Do Mindfulness and/or Thought Suppression Mediate Treatment Effects on Cardiac Vagal Control in Substance Abusers treated with Mindfulness-Based Relapse Prevention, Relapse Prevention or Treatment as Usual?

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Abstract

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Thought suppression, or the effort to reduce or stop thinking about a particular thought (i.e., target thought of anticipated pleasant sensations associated with drug), is involved with many effective therapeutic strategies for substance use disorders such as cognitive behavioral therapy, but paradoxically associated with rebound effects, or an increased occurrence of the target thought (Rassin, 2005). Mindfulness stands in contrast to thought suppression by fostering a non-judgmental attitude towards and acceptance of thoughts. For example, Mindfulness-Based Relapse Prevention (MBRP) treatment for substance use aims to increase tolerance of negative physical, emotional, and cognitive states. Initial research with MBRP aftercare treatment for substance use disorders suggests efficacy as MBRP program completers engage in less substance use than Treatment as Usual (TAU) completers and show decreases in craving

(Bowen, et al., 2009). Additionally, MBRP is associated with favorable psychophysiological outcomes when compared to cognitive behavioral therapy. Thus, the current project compares the effects of thought suppression and mindfulness on psychophysiological reactivity to stress in MBRP to Relapse Prevention (RP, cognitive behavioral therapy) and TAU. Mediation models assessing if thought suppression and mindfulness mediated the effect of treatment (MBRP, RP, TAU) onto psychophysiological outcomes suggest that MBRP is positively related to mindfulness and negatively related to thought suppression, where RP is negatively related to mindfulness and positively related to thought suppression. However, no significant overall mediation models were found. Future research should continue to identify contributors to health outcomes following treatment for substance use disorders.

Introduction

Thought Suppression

Thought suppression, or the effort to stop thinking about a target thought (often unwanted or intrusive), is paradoxically associated with rebound effects, or an increased occurrence of the target thought (Rassin, 2005). Researchers have theorized many behavioral disorders, including substance use disorders, stem from avoidance of emotional experience (termed experiential avoidance), with unhealthy efforts to suppress and avoid unpleasant states (Hayes, Wilson, Gifford, Follette, & Strosahl, 1996). Indeed, research has shown higher levels of thought suppression in current smokers compared to ex-smokers (Toll, Sobell, Wagner, & Sobell, 2001). Additionally, smokers who were asked to try as hard as they could to suppress thoughts of smoking experienced an increase in intrusive thoughts (Salkovskis & Reynolds, 1994). In a similar study, participants exposed to alcohol cues who were asked to suppress the urge or craving to drink, as compared to how they typically approach alcohol, were quicker to endorse alcohol use expectancies during a timed computer task (Palafai, Monti, Colby, & Rohsenow, 1997).

However, some researchers have also theorized that thought suppression is involved with many effective therapeutic strategies. For example, cognitive behavioral therapy (CBT) includes cognitive restructuring, which identifies certain thought patterns as “faulty,” and is very similar in structure to thought suppression (Arch & Craske, 2008). Relapse Prevention (RP) is one frequently used evidence-based cognitive behavioral strategy developed by Marlatt and Gordon (1985) that uses cognitive strategies to identify and cope with high-risk situations associated with addictive behaviors in order to

prevent relapse (Larimer, Palmer, & Marlatt, 1999; Marlatt & Gordon, 1985). Specifically, RP identifies immediate and distal situations that preceed relapse such as lifestyle factors, cravings, and high-risk situations. RP sets up specific interventions to enhance coping skills when in these situations. RP also aims to increase self-efficacy of reducing drug use and restructure the perception of the situations. RP, a gold standard of treatment for substance use, is effective at reducing substance use in those with substance use disorders. RP intentionally incorporates strategies and theoretical concepts counter to thought suppression (e.g., abstinence violation effect, urge surfing) to bring awareness to situations that elicit craving, instead of suppressing all thoughts of drug use (Marlatt & Witkiewitz, 2005).

Mindfulness

In contrast to suppression of thoughts deemed unwanted or restructuring of "faulty" thoughts, mindfulness involves a non-judgmental attitude towards and acceptance of thoughts. While some concerns have been expressed over the operationalization of mindfulness (Grossman, 2008), Bishop and colleagues (2004) have identified and eloquently articulated a two-component description of mindfulness. The first component is described as self-regulation of attention that is focused on the immediate present experience. Self-regulation of attention involves paying attention to the present experience in a non-elaborative manner, or the ability to focus on present moment experiences without being "carried away" by elaboration or stories about the present moment. The second component of mindfulness is orientation towards the present moment in a very particular way that involves an attitude of curiosity and openness, while accepting present moment experience as simply what is – in the

moment (Bishop et al., 2004). Applying these principals to substance use disorders, it may be that mindfulness strategies allow space for cravings and urges to occur and be accepted without the need to act on them, and without the rebound effects associated with thought suppression.

Research has begun to explore the effects of this mindful, non-judgemental, present moment awareness on substance use and related consequences. For example, in a study of incarcerated individuals with substance use disorders who completed a 10-day Mindfulness (Vipassana) course, thought suppression was reduced post course and partially mediated the positive effects of the course on alcohol use and related negative consequences post release (Bowen, Witkiewitz, Dillworth, & Marlatt, 2007). This study suggests that mindfulness practice is related to reductions in thought suppression, and these reductions may facilitate reduced substance use and related consequences. With mindfulness, an attitude of acceptance is cultivated. To study this attitude of acceptance and how it compares to thought suppression, Rogojanski, Vettese, and Antony (2010) investigated the effects of accepting of suppressing craving in smokers. This study found that individuals who were told to suppress or accept cigarette cravings both reported reduced levels of smoking one week later, but only the acceptance group reported decreases in negative affect and depression. As an attitude of acceptance is cultivated with mindfulness practice, this suggests that mindfulness, but not thought suppression, facilitates decreases in negative affect in substance users. Additionally, Erksine and colleagues (2012) investigated the effects of thought suppression on smoking. While Erksine and colleagues did not find that engaging in a thought suppression task was related to an increased desire to smoke, trait mindfulness

was inversely related to higher levels of self-reported thought suppression and a higher reported desire to smoke at the baseline assessment (Erskine et al., 2012). If mindfulness qualities are negatively associated with thought suppression and substance use at baseline, it may be that cultivating mindfulness reduces thought suppression and subsequent substance use. Thus, the present study examines if mindfulness and thought suppression mediate treatment outcomes in substance users treated with mindfulness therapy, cognitive-behavioral therapy, or treatment as usual.

Mindfulness for Substance Use Disorders

Mindfulness practice has been incorporated into the treatment of myriad clinical maladies such as chronic pain (Kabat-Zinn, 1990), depression relapse (Teasdale et al., 2000), and substance use disorders (Bowen et al., 2009; Zgierska et al., 2009). The application of mindfulness to the treatment of substance use disorders has taken many forms including the adaptation of existing treatments such as Mindfulness Based Stress Reduction (MBSR, Kabat-Zinn, 1990) for smoking and substance use. For example, MBSR has been modified for smoking cessation (Davis, Fleming, Bonus, & Baker, 2007), adolescents with sleep and substance use disorders (Britton et al., 2012), and women with substance use disorders (Vallejo & Amaro, 2009). The present study employed a mindfulness-based intervention developed for addictive behaviors, Mindfulness Based Relapse Prevention (MBRP, Bowen et al, 2009; Bowen, Chawla, & Marlatt, 2010).

MBRP is an 8-week treatment program that draws on mindfulness-based interventions (e.g., MBSR, Kabat-Zinn, 1990; Mindfulness-Based Cognitive Therapy, Teasdale et al., 2000) and RP (Marlatt & Gordon, 1985) to cultivate mindful awareness

and teach beneficial cognitive strategies for use in high risk situations. Weeks 1 through 4 of the MBRP program focus on laying a foundation of mindfulness. Mindfulness practices in MBRP are both formal (e.g., body scan, sitting meditation) and informal (e.g., urge surfing). In The last 4 weeks of MBRP, participants learn more cognitive skills that emphasize incorporating mindfulness into high-risk situations in daily life. Initial research with MBRP for those with substance use disorders suggests efficacy as those who complete the MBRP program engage in less substance use as compared to TAU and show decreases in craving (Bowen, et al., 2009). Additional evidence suggests that mindfulness-based therapies for substance use disorders, including MBRP, have favorable effects on psychophysiology.

Mindfulness and Psychophysiology

One psychophysiological index impacted by mindfulness treatment is cardiac vagal control. One way to measure cardiac vagal control is with High frequency Heart Rate Variability (HF-HRV). Heart Rate Variability (HRV) is a misnomer in that HRV is not a measure of rate variability, but rather a measure of time variance between adjacent R waves (indicative of ventricular depolarization) on the electrocardiogram. Spectral analysis of R-R variance, or the variance between subsequent R wave peaks, allows for the conversion power density as a function of frequency, yielding high-, low-, and very low- frequency power densities. In particular, high frequency power density is the measure of vagal traffic to the sinoatrial node, or what some call vagal braking given that vagal input slows heart rate, whereas sympathetic input increases heart rate. Measurement of vagal braking has been referred to in the literature as a measure of stress adaptation or self-regulation (Thayer & Lane, 2007). Thus, High Frequency Heart

Rate Variability (HF-HRV) is a measure of cardiac vagal control, or an index of inhibitory vagal efferent traffic to the sinoatrial node where, generally speaking, high levels of HF-HRV indicate higher levels of self regulation.

Studies have investigated cardiac vagal responses to stress provocation in substance abusers as an index of post-treatment self-regulatory capabilities. For example, Brewer and colleagues (Brewer et al., 2009) compared cardiac vagal control in participants receiving treatment for alcohol or cocaine dependence with either 12-weeks of cognitive-behavioral therapy (CBT) or 9-weeks of mindfulness-training therapy; a technique adapted from MBRP as developed by Bowen and colleagues (2010). Within 2-weeks post-treatment, participants completed a stress provocation task involving scripted stress imagery. Specifically, scripts were generated from participants details on a stressful event, which was read back to them during a laboratory session while Galvanic skin response (GSR) and ECG were continuously monitored. Inter-beat interval (i.e., R-R interval) was used to calculate HRV and was reported as a ratio of sympathetic and parasympathetic indices of HRV. Results revealed no significant differences between CBT and mindfulness-training in GSR or heart rate. However, the mindfulness-training group showed increased parasympathetic activity during stress provocation (i.e., cardiac vagal control) as compared to the CBT group who showed a significant increase in sympathetic activity. Moreover, Brewer et al. (2009) found significant differences between pre- and post- course Five Factor Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkings, Krietemeyer, & Toney, 2006) scores for both the CBT and mindfulness groups such that both groups showed increases on the FFMQ over time. There was a trend, albeit insignificant, for the mindfulness group to

show larger increases on the FFMQ than the CBT group. The FFMQ is one frequently used measure of mindfulness. The development of the FFMQ involved rigorous psychometric investigation of several previously published measures of mindfulness resulting in the inclusion of subscales for five constructs of mindfulness: observe, describe, act with awareness, non-judgment, and non-reactivity (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Brewer and colleagues utilized the FFMQ as an outcome measure, however, they did not assess if physiological effects were associated with the mindfulness scores. The present study seeks to fill the gap in our understanding of interrelationships between FFMQ and psychophysiological responses to stress provocation.

Another related study examined cardiac vagal control as indexed by the root mean square of successive differences of R-R intervals (RMSSD) in participants receiving treatment for alcohol dependence who completed either a mindfulness oriented recovery enhancement (MORE) group or an alcohol support group (Garland, Gaylord, Boettiger, & Howard, 2010). Physiological reactivity was measured during an alcohol cue-induced paradigm pre-, mid-, and post-course. Electrocardiogram (ECG) was used to assess cardiac vagal tone as indicated by RMSDD. Results of the post-course assessment revealed no significant intervention by testing session (pre-, mid-, post-course) interaction. However, there was a significant intervention x condition interaction that suggests a differential pattern of responses to the alcohol cue exposure and recovery by group such that participants who completed the MORE program showed higher RMSDD during the alcohol cue-stressor with decreased RMSDD post-stressor. In contrast, participants in the alcohol support group showed decreased

RMSDD during the alcohol cue-stressor with increased RMSDD post-stressor. These results suggest that the MORE program is associated with increased vagal activity in the face of a stressor in those with alcohol use disorders. However, because Garland and colleagues (2010) did not find any changes in FFMQ scores from pre- to post-course they did not assess the relationship of mindfulness to RMSDD.

While not a study of stress provocation, Libby and colleagues (2012) investigated the effects of meditation on acute autonomic nervous system responses. HF-HRV in smokers was assessed during a meditation task post-treatment while undergoing a brain scan as part of a larger study. Those who received four weeks of mindfulness training were compared to novice meditators (Libby, Worhunsky, Pilver, & Brewer, 2012). Heart rate was detected via pressure transducer. Participants meditated in response to instructions during a fMRI scan. Spectral analyses calculated HF-HRV. Results revealed no differences between the novice meditators and experienced meditators on HF-HRV during meditation. Libby et al. (2012) found longer smoking abstinence times in those who experienced an increase in HF-HRV as opposed to a decrease in HF-HRV during an acute meditation task. While these results suggest that meditation induced physiological effects of mindfulness are important for substance use outcomes, Libby et al. (2012) did not look at levels of mindfulness and nor whether psychological construct of mindfulness relates to increased HF-HRV.

Purpose and Hypotheses

Collectively, the psychophysiological research cited here shows that mindfulness training is associated with increased cardiac vagal control during stress provocation in substance abusers. Moreover, increased cardiac vagal control during a brief

mindfulness exercise is associated with less substance use (e.g., smoking) several weeks out from treatment end. What remains to be elucidated is whether mindfulness training exerts these salutary effects by increasing mindfulness qualities and/or reducing thought suppression. The present study will test these mediation models in a subsample of participants from a large Phase III clinical trail assessing MBRP treatment efficacy.

The proposed mediation modeling will extend our initial findings in which we compared cardiac vagal control to a cognitive stressor in individuals receiving aftercare treatment with MBRP, RP, or TAU (Lustyk et al., In Progress). Within 2-months of treatment end, participants completed a stress testing session where ECG was continuously monitored during a cognitive challenge. The inter-beat-interval was extracted from the ECG to calculate HF-HRV. Preliminary Evidence revealed that MBRP participants showed increased HF-HRV in response to the stressor. The purpose of the proposed mediation analyses is to assess whether the increased HF-HRV response with MBRP is mediated by mindfulness qualities as indexed by the self-report FFMQ and measures of thought suppression.

We hypothesized that psychophysiological reactivity, as indexed by heart-rate variability, would be successfully mediated by factors of the FFMQ, a self-report measure of mindfulness, and thought suppression, such that higher levels of mindfulness and lower levels of thought suppression would relate to more favorable autonomic nervous system reactivity to a cognitive stressor.

Method

Participants

Participants (N = 34) were recruited from a Phase III Clinical Trial (NIH/NIDA: 1 R01 DA025764-01A1), hereafter referred to as the parent study, assessing the therapeutic efficacy of Mindfulness-Based Relapse Prevention among clients at a private, nonprofit substance abuse care facility in the Pacific Northwest. The treatment agency provides addiction services to a broad population. More information about the agency can be found in (Bowen, et al., 2009). Participants were eligible for the parent study if they were: (1) fluent in English, (2) between the ages of 18 to 70, (3) medically cleared to participate in treatment, (4) had completed intensive outpatient treatment at least within the last two weeks with a continuing care plan set up within the target treatment center, and (5) willing to be randomly assigned to either the MBRP, RP, or TAU treatment group. Participants were excluded for psychosis and suicidality. In the present study, eligible participants had completed the MBRP, RP, or TAU groups within the last two months, and had no pre-existing health condition (e.g., hypertension) or taking any medications (e.g., antipsychotics) known to affect the stress response.

Measures

Measures included in the present analyses were collected via two mechanisms. Measures collected as a part of the parent study included the demographic information, the FFMQ, the Addiction Severity Index (ASI) and the White Bear Though Suppression Inventory (WBSI). These measures were collected during computer-administered assessments at the community health clinic where treatment took place. Participants in the parent study completed five assessments: a baseline assessment before aftercare treatment began and assessments at 2-, 4-, 6-, and 12- months following the completion of the treatment group. The assessments used in the present study were collected at

post-course 2-month assessment. The measures collected during the physiological protocol as part of the present study include a self-report measure of maximum oxygen volume ($V0_2Max$), state and trait anxiety, visual analogue scales, and the hemodynamic measures.

Demographic Information

Demographic Information included variables such as participant gender, age, and ethnicity. Participants were primarily male (73%) with a mean age of 43.4 (SD = 9.7). Reported racial and ethnicity was 43% Caucasian, 24% Black, 12% Hispanic, 9% Native American, 3% Asian.

$V0_2Max$

The University of Houston Non-Exercise Test (Non-Ex; Rossy & Thayer, 1998) is a self-report measure that assesses basic health and fitness levels of participants to estimate $V0_2Max$. $V0_2Max$ represents the cardiovascular fitness and aerobic power. Participants report their height, weight, age, gender, and normal activity level. The $V0_2Max$ is then calculated to consider participant gender, body mass index (BMI) and frequency and intensity of activity in a typical week (Rossy & Thayer, 1998). $V0_2Max$ was used as a co-variate in the HF- HRV analyses.

State-Trait Anxiety Scale

State (STAI-S) and trait anxiety (STAI-T) were assessed using the Spielberger State/Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Luschene, Vagg, & Jacobs, 1983). The STAI asks participants to evaluate their feelings (e.g., I feel pleasant) based on either typical experience (STAI-S) or the present moment (STAI-S) on a scale from 1 to 4 where (1) indicates *not at all,* (2) indicates *somewhat,* (3) indicates *moderately so*,

and (4) indicates *very much so* (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The STAI-S was administered verbally as it occurred during physiological assessment during which the participants could not write. Therefore, the assessment rating scale was visually displayed on a flip-board.

Visual Analogue Scale

A visual analogue scale (VAS) assessed present moment state craving with the verbal prompt “how much craving or desire to drink or use drugs do you feel now” rated from 1 to 10 where (1) indicated *no feeling at all*, and (10) indicated *very extreme feeling*, the most extreme you have ever experienced. The verbal prompt was concurrently represented with a visual/written representation of these questions and the rating scale on a flip-board.

Mindfulness

The Five-Factor Mindfulness Questionnaire (FFMQ, Baer, et al., 2006) is a 39-item questionnaire that identifies five facets of mindfulness: (1) observe, (2) describe, (3) act with awareness, (4) non-judgment, and (5) non-reactivity. The facets have been described as (1) observing internal and external stimuli, (2) describing the stimuli verbally either mentally or out loud, (3) acting with awareness in a manner that brings awareness to intentions and actions such that one is not acting on automatic pilot, (4) non-judgment of the internal and external stimuli, allowing these events to occur without evaluation, and (5) non-reactivity to inner experiences such that the internal stimuli can exist without getting caught up in them (Lustyk, Gerrish, Douglas, Bowen, & Marlatt, 2011). Participants responded to prompts such as “I am easily distracted” on a scale from 1 to 5 where (1) indicated *never or rarely true*, and (5) indicated very often or

always true. The FFMQ has good internal consistency ranging from .75 to .91, and is negatively related to thought suppression (Baer, et al., 2006).

Thought Suppression

The White Bear Suppression Inventory (WBSI, Wegner & Zanakos, 1994) is a 15-item measure of thought suppression. Participants respond to statements such as “I have thoughts I cannot stop“ on a 5-point scale ranging from strongly disagree to strongly agree. The WBSI has good internal consistency with alphas of .87 to .89, and is related to constructs such as obsessional thinking and anxious affect, but negatively related to repression (Wegner & Zanakos, 1994).

Substance Use Severity

The Addiction Severity Index (ASI; McLellan et al., 1992) is a semi-structured interview that assesses the severity of substance use disorders. The original ASI has been modified to a self-report measure (McLellan et al., 1992; Rosen, Henson, Finney, & Moos, 2000). Rosen et al. (2000) found the self-report version correlates well with the interview format with correlations ranging from .59 to .89. The self-report measure was used in the present study. Participants responded to 16-items assessing specific drug use in the past 30 days.

Hemodynamics

Throughout the duration of the stress testing session, heart rate (HR) was measured continuously with ECG via Powerlab Data Acquisition System (Powerlab, ADInstruments Inc., Boulder, CO). An auto-inflating sphygmomanometer took Blood pressure (BP; Dinamap 1846: Critikon, Inc., Tampa, FL) at timed intervals.

High-Frequency Heart Rate Variability

HF-HRV analytic methods adhered to the Task Force of the European Society of Cardiology & the North American Society of Pacing and Electrophysiology Guidelines (Task Force, 1996). Age, gender, VO2max, and severity of use at baseline and smoking were covaried in all models. For analyses, HF-HRV results were divided into baseline, or tonic, and stressor induced or phasic phases.

Stressor

The Paced Auditory Serial Addition Task (PASAT; Gronwall, 1977) was developed as a measure of recovery from concussion but has been subsequently used as a laboratory stressor (Lustyk, Olson, Gerrish, Holder, & Widman, 2010). The PASAT requires participants to add digits ranging from 1 to 9 presented in random order in pairs with increasing rapidity (Gronwall, 1977). In the current study, the PASAT consisted of three trials of 61 digits each presented 2.4, 2.0, and 1.6-sec apart by trial and was administered via computer recording (McInerney, http://www.robertmcinerney.ca/pasat.html).

Treatment Groups

Participants in the parent study were randomly assigned to participate in 8-weeks of MBRP, RP, or TAU. All groups were held once a week. If participants were required by the treatment agency to attend more than one group a week, the second group was a TAU supplement. All treatment contact, including urine analyses, weekly check-ins, and sober support groups (e.g., Alcoholics Anonymous) were tracked. MBRP (Bowen, et al., 2010) was performed in accordance with the published manual. RP (Marlatt & Gordon, 1985) was modified to be used in a group format. TAU included

process oriented groups, such as 12-step, as facilitated on a regular basis at the community treatment agency.

Procedure

Following approval of the University of Washington and Seattle Pacific University Institutional Review Boards, participants who had completed the MBRP, RP, or TAU groups within the last two months were contacted over the phone. A researcher described the study and provided interested participants with a number to call for screening. A research assistant described the procedures to potential participants (*n* = 77). Among those contacted, only 4 indicated a lack of interest. Those with health conditions known to affect the stress response such as respiratory or cardiovascular disorders (*n* = 25) were excluded. Out of the eligible participants (*n* = 48; MBRP *n* = 16; RP *n* = 16; TAU *n* =16) approximately 25% of participants (*n* = 13) did not come to their stress testing appointment, resulting in *n* = 35 participants who completed the stress testing protocol. One additional TAU participant was subsequently excluded from analyses for protocol violation (i.e., completed the parent study as an RP participant and re-enrolled as TAU participant), resulting in a final sample of 34 participants (MBRP *n* = 12, RP *n* = 12; TAU *n* = 10). Because the luteal phase of the menstrual cycle is associated with increased hemodynamic responses to laboratory stressors (Lustyk, et al., 2010), craving (Carpenter, Saladin, Leinbach, Larowe, & Upadhyaya, 2008; Franklin et al., 2004; Lustyk, et al., 2011), anxiety in women with SUDs (Fox & Sinha, 2009), and reduced HF-HRV (Sato, Miyane, Akatsu, & Kumashiro, 1995; Xiaopeng, Li, Zhou, & Li, 2009), all menstruating female participants (n = 4) were tested during the follicular menstrual cycle phase (cycle days 5-9). Female participants who were not menstruating

(e.g., menopausal, n = 3) were scheduled for the next convenient stress-testing time block. Analyses were run to confirm that there was no systematic time bias between finishing the treatment group and the stress testing session by gender or group. A one way ANOVA revealed no significant differences between the groups on time between the treatment end date and the stress testing session (F (2) = .01, p = .99); and an independent samples t-test revealed no significant differences between the genders on time between the treatment end date and the stress testing session (t (32) = -.76, p = *.46*).

Eligible participants were scheduled for a one-hour stress testing session (see Figure 1). The stress testing session was scheduled mid-day, between the hours of 11:00 and 17:00, to control for cortisol diurnal rhythm and accommodate participant availability. While we did not assess cortisol, this glucocorticoid has been shown to amplify hemodynamic responses to stress once they have occurred (McEwan & Stellar, 1993) and as such we wanted to avoid sharp decreases or increases associated with natural release patterns. Participants were asked to refrain from exercise for one hour prior to testing, and maintain abstinence from alcohol and other drug use before the stress test. We observed 100% compliance with alcohol and other drug abstinence as indicated by salivary drug screening. Two salivary drug screens were used to screen for cocaine, opiates, amphetamine, methamphetamine, phencyclidine, THC (Oral Lab +6 Panel, Varian, Inc., NC) and alcohol (Alcohol Panel, Varian, Inc., NC). Following consent, participants completed the Oral Lab +6 Panel that took 3 minutes to collect, and 10 minutes to read. Next, participants completed the Alcohol Panel that took less than 30 seconds to collect and 2 minutes to read. Following drug screening, participants

completed the demographic, Non-Ex, and STAI-T measures. After completing these measures, the 15-min baseline began. During baseline, participants completed the VAS and the STAI-S. Following baseline, participants were instructed in the PASAT with a standardized instruction protocol. The PASAT lasted 7min on average. Immediately following the PASAT, participants completed the verbal analogue scales and the STAI-S for the second time and transitioned into a 15-min recovery period. After recovery participants completed the verbal analogue scales and the STAI-S for a final time. Following the stress testing session, participants were compensated with a $20 Safeway gift card and continued enrollment in the parent study.

Results

In order to assess if mindfulness qualities as measured by the FFMQ and thought suppression as measured by the WBSI (for means see Table 1) mediate the relationship between treatment for substance use disorder and tonic and phasic HF-HRV (see Figure 2 and 3), we ran mediation analyses with bootstrapping using contrast coding for treatment groups indicating MBRP versus control and RP versus control.

Results of the bootstrap mediation models (See Table 2) replicated the findings presented in Lustyk et al. (In Progress) in that MBRP is associated with increased HF-HRV levels. Additionally, MBRP was significantly positively related to mindfulness as measured by the FFMQ factor of non-reactivity, where RP was significantly inversely related to mindfulness as measured by the FFMQ total score. Moreover, RP was significantly positively related to thought suppression as measured by the WBSI, where MBRP was significantly inversely related to thought suppression as measured by the WBSI. However, no significant overall mediation models were found.

Discussion

In sum, our observed increases in phasic and tonic HF-HRV for MBRP align with previous findings as presented in Lustyk et al., (In Progress). As expected, MBRP was associated with higher levels of some factors of mindfulness and RP was associated with higher levels of thought suppression. Thus, MBRP was associated with measureable increases in HF-HRV. These findings may be interpreted as “Pausing” or applying the vagal brake in the face of stress among those who received MBRP. So in the face of stress, as social beings, we may want to throw a fit, or if an abuser, get a fix, but we could engage our flexible vagus to self-regulate and self-sooth. Those who practice mindfulness produce psychophysiological responses to stress that suggest they are engaging the latter. These results are an important step to identifying the mechanisms of action by which MBRP, as one in a set of many emerging new therapies involving mindfulness, functions. The relationship of these results to therapeutic outcomes is currently being explored. Future research will continue to identify the physiological, neurobiological, and psychological mechanisms of action in MBRP. Future research should also continue to examine the other mechanisms by which mindfulness-based interventions exert salutary effects, which include many different components of treatment besides meditation.

While our lack of mediation findings are not as hypothesized, results are perhaps not surprising given several limitations in the design of the current study. First of all, given the small sample size collected, the present mediation analyses lack the power necessary to detect modest significant effects. Additionally, we might actually be observing profound variability and overall problems in the measure of mindfulness. As

discussed in Grossman (2008), measures of mindfulness to date are somewhat poor. Our current measures of mindfulness rely mostly on self-report. Thus, future research will need to elucidate the most effective way to measure mindfulness.

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Table 1. Means of Mindfulness and Thought Suppression Measures by Group

	MBRP		RP		TAU	
	M	SD	M	SD	M	SD
FFMQ Tot	116.00	14.43	109.12	1.31	96.63	12.15
FFMQ Act	30.18	5.98	26.54	6.64	23.42	6.75
FFMQ Describe	29.82	5.71	27.73	6.20	25.80	5.27
FFMQ Observe	30.17	6.69	30.22	7.45	25.00	6.40
FFMQ Non-Judge	28.45	7.06	26.17	7.30	25.10	8.80
FFMQ Non-React	25.00	3.87	21.75	3.09	21.56	4.85
WBSI	38.81	13.98	44.00	12.80	43.38	16.54

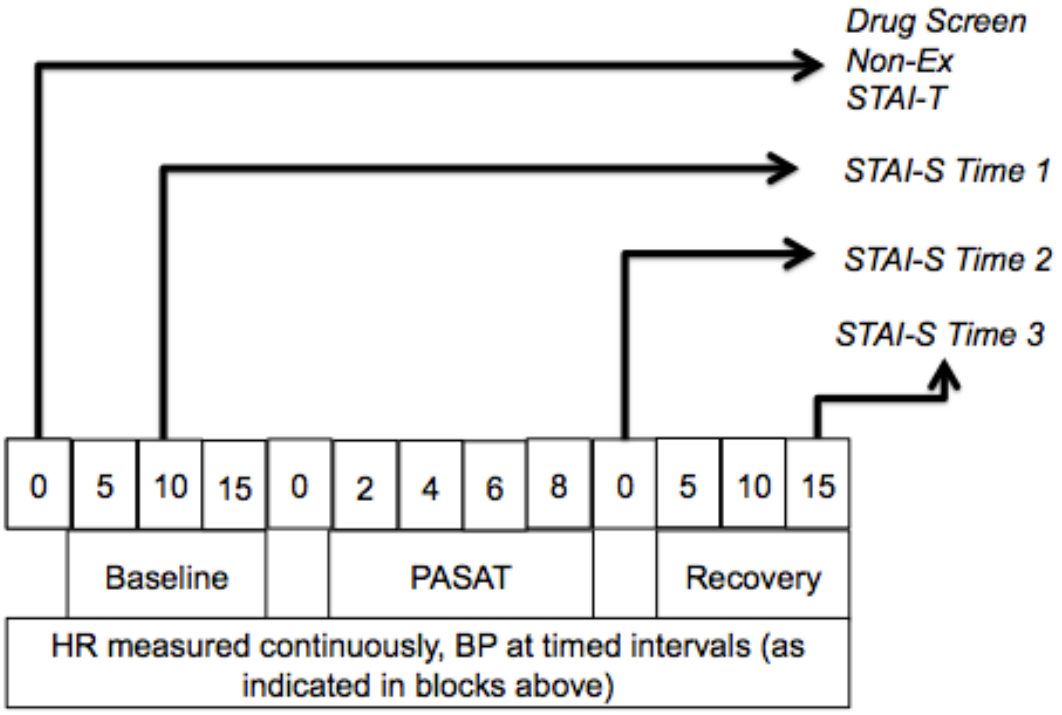
Notes: MBRP = Mindfulness Based Relapse Prevention; RP = Relapse Prevention; TAU = Treatment as Usual; FFMQ Tot = Five Factor Mindfulness Questionnaire Total Score; FFMQ Act = Five Factor Mindfulness Questionnaire Acting with Awareness Subscale; FFMQ Describe = Five Factor Mindfulness Questionnaire Describe Subscale; FFMQ Observe = Five Factor Mindfulness Questionnaire Observe Subscale; FFMQ Non-judge = Five Factor Mindfulness Questionnaire Non-judgment Subscale; FFMQ Non-React = Five Factor Mindfulness Questionnaire Non-reactive Subscale; WBSI = White Bear Suppression Inventory

Table 2. Mediation of Treatment Condition onto Physiological Outcomes by Mindfulness and Thought Suppression

	a	b	c'	IE	SE	LCI	UCI
MBRP/RP							
Mindfulness							
Phasic HF-HRV	13.13*	-.001	.68*	-.03	.07	-.20	.09
Tonic HF-HRV	13.13	-.01	.55*	-.11	.11	-.48	.01
Thought Suppression							
Phasic HF-HRV	-4.93	.0008	.64*	-.004	.04	-.12	.05
Tonic HF-HRV	-4.93	.005	.41*	-.03	.05	-.22	.03
RP/TAU							
Mindfulness							
Phasic HF-HRV	2.24	.01	-.41*	.01	.07	-.06	.24
Tonic HF-HRV	.77	-.001	-.54*	-.003	.04	-.15	.05
Thought Suppression							
Phasic HF-HRV	3.26	-.002	-.37*	-.004	.04	-.12	.05
Tonic HF-HRV	3.26	.004	-.45*	.01	.04	-.03	.18

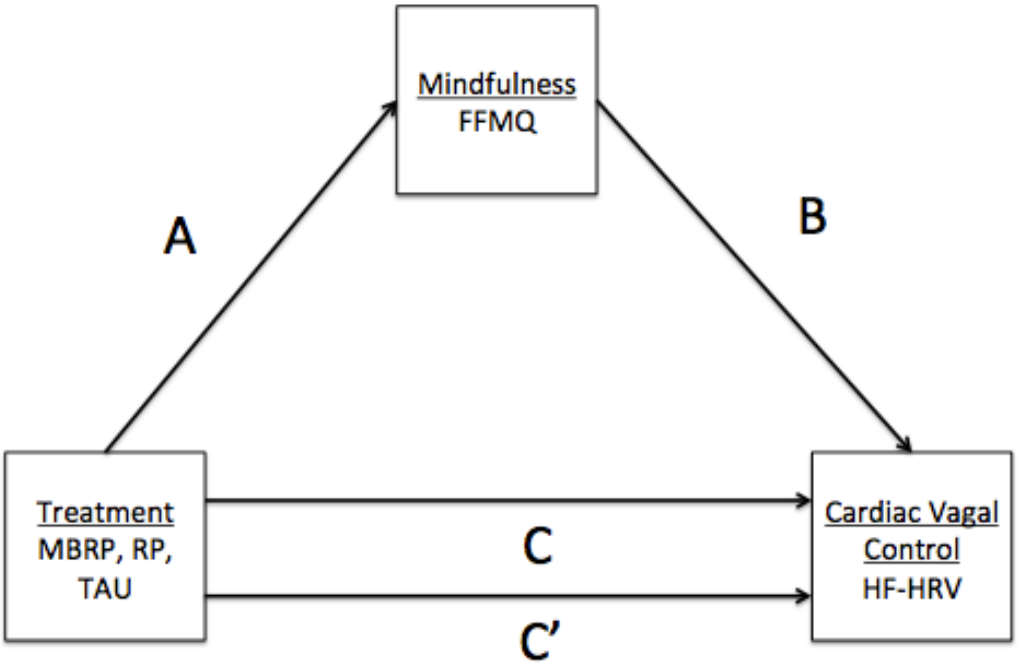
Note: a = a path, b = b path, c' = c' path, IE = Indirect effect, LCI = Lower confidence interval, UCI = Upper confidence interval, MBRP = Mindfulness Based Relapse Prevention; RP = Relapse Prevention; TAU = Treatment as Usual; Mindfulness = Five Factor Mindfulness Questionnaire Total Score; Thought Suppression = White Bear Suppression Inventory, Phasic HF-HRV = High Frequency Heart Rate Variability, Tonic HF-HRV = Baseline High Frequency Heart Rate Variability

Figure 1. Stress Testing Protocol



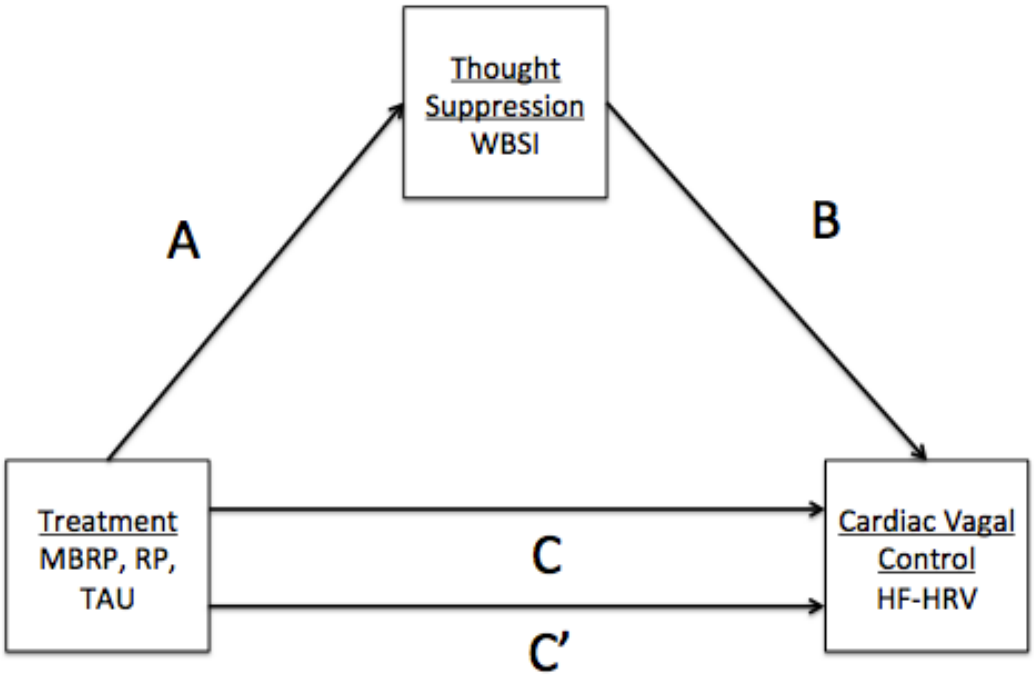
Note: Drug Screen = Oral Lab +6 and Alcohol Panel; Non-Ex = Houston Non-Exercise Inventory; STAI-T = Trait portion of the State-Trait Anxiety Inventory; STAI-S = State portion of the State-Trait Anxiety Inventory; HR = Heart Rate; BP = Blood Pressure

Figure 2. Mediation model for Treatment Effects on Cardiac Vagal Control Mediated by Mindfulness



Note: MBRP = Mindfulness Based Relapse Prevention; RP = Relapse Prevention; TAU = Treatment as Usual; FFMQ = Five Facet Mindfulness Questionnaire; HF-HRV = High Frequency Heart Rate Variability

Figure 3. Mediation model for Treatment Effects on Cardiac Vagal Control Mediated by Thought Suppression



Note: MBRP = Mindfulness Based Relapse Prevention; RP = Relapse Prevention; TAU = Treatment as Usual; WBSI = White Bear Suppression Inventory; HF-HRV = High Frequency Heart Rate Variability