical Rheumatology, 30*(8), 1045–1054.

Weinstein, N., Brown, K. W., & Ryan, R. M. (2009). A multi-method examination of the effects of mindfulness on stress attribution, coping, and emotional well-being. *Journal of Research in Personality, 43*, 374–385.

Welkowitz, L. A., Papp, L. A., Martinez, J. M., Browne, S., & Gorman, J. M. (1999). Instructional set and physiological response to CO2 inhalation. *American Journal of Psychiatry, 156*, 745–748.

Wilksch, S. M., & Wade, T. D. (2014). Depression as a moderator of benefit from Media Smart: a school-based eating disorder prevention program. *Behavior Research and Therapy, 52*, 64–71.

Wolpe, J. (1969). *The practice of behavior therapy. New York*. NY: Pergamon Press.

Zvolensky, M. J., Solomon, S. E., McLeish, A. C., Cassidy, D., Bernstein, A., Bowman, C. J., & Yartz, A. R. (2006). Incremental validity of mindfulness-based attention in relation to the concurrent prediction of anxiety and depressive symptomatology and perceptions of health. *Cognitive Behaviour Therapy, 35*, 148–158.