Does how one uses mindfulness meditation matter? : an experimental evaluation of the acute impact of mindfulness in a control vs. acceptance context on anxious arousal in a non-clinical sample

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Does How One Uses Mindfulness Meditation Matter?

An Experimental Evaluation of the Acute Impact of Mindfulness in a Control vs. Acceptance Context on Anxious Arousal in a Non-Clinical Sample

by

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Abstract
Mindfulness meditation has existed in Eastern cultures for thousands of years; nonetheless, its introduction to Western society and psychological science is a recent development. Numerous psychosocial interventions now include mindfulness practice as a core therapeutic intervention. Increasingly, mindfulness and other meditative practices are being promoted within popular culture as strategies to regulate stress, anxiety, and other unpleasant emotional or psychological events. Yet, using mindfulness to regulate and control unwanted private experiences is antithetical to the original intended purpose of such strategies, namely, to observe, welcome and accept private experiences just as they are. Research in emotion regulation and thought suppression highlight the paradoxical iatrogenic effects of suppression and control of private events. Thus, using mindfulness to control or regulate unpleasant emotional or psychological events may backfire, contributing to worsening of emotional distress and disappointing outcomes. The current study aimed to address this issue by evaluating the acute psychophysiological impact of mindfulness meditation when used as an acceptance strategy or a control strategy. Healthy participants (N = 47) were randomized to an acceptance context or a control context. Participants breathed a panicogenic dose of 10% carbon dioxide-enriched air while listening to a 10-minute guided mindfulness meditation. Self-report and psychophysiological responses served as indices of emotional responding. Participants who used mindfulness as a control strategy reported more intense bodily sensations during exposure to the gas and greater heart rate reactivity compared to their acceptance counterparts. Self-reported indices of distress attenuated from the first to the second trial of CO2 exposure. Though preliminary, main and exploratory findings suggest how one uses meditation may influence the intensity and associated distress of anxiety-related bodily sensation, subsequent willingness to experience unwanted private events, and struggle attempting to control private experiences.
Does How One Uses Mindfulness Meditation Matter?:

An Experimental Evaluation of the Acute Impact of Mindfulness in a Control vs. Acceptance Context on Anxious Arousal in a Non-Clinical Sample

Overview and Structure

Understanding the nature of human emotions has been a focus of psychological study for decades. In the area of mental health, much of this work has focused on reducing functional impairment associated with aversive emotions (e.g., anxiety, sadness, and anger), while cultivating positive emotions and experiences (e.g., happiness, joy, and peace). Accounts of psychopathology suggest that disordered psychological pain results from emotions that are inappropriate in their frequency, intensity, duration, or contexts (Gross & Jazaieri, 2014). As such, attempts to reduce negative emotions in favor of positive emotions makes intuitive sense.

The “out-with-the-bad” and “in-with-the-good” approach is often reinforced in the external environment. For example, if a car breaks down, it can be repaired or replaced. Traditional cognitive-behavioral therapies (CBT) align with the car repair model. Treatments identify dysfunctional or problematic thoughts and emotions, and thereafter provide a number of skills (e.g., exposure, relaxation, thought disputation) to help clients “repair” their negative emotions to reduce their impact. On the surface, this approach is fair. After all, no one wants to feel anxious, scared, sad, or angry. Thus according to traditional CBT models, by learning new skills, unwanted emotions may reduce over time. On the other hand, this approach may communicate a pernicious message that some emotions (and associated thoughts) are bad and thus efforts should be taken to eliminate or reduce their occurrence, frequency, and/or intensity.

Individuals with anxiety disorders often engage in a variety of strategies to control their emotional experience in the form of escape, avoidance, or substance use (Barlow, 2002).
Acute, such strategies often offer some temporary relief. Nonetheless, when applied rigidly and broadly, control strategies may paradoxically contribute to more suffering (Abramowitz, Tolin, & Street, 2001; Cioffi & Holloway, 1993; Hayes, Strosahl, & Wilson, 2012). Moreover, behavioral repertoires narrow as the focus shifts from living a full and meaningful life to controlling the frequency, duration, and occurrence of unpleasant emotions. In this vein, traditional CBT interventions may feed into clients’ control agendas, perpetuating suffering.

More recently, researchers have examined experiential avoidance (EA) – the unwillingness to experience private events and subsequent efforts to alter their form, frequency, or duration (Hayes, Wilson, Gifford, Follette, & Strosahl, 1996). This line of research highlights the role of EA in psychopathology (Blackledge & Hayes, 2001; Hayes et al., 2012) suggesting that the experience and expression of emotion itself is not problematic. Rather, responses to the emotions become problematic in the context of the rigid attempts to control the emotions, and thus contribute to unnecessary suffering (Hayes et al., 2012).

Along these lines, newer mindfulness-based CBT approaches (Hayes et al., 2012; Kabat-Zinn, 1994; Linehan, 2014; Roemer & Orsillo, 2009; Segal, Williams, & Teasdale, 2013) aim to undermine rigid and inflexible EA by emphasizing mindful acceptance of private events for what they are (i.e., opening up to experience as it is in the moment while letting go of the fight against emotions and related thoughts and physical sensations). The acceptance rationale is supported by the emotion and thought suppression literature which shows that suppressing unwanted experiences does not reduce their form (Gross & Levenson 1993, 1997; Wegner and Zanakos, 1994) and may even lead to more intense or prolonged suffering (Cioffi & Holloway, 1993).

Mindfulness meditation, a practice with Buddhist origins dating back over 2,500 years, aims to increase acceptance of experience in the present moment. During practice, individuals
learn to simply notice or observe their experience without trying to change it or make it go away (Kabat-Zinn, 1994). Empirical evidence supporting mindfulness is now well established for numerous forms of human suffering in mental health and medicine (Baer, 2003). Not surprisingly, mindfulness has also gone mainstream in the popular culture, with publications and media outlets promoting the benefits of mindfulness practice for a wide range of human woes. Control of emotions, specifically using methods such as distraction, avoidance, and suppression are common in clinical and nonclinical populations (Barlow, 2002; Barlow et al., 2004; Brans, Koval, Verduyn, Lim, & Kuppens, 2013). As a result, there is a risk that the general public may seek out and apply mindfulness practice as another method to control their experience. Findings from the emotion and thought suppression literature suggest that using mindfulness in this fashion may be contraindicated, and in fact produce unintended iatrogenic consequences. In fact, emerging research suggests mindfulness meditation is not a panacea for all, but can have unintended adverse effects (Lindahl et al., 2017; Lomas, Cartwright, Edginton, & Ridge, 2015).

The central aim of this thesis is to evaluate the following: Does it matter how one uses mindfulness mediation? This is a different question than whether mindfulness mediation is helpful. Evidence suggests it is (see Baer, 2003). Instead, the focus in the current study is on how mindfulness practice is being used (i.e., as a control strategy to down regulate unpleasant emotional events or as a method to cultivate acceptance and present moment awareness), and the acute impact of such strategies on the experience of unwanted private events, namely fear and anxiety.

To provide a context for the study that follows, the literature on emotion and emotion regulation is described, including alternative mindfulness and acceptance-based strategies. As will be seen, this work suggests that using mindfulness to regulate and/or avoid unpleasant
emotions may yield disappointing outcomes. Following the review, an experimental study is described involving two 10-minute panicogenic challenges using CO2-enriched air. During the challenge, participants were instructed to use a mindfulness mediation in one of two ways: (a) to control or regulate their emotional responses or (b) to mindfully observe and accept their emotional responses just as they are. Following a discussion of the results of the main and exploratory analyses, the discussion will address limitations of the current study and future directions will be offered.

**Emotion and its Regulation**

**Are Emotions the Problem?**

Human beings are incapable of avoiding psychological pain. At some point in their lives, humans will face painful and aversive psychological experiences. These negative experiences may manifest as grief at the loss of a loved one, anxiety about a looming deadline, work-related stress, painful memories of a traumatic experience, upset at spilling coffee on one’s lap, or worry about future tasks or catastrophic disasters. Humans may also respond to these events with a variety of methods to minimize contact with the aversive thoughts, emotions, and other bodily sensations, or act in ways to cultivate more positive experiences. Individuals may avoid situations that lead to anxiety, turn to substances to help suppress painful memories, repeat positive affirmations to themselves, exercise to release stress, or use a number of other regulatory strategies.

Whereas unpleasant emotions are ubiquitous, some accounts of psychopathology posit that such emotions become disordered when they occur too frequently or infrequently, are too intense, last too long, or arise in inappropriate contexts (Gross & Jazaieri, 2014). In the context of anxiety, traditional cognitive-behavioral therapies (tCBT) include protocols to implement
skills aimed at altering the frequency, intensity, duration, and context of unpleasant emotions through emotion regulation, exposure, cognitive restructuring, reappraisal, relaxation and other strategies (Barlow, 2002).

More recent developments, by contrast, suggest that emotions are not problematic simply because of their valence, frequency, intensity, duration, or situational occurrence. Rather, suffering and functional impairment linked with aversive emotional states has to do with the application of rigid and inflexible emotional and self-regulation strategies (e.g., emotional suppression and control; see Hayes et al., 1996). Indeed, “third-generation” CBT interventions aim to alleviate suffering by targeting individuals’ relationship with emotional responses rather than attempting to increase or decrease the emotion itself (Hayes et al., 2012). That is, clients’ avoidance of unwanted emotions, thoughts, and physical sensations is the problem and the target for therapeutic change (Barlow 2002; Barlow, Allen, & Choate, 2004).

**Experiential Avoidance – A Core Process Underlying Human Suffering**

More recently, research attention has focused on the rigidity and inflexibility of avoidant emotion regulatory strategies (i.e. experiential avoidance). Experiential avoidance (EA) is the unwillingness to experience private events (e.g. emotions, thoughts, memories, and bodily sensations) and subsequent efforts to alter the form, frequency, or contexts of unwanted private events (Hayes et al., 2012; Hayes et al., 1996). EA is different from adaptive forms of avoidance of aversive situations that could potentially cause harm (e.g., a pedestrian avoiding oncoming traffic). Rather, EA entails a repertoire narrowing strategy that is broadly applied and largely ineffective in that it leads to more psychological pain (Boulander, Hayes, & Pistorello, 2010).

Evidence strongly implicates EA as a core process underlying the development and maintenance of anxiety and several forms of psychopathology (Blackledge & Hayes, 2001;
Chawla & Ostafin, 2007; Hayes et al., 1996; Hayes et al., 2012). For example, healthy participants high in EA report greater anxiety compared to those low EA when undergoing an anxiety-provoking biological challenge (Feldner, Zvolensky, Eifert, & Spira, 2003). Participants high in EA also report more physical and cognitive symptoms of panic, including more severe cognitive symptoms, compared to participants low in EA (Karekla, Forsyth, & Kelly, 2004).

Individuals with anxiety disorders often view their anxiety as unacceptable and engage in a range of behaviors to avoid, minimize, reduce, or eliminate their anxiety (e.g., distraction, escape, suppression, safety behaviors; Barlow 2002; Barlow et al., 2004; Campbell-Sills, Barlow, Brown, & Hofmann, 2006a). That is, in the face of anxiety, behavioral repertoires narrow and avoidance behaviors function to control or limit aversive private experiences. Unfortunately, these control methods are unsuccessful as a long-term strategy and may backfire to perpetuate anxiety and functional impairments linked with anxiety disorders (Ascher, 1989; Blackledge & Hayes, 2001; Hayes et al., 2001; Hayes et al., 1996). This may explain, in part, treatment failures following traditional CBT protocols, where the therapeutic rationale and intervention strategies aim to reduce unwanted private events through a variety of methods.

For example, participants with panic disorder who completed a course of CBT with breathing retraining demonstrate poorer outcomes than those who received CBT without breathing retraining (Schmidt et al., 2000). In one laboratory experiment, highly anxious female undergraduate students reported greater intensity of fear and more catastrophic thoughts during a CO2-enriched air inhalation challenge if they were taught diaphragmatic breathing (a common strategy found in tCBT protocols) compared to an acceptance strategy. Moreover, the participants who practiced diaphragmatic breathing were more likely to drop out of the study compared to those practicing acceptance (Eifert & Heffner, 2003). Further, strategies that target
emotional components directly may inadvertently communicate to the client that some emotional experiences are inherently problematic; otherwise, targeting unwanted emotions would not make sense in therapy. This view, ironically, is often what clients with anxiety-related concerns think needs to be done when they enter therapy. Thus, efforts to teach emotional regulation and control may play into the very system that originally brought clients into therapy.

**Paradoxical Effects of Controlling Private Events**

The paradoxical effects of controlling anxiety are well established in the emotion and thought suppression literatures. Expressive and emotional suppression, defined as attempts to hide behavioral responses or push away the emotion itself, not only appear to fail at decreasing negative affect (Gross, 1998; Gross & John, 2003; Gross & Levenson, 1997), but also result in decreased positive emotions (Butler & Gross, 2004; Gross & Levenson, 1997). Further, suppression appears to be more effortful as evidenced by increased sympathetic nervous system activation (Gross 1998; Gross & Levenson 1993, 1997), impaired memory (Gross & John, 2003), and impaired self-control (Alberts, Schneider, & Martijn, 2012). Suppression may also come with social costs (e.g., alienation and isolation; see Butler & Gross, 2004; Gross, 2002; Gross & Levenson, 1993).

Other research suggests suppressing unwanted thoughts and emotions may backfire and lead to more unwanted thoughts and emotions (Lavy & van den Hout, 1990; Wegner, Schneider, Carter, & White, 1987; Wegner & Zanakos, 1994; for reviews see Abramowitz et al., 2001; Purdon, 1999). For instance, participants who suppressed personal intrusive thoughts endorsed a greater frequency of thoughts and greater distress compared to those instructed to accept or simply monitor thoughts (Marcks & Woods, 2005). Further, suppression of thoughts not only increases the frequency of the target thought, but also increases emotional reactivity to the
thought as evidenced by elevated skin conductance (Gold & Wegner, 1995). Other researchers found a similar pattern with self-reported anxiety. Participants who were instructed to suppress anxious thoughts reported heightened anxiety compared to participants who expressed thoughts openly (Roemer & Borkovec, 1994). Thought suppression may also have unintended consequences on mood and sense of self-efficacy. In a healthy sample, participants instructed to suppress negative self-referential thoughts reported lower self-esteem and heightened anxiety and depression compared to controls (Borton, Markowitz, & Dieterich, 2005).

Nonetheless, some research has failed to find evidence of the immediate paradoxical effect of thought suppression on thought frequency (Purdon & Clark, 2001); whereas others showed the paradoxical effect is delayed (Clarke, Ball, & Pape 1991) and may result in slower recovery from negative emotions (Campbell-Sills et al., 2006b). Tull and colleagues found that after watching a distressing film clip, participants in a suppression group reported significantly heightened distress after a recovery period (Tull, Jakupcak, & Roemer, 2010). Further, adults with attention-deficit hyperactivity disorder who were asked to suppress emotions reported poorer recovery in mood after watching a sad film compared to participants asked to accept their emotions (Matthies, Philipsen, Lackner, Sadohara, & Svaldi, 2014).

The delayed rebound effect is also evident in the experience of somatic discomfort. Participants who were asked to suppress sensations of pain during a cold-pressor task rated an innocuous vibration as more unpleasant and showed a slower recovery from pain compared to participants in a distraction or monitoring group (Cioffi & Holloway, 1993). In another cold-pressor task, participants asked to suppress pain sensations showed less pain tolerance time, reported greater pain and distress, and a slower rate of recovery compared to an acceptance group and a spontaneous coping group (Masedo & Esteve, 2006).
The immediate success of suppression attempts and subsequent rebound effects may also depend on the strength of the aversive event. Participants who underwent a biological challenge by inhaling carbon dioxide-enriched air designed to elicit panic symptoms and were asked to suppress their emotional responses were initially successful if they rated the emotions as less severe, but later reported a rebound of heightened negative emotion after recovery. Those who reported the experience as more intense showed elevated negative affect immediately after the task (Feldner, Zvolensky, Stickle, Bonn-Miller, & Leen-Feldner, 2006).

Taken together, this body of research suggests efforts to suppress negative emotions and thoughts do not reduce their frequency or impact in both clinical and nonclinical samples. In fact, suppression attempts appear to result in more frequent thoughts and negative emotions over a longer period of time. Suppression not only fails to reduce negative thoughts and emotions, but also reduces positive emotions. Moreover, suppression appears to be effortful and results in memory impairments, heightened sympathetic nervous system activation, and inhibited self-control.

Whereas suppression may be an effective short-term strategy (i.e., offering acute relief), ongoing efforts to suppress unpleasant emotions may result in long-term potentiation of negative emotions. Because the effect of suppression is delayed, initial success may reinforce individuals’ use of suppression. When applied rigidly, chronic suppression may aid in the development and maintenance of psychopathology. In the context of anxiety disorders, unwillingness to experience aversive private events and the subsequent efforts to control experience may serve to perpetuate anxious suffering. Collectively, this body of work strongly suggests that using mindfulness as a means to control and regulate unpleasant emotional events may yield disappointment, and paradoxically produce more emotional distress and suffering.
Mindful Acceptance of Emotion

Acceptance: An Alternative to Control

Acceptance has been described as a healthy alternative to emotional control and regulation of experience (Eifert & Forsyth 2013; Hayes et al., 2012; Orsillo & Roemer, 2011). Acceptance can be defined as a choice to willingly “sustain contact with private experiences or the events that will likely occasion them…[and] the adoption of an intentionally open, receptive, flexible, and nonjudgmental posture with respect to moment-to-moment experience” (Hayes et al., 2012, p. 77). Put simply, acceptance is taking what is offered, particularly events that one cannot control or change but are happening anyway.

Acceptance strategies are found in several evidence-based interventions including Acceptance and Commitment Therapy (ACT; Hayes et al., 2012), Dialectical Behavior Therapy (Linehan, 2014), Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 2013), Mindfulness-Based Cognitive Therapy for depression (MBCT; Segal, Williams, & Teasdale, 2002) and Integrative Behavioral Couples Therapy (Jacobson, Christensen, Prince, Cordova, & Eldridge, 2000). In a recent review, acceptance was shown to have a small to large effect size in the treatment of a variety of psychological disorders (Levin, Hildebrandt, Lillis, & Hayes, 2012). Acceptance has also been found to correlate with reduced pain intensity, pain-related anxiety, avoidance, and depression in a sample of clients with chronic pain (McCracken, 1998; McCracken, Spertus, Janeck, Sinclair, & Wetzel, 1999). Compared to suppression, the therapeutic benefits of adopting an acceptance stance when faced with psychological, physiological, and emotional events that are not entirely within one’s control are robust.

Some research suggests that acceptance has a greater impact on the subjective experience of anxiety but does little to alter the physiological components of anxiety. In Eifert and
Heffner’s study (2003), participants in the acceptance condition reported less intense fear and cognitive symptoms and fewer catastrophic thoughts during the panicogenic challenge, despite showing no differences in physiological responses, compared to their control-agenda counterparts (Eifert & Heffner, 2003). Further, the acceptance participants were more willing to repeat the experiment and showed more willingness to experience discomfort as evidenced by differences in drop-out rates; none of the participants in the acceptance condition dropped out of the study compared to 20% of participants in the control agenda condition (Eifert & Heffner, 2003). Findings from this study have been replicated in a sample of adults with panic disorder (Levitt, Brown, Orsillo, & Barlow, 2004), and in paradigms that used aversive film clips to elicit negative emotions (Wolgast, Lundh, & Viborg, 2011). Studies evaluating psychophysiological response in relation to acceptance offer mixed results. In a study of individuals with mood and anxiety disorders, acceptance was shown to decrease heart rate, compared to the suppression group who demonstrated an increase in heart rate. No differences were found in skin conductance or respiratory sinus arrhythmia (Campbell-Sills et al., 2006b).

Research in thought suppression has revealed a similar pattern. Participants who accepted intrusive thoughts did not report significant reduced frequency of thoughts. However, these participants reported significantly reduced distress from the thoughts compared to a group instructed to suppress thoughts (Marcks & Woods, 2005). Acceptance also appears to be less cognitively taxing than effortful emotion suppression, as evidenced by greater self-control in an acceptance group compared to those in a suppression condition (Alberts et al., 2012).

Suppressing aversive private events can be successful, yielding short-term relief while reinforcing avoidance behaviors. Yet, deleterious effects may be delayed and impact recovery from unpleasant emotional events (Campbell-Sills et al., 2006b; Cioffi & Holloway, 1993; Clark
et al., 1991; Matthius et al., 2014; Wegner, 1989). Acceptance, by contrast, appears to have the opposite effect. Acceptance of aversive experiences reduces emotional recovery time after watching distressing films (Campbell-Sills et al., 2006b; Matthius et al., 2014; Tull et al., 2010), including pain induced by a cold-pressor task (Masedo & Esteve, 2006). Further, acceptance is linked with greater pain tolerance and willingness to experience laboratory-induced pain in the future compared to strategies focused on controlling pain (Gutierrez, Luciano, Rodriguez, & Fink, 2004).

This body of literature suggests interventions emphasizing acceptance of experience have benefits on the subjective experience of distress, willingness to experience distress, and recovery from distressing events. Acceptance appears to be an effective alternative to control-based strategies in addressing psychological and physical forms of pain. Acceptance allows individuals to let go of struggling with experience in favor of expanding behavioral repertoires adaptively. That is, individuals are able to behave flexibly despite unwanted private events for which they have limited control. With acceptance, efforts are no longer directed towards changing private events, but towards behaviors that lead to a meaningful life.

**Cultivating Acceptance Through Mindfulness**

Acceptance can be cultivated through mindfulness practice (Baer, 2003; Eifert & Forsyth, 2013; Kabat-Zinn, 1994; Roemer & Orsillo, 2009; Orsillo & Roemer, 2011; Segal et al., 2013). Though mindfulness has been variously described in the literature, most definitions include the following: paying attention to the experiences that arise in the present moment with an open, curious, and nonjudgmental attitude (Bishop et al., 2004; Kabat-Zinn, 1994). Mindfulness practice encourages experiencing private events as they are without trying to make them go away. That is, mindfulness promotes observing experience as it is, rather than fighting,
suppressing, or otherwise making efforts to alter experience. Mindfulness is a core treatment strategy in several evidence-based interventions (Hayes et al., 2012; Linehan, 2014; Segal et al, 2013; Roemer & Orsillo 2009). Moreover, mindfulness practice has been shown to be effective in the treatment of chronic pain, anxiety and mood disorders, and in the distress associated with other medical disorders (for recent reviews see Baer, 2003; Hofmann, Sawyer, Witt, & Oh, 2010).

Mindfulness can be practiced in formal or informal settings. Some psychosocial interventions incorporate formal mindfulness practice in the form of mindfulness meditation in which participants sit for 15-45 minutes and focus attention on the breath, sound, or other internal/external stimuli (Kabat-Zinn, 2013; Segal et al., 2013). During the practice, participants are instructed simply notice and observe whatever thoughts, emotions, or sensations arise in the moment. When participants find that their minds have wandered, they are instructed to return their attention to the breath or other anchor gently and without judgment. Other approaches encourage informal mindfulness practice in daily life, wherein individuals are encouraged to bring mindful awareness to thoughts, emotions, and bodily sensations while engaging in everyday activities, such as eating or walking (Kabat-Zinn, 1994), or through the use of metaphors and experiential exercises (Hayes et al., 2012; Linehan, 2014).

Correlational and laboratory-based studies support the benefits of mindfulness practice. After viewing emotionally salient pictures, undergraduates in a focused breathing condition reported lower negative affect after viewing distress pictures and greater willingness to view the pictures when compared to an unfocused breathing or worry group (Arch & Craske, 2006). In undergraduates, mindfulness meditation decreases dysphoric mood more than distraction or rumination strategies (Broderick, 2005). Participants who received a mindfulness intervention
also report increased positive mood and decreased negative mood after watching a variety of film clips compared to healthy controls who received neutral educational information (Erisman & Roemer, 2010). More broadly, participants who practiced mindfulness meditation reported reduced negative mood, depression, fatigue, and heart rate compared to a control group asked to sit quietly (Zeidan, Johnson, Gordon, & Goolkasian, 2010).

Mindfulness is associated with reduced stress in cancer patients (Brown & Ryan, 2003) and reductions in overall distress (Coffey & Hartman, 2008), greater positive affect, and reduced negative affect (Brockman, Ciarrochi, Parker, & Kashdan, 2017). Additionally, participants who scored high on a measure of trait mindfulness reported less stress and reactivity when instructed to suppress emotional experiences during a CO₂-enriched air challenge (Bullis, Boe, Asnaani, & Hofmann, 2014) suggesting that mindfulness may buffer against the deleterious impact of suppression. In a separate CO₂-enriched air challenge, participants who practiced either open monitoring or focused attention, two components of mindfulness meditation, reported significantly reduced self-reported anxiety, but did not differ in physiological responses, compared to a relaxation group (Ainsworth et al., 2015).

In summary, acceptance of private events can be cultivated through formal and informal mindfulness practice. Laboratory and correlational studies have suggested that mindfulness practice can be beneficial not only in the treatment of clinical complaints, but also for the promotion of well-being in nonclinical populations. Such benefits, in turn, appear to be a byproduct of the practice itself and not attributable to the use of mindfulness as a direct form of thought or emotion regulation, an approach that would depart significantly from the intended purpose of mindfulness meditation.

**Mindfulness in Mainstream Popular Culture**
Despite the practice of mindfulness meditation existing in Eastern traditions for millennia, its adoption into mainstream Western culture and psychotherapy has only occurred in the last several decades. Meditation as a form of contemplation is not new to the West and is found in numerous religious traditions, including Christianity; however, mindfulness, which originated in Buddhism, was relatively unknown in the West until Kabat-Zinn’s development of MBSR in the late 1970’s (Lutkajtis, 2018). Since then, mindfulness has been embraced as a secular technique for reducing stress, improving health, and improving concentration and productivity (Brown, 2016; Purser & Loy, 2013). Given the reported benefits of practicing mindfulness (e.g., Baer, 2003), it comes to no surprise that mindfulness has been commodified. For instance, Time magazine published a special issue on mindfulness in 2016. Mindful, a bimonthly magazine, published its first issue in 2013. Other books like Mindfulness for Parents (Hatch, 2017), Mindful Politics (McLeod, 2006), and similar prints appear to intend to bring mindfulness to virtually all arenas of society and the general population. Smartphone applications such as Calm, Headspace, and Insight Timer bring thousands of guided meditations to the fingertips of users. Some research suggests that more than 20 smartphone apps contributes to a billion-dollar meditation industry, serving 18 million meditators (Lindahl et al., 2017).

The popularity of mindfulness has not been received entirely without reservations, however. More recently, critiques of the secularization and commodification of the practice have begun surfacing in the discourse of mindfulness (Drougge, 2016). In 2013, Ron Purser and David Loy published Beyond McMindfulness in a blog in the Huffington Post criticizing the use of mindfulness as a way to reinforce “unwholesome roots of greed, ill will and delusion” in the corporate sector (Purser & Loy, 2013). Others argue that mindfulness has been stripped of its original intention of liberation and enlightenment for “comparatively trivial goals, such as well-
being and stress reduction” (Drougge, 2016, p. 173). For example, many meditation smartphone applications have meditations grouped under headers such as “Stress & Anxiety.”

Emerging research suggests that mindfulness and meditation may not be a harmless panacea in the treatment of all human woes (Lindahl et al., 2017; Lomas et al., 2015; Lutkajtis, 2018, 2019). While the benefits of mindfulness and meditative practices are well known (Baer, 2003), a striking dearth in research on adverse effects of mindfulness is present (Baer, Crane, Miller, & Kuyken, 2019; Irving, Dobkin, & Park, 2009). In a recent review of harm in mindfulness-based interventions, Baer and colleagues (2019) note that of the relatively few studies reporting adverse effects, many are presented as case studies of one or a few individuals who report psychosis, negative affect, mania, depersonalization and derealization, and traumatic memories. In that same review, only four studies reported the frequency and type adverse effects of meditation in large samples (Baer et al., 2019). Adverse effects ranged from 4.5 – 100% of meditators and included unpleasant thoughts and emotions, anxiety, depression, disorientation, pain, and suicidality (Baer et al., 2019).

Although mindfulness meditation has numerous psychological and physical benefits, the practice is not a cure all. More recent research suggests that mindfulness and other meditative practices can have serious adverse effects. The promotion of the practice appears to be outpacing the research on the topic (Irving et al., 2009). Given the exponentially increasing popularity and promotion of meditative practices, research examining reasons for adverse effects is imperative to deliver safe and effective experiences in psychotherapy and the population writ large.

**Summary and Aims of the Present Research**
While mindfulness meditation has existed for over 2,500 years in Eastern Buddhist contexts, its introduction to Western society and psychological science is a more recent development. Over the past decade, mindfulness has gone mainstream in the general public. Numerous publications, podcasts, and smartphone applications have emerged both supporting and promoting the benefits of practicing mindfulness. Yet, there is an emerging literature suggesting that mindfulness practice may yield adverse effects (Baer, 2019; Cebolla, Demarzo, Martins, Soler, & Garcia-Campayo, 2017; Lindahl et al., 2017; Van Dam et al., 2018a; Van Dam et al., 2018b). Though this line of work is preliminary, poor outcomes linked with mindfulness practice may have to do with drift regarding the intended purpose of the practice.

Indeed, as the emotion regulation literature suggests, using mindfulness to regulate, suppress, or avoid unpleasant emotional experiences may backfire. To date, no studies have addressed this issue. Yet, owing to the increasing popularity of mindfulness practices in mental health and society writ large, individuals may be applying mindfulness practice in a manner far from its intended purpose. In short, mindfulness may produce poor outcomes largely because individuals are using it to regulate or control their private experiences. As such, mindfulness may become another control strategy used in the face of unwanted private experiences.

In fact, several authors caution clinicians to assess how clients use mindfulness strategies, and to redirect clients when mindfulness is functioning as another control strategy (Eifert & Forsyth, 2013; Hayes et al., 2012; Leahy, Tirch, & Napolitano, 2011). This caution appears warranted in the context of research evaluating the deleterious effects of thought and emotion suppression and control. Further, research suggests the quality of mindfulness practice, including the degree of acceptance of private events, relates to improvements in psychological functioning (Del Re, Fluckiger, Goldberg, & Hoyt, 2013). Because individuals with panic and
anxiety disorders are more likely to engage in various control strategies such as suppression, avoidance, or escape (Campbell-Sills et al., 2006a, Cox, Swinson, Norton, & Kuch, 1991), they may be more likely to practice mindfulness as another control strategy, thus unintentionally perpetuating their suffering, leading to frustration with the practice itself and disappointing outcomes.

To date, there has been no research evaluating whether it matters how individuals use mindfulness. Indeed, it may be the case that mindfulness practice is impactful, regardless of how one uses it. Alternatively, based on findings from emotion science, using mindfulness to regulate and control negative psychological and emotional events may yield iatrogenic and disappointing results relative to use of such practices as they are intended to be used (i.e., from an open, receptive stance, acknowledging what arises as it is without judgment or struggle and resistance).

The current study aims to address this issue by manipulating the context in which mindfulness meditation is practiced (i.e., control/self-regulation vs. acceptance/openness) and evaluating its impact on acute psychological and physiological responses to laboratory-induced anxiety. Healthy participants received either (a) an acceptance-based rationale, instructing them to use a guided mindfulness-meditation to be open and accepting of anxiety symptoms, or (b) a control-based rationale, instructing participants to use the guided meditation as a way to reduce their anxiety. Participants then breathed 10% CO₂-enriched air while listening to a standardized 10-minute mindfulness meditation adapted from MBSR (Kabat-Zinn, 2013).

Breathing increased concentrations of CO₂ is a well-established paradigm to induce several involuntary symptoms associated with anxiety and panic including tachycardia, breathlessness or smothering sensations, dizziness, lightheadedness, sweatiness, and fears of
losing control (Bailey, Argytopoulos, Kendrick, & Nutt, 2005; Forsyth, Eifert, & Canna, 2000; Forsyth, Lejuez, & Finlay, 2000; Zvolensky & Eifert, 2001). Previous research has shown that the use of carbon dioxide-enriched air is useful and ecologically valid paradigm for the study of fear and panic in a controlled laboratory setting (Ainsworth et al., 2015; Forsyth & Eifert, 1996; Zvolensky & Eifert, 2001).

**Study Hypotheses.** Based on previous research comparing acceptance and suppression, we anticipated the following:

First, participants given the acceptance-based rationale for mindfulness meditation would report less distress, fear and anxiety, and struggle with their emotional experience, and greater willingness and sense of control while meditating and breathing CO2-enriched air compared to those given the control-based rationale. Further, we anticipated that self-reported intensity of bodily reactions to the CO2-enriched air would not discriminate between conditions. This later prediction is consistent with the acceptance literature showing that distress and reactivity, not extent of emotional or physiological arousal, is what tends to discriminate between acceptance and control/regulation approaches (e.g. Ainsworth et al., 2015; Arch & Craske, 2006; Bullis et al., 2014; Campbell-Sills et al., 2006b; Feldner et al., 2006; Gross & Levenson, 1993; Levitt et al., 2004).

Second, participants in the control-based condition were expected to show slower recovery of panicogenic symptoms (i.e., elevated distress, fearfulness, and subjective intensity) following each meditation+CO2 trial compared to participants in the acceptance-based condition (e.g., Campbell-Sills et al., 2006b; Matthies et al., 2014; Tull et al., 2010). Further, we anticipated that the control-based condition would evidence a rebound effect, reporting greater
distress, fearfulness, and subjective emotional intensity in the second trial of the breathing challenge compared to the first trial (e.g., Cioffi & Holloway, 1993; Masedo & Esteve, 2006).

Third, we did not anticipate any between-condition differences on self-reported somatic symptoms of panic or physiological arousal (e.g., Eifert & Heffner, 2003). That is, we expected that the procedure would yield equivalent somatic panicogenic symptoms, regardless of how mediation is applied. We did, however, expect that participants in the acceptance-based condition would report fewer and less severe cognitive symptoms of panic, fewer catastrophic thoughts (similar to Eifert & Heffner, 2003) and more positive thoughts relative to their emotional control counterparts. The hypothesis of more positive thoughts is based on research showing mindfulness practice increasing positive affect (e.g., Brockman et al., 2017).

Fourth, given the pattern drop-out observed in Eifert & Heffner (2003), we expected more participants in the meditation control context would discontinue a trial of meditation+CO2-enriched air relative to their acceptance-based counterparts.

Finally, participants in the acceptance-based group were expected to endorse the strategy and practice as more effective, report more willingness to repeat the experiment again, and report higher likelihood to recommend the strategy to a friend compared to their control-based counterparts (e.g., Eifert & Heffner, 2003).

Methods

Participants

Participants were \(N = 47\) undergraduates at the University at Albany, SUNY \((M_{\text{age}} = 19.57, SD_{\text{age}} = 1.91)\). The ethnic/racial background of the sample was as follows: 42.6\% White \((n = 20)\), 19.1\% Black or African American \((n = 9)\), 19.1\% Asian \((n = 9)\), 17\% Hispanic or Latino/a \((n = 8)\), and 2.1\% American Indian or Alaskan Native \((n = 1)\). The sample was 66\%
female \((n = 31)\). Participants reported they had little or no prior experience with mindfulness meditation. Study candidates reporting a past or present history with any of the following were excluded to avoid any complications arising from breathing CO2-enriched air: cardiovascular problems, asthma, epilepsy or another seizure disorder, panic disorder, hypertension, migraines, respiratory illness or other lung disorder (e.g. emphysema), current flu/common cold symptoms, or being pregnant and/or endorsing the possibility of being pregnant. Participants provided informed consent and were randomized to either a control agenda condition \((\text{Med}_{\text{Ctrl}}; n = 25)\) or to an acceptance agenda condition \((\text{Med}_{\text{Accept}}; n = 22)\). Conditions did not differ on gender \((\chi^2 (1, N = 47) = .09, ns)\), age \((F(1,46) = .21, ns)\), or ethnic/racial background \((\chi^2 (4, N = 47) = 2.13, ns)\). Participants received research credit for participation in the study.

**Materials**

CO2-enriched air \((10\% \text{ CO}_2, 21\% \text{ O}_2, 69\% \text{ N}_2)\) was administered through a Hans Rudolph Inc. 7940 Series mouth-breathing-only respiratory mask with head strap. Participants wore a nose clip to minimize olfactory detection of the CO2 and to maximize ventilation. The respiratory mask was attached to corrugated tubing and attached to one side of a Hans Rudolph 8500 Series Pneumatic 3-Way Sliding Type directional control valve. One free port of the 3-way valve was connected to a 60-L non-diffusing gas collection bag. The bag was inflated with the CO2-enriched air supplied by a nearby tank using .25 inch Tygon tubing. The other port of the valve was left unattached to feed normal room air from the laboratory atmosphere. Participants breathed the gas directly from the bag to minimize detection of changes in air pressure from the gas tank. The directional control valve was activated by depressing a foot pedal attached to a Hans Rudolph 4285 Series automatic controller. This allowed for uninterrupted, precise switching between normal room air and the CO2-enriched air, and prevented normal room air
and CO₂-enriched air from being mixed. The CO₂ delivery apparatus was located in a sound-attenuated room adjacent to the experimental room.

A capnostat sensor was attached to the exhalation end of the breathing mask to measure breathing rate. The capnostat was connected to a NovaMetrix CO₂SMO Model No. 7100 capnograph. An infrared pulse oximeter measuring heart rate was attached to the capnograph and connected to the index finger of the participant’s non-dominant hand.

A white wooden board was laid across the participant’s lap to serve as a desk for completion of experimental assessments.

Instructions and the guided mindfulness meditation audio were pre-recorded and uploaded to an iPod. The iPod was connected to one stereo speaker located above and behind the participant. The guided audio was adapted from a 20-minute guided mindfulness meditation commonly used as part of the MBSR program (Kabat-Zinn, 2013). For pragmatic purposes, the 20-min guided meditation was edited to eliminate the opening instructions, lengthy pauses, and narration instructing participants to resist trying to control their experiences. This yielded a 10-minute mediation that retained the core elements of the practice. The meditation instructed participants to focus their attention to noticing the sensations of the breath. Additionally, participants were guided to shift attention to physical sensations as they arise and breathe with the sensations. Periodically, the meditation asked participants to shift attention gently back to physical sensations if they notice being caught up in thoughts.

**Measures**

Participants were administered the following measures to evaluate demographics and individual difference variables that may impact response to the meditation and CO₂-inhalation provocation:
**Background and demographics.** Participants were asked to provide their age, gender, ethnicity, and meditation experience. If participants indicated that they meditated, they were then asked about frequency, duration of meditation practices, and how they learned to meditate. Questions regarding meditation were asked post-experiment to limit potential bias during the experiment.

**Acceptance and Action Questionnaire.** The Acceptance and Action Questionnaire-II (AAQ-II; Bond et al., 2011) is a seven-item measure assessing EA. Scores range from 7-49 with higher scores indicating greater experiential avoidance. The AAQ-II demonstrates adequate internal reliability ($\alpha = .84$) and appropriate discriminate validity. Cronbach’s alpha in the present sample was adequate ($\alpha = .83$).

**Anxiety Sensitivity Index.** The Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky, & McNally, 1986) is a 16-item measure assessing the construct of anxiety sensitivity, or the fear of anxiety and the physical sensations associated with anxiety. Participants rate the degree that each item applies to them on a 5-Point Likert scale from 1 (*very little*) to 5 (*very much*). The total score ranges from 16-80. The ASI demonstrates adequate internal consistency ($\alpha = .88$; Peterson & Heilbronner, 1987). Cronbach’s alpha in the present sample was adequate ($\alpha = .86$).

**State-Trait Inventory for Cognitive and Somatic Anxiety.** The State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA; Ree, French, MacLeod, & Locke, 2008) is a 21-item measure assessing cognitive (e.g. anxious thoughts) and somatic symptoms (e.g. physiological arousal) related to anxiety. The trait version of the STICSA asks participants to rate how often, in general, each statement is true. The state version asks participants to rate how they feel right now. Participants rate each item on a 4-point Likert scale from 1 (*not at all*) to 4...
(very much so). Total scores represent anxiety at the state or trait level. Total scores range from 21-84. Somatic anxiety measured by the state version was found to be sensitive to trials of CO2-enriched air inhalation (Ree et al., 2008). The scale demonstrates adequate internal reliability (α > .90). Cronbach’s alpha of the total score in the present sample was adequate (α = .91).

**Believability of Anxious Feelings and Thoughts.** The Believability of Anxious Feelings and Thoughts (BAFT; Herzberg et al., 2012) is a 16-item measure, based in ACT, assessing the degree to which one’s relation with anxious private experiences is fused or defused. Participants rate how valid or believable each item is to them on a 7-point Likert scale from 1 (not at all believable) to 7 (completely believable). Possible scores range from 16-112 with higher scores indicating greater fusion. The BAFT demonstrates adequate internal consistency in anxious samples (α = .91), test-retest reliability (r = .77), and construct validity. Cronbach’s alpha in the present sample was adequate (α = .91).

**Difficulties in Emotion Regulation Scale.** The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) is a 36-item measure assessing emotion regulation and dysregulation. Participants rate how often each statement applies to them on a 5-point Likert scale from 1 (almost never) to 5 (almost always). Total scores range from 36-180. Higher scores indicate greater difficulties with emotion regulation in six categories: Nonacceptance of emotional responses (6 items), difficulties in engaging in goal-directed behavior (5 items), impulse control difficulties (6 items), lack of emotional awareness (6 items), limited access to emotion regulation strategies (8 items), and lack of emotional clarity (5 items). The DERS demonstrates adequate internal consistency (total α = .93) and construct validity. Cronbach’s alpha in the present sample was adequate (total α = .94).
**Distress Tolerance Scale.** The Distress Tolerance Scale (DTS; Simons & Gaher, 2005) is a 15-item measure assessing one’s distress tolerance. Participants rate agreement to statements on a 5-point Likert scale from 1 (*strongly agree*) to 5 (*strongly disagree*). Scores range from 15-75 with higher scores indicating a greater ability to tolerate emotional distress. The DTS demonstrates adequate internal consistency ($\alpha = .82 - .85$) and construct validity. Cronbach’s alpha in the present sample was adequate ($\alpha = .92$).

**Freiburg Mindfulness Inventory.** The Freiburg Mindfulness Inventory (FMI; Walach, Buchheld, Buttenmuller, Kleinknecht, & Schmidt, 2006) is a 30-item measure of mindfulness. Participants rate how often they experience each item on a 4-Point Likert scale from 1 (*rarely*) to 4 (*almost always*). Scores range from 30-120 with higher scores indicating greater mindfulness. The FMI demonstrates adequate internal consistency ($\alpha = .93$). Cronbach’s alpha in the present sample was adequate ($\alpha = .87$).

**Positive and Negative Affect Schedule.** The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) is a 20-item measure assessing positive and negative affect. The measure produces a score on each subscale representing positive affect (PA; 10 items) and negative affect (NA; 10 items). Positive affect is the degree to which individuals experience pleasurable engagement with their environment; negative affect is the degree of subjective distress and unpleasurable engagement with the environment. Respondents rate the degree to which they experience each emotion in general on a 5-point Likert scale ranging from 1 (*very slightly*) to 5 (*extremely*). The measure demonstrates adequate construct validity and internal consistency ($\alpha = .89$ for PA and .85 for NA) (Crawford & Henry, 2004). Cronbach’s alpha in the present sample was adequate (PA $\alpha = .85$, NA $\alpha = .88$).
White Bear Suppression Inventory. (WBSI; Wegner & Zanakos, 1994). The WBSI is a 15-item measure assessing one’s general tendency to suppress unwanted negative thoughts. Respondents rate the degree that they agree or disagree to statements regarding thought suppression on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Scores range from 15-75 with higher scores indicating a greater tendency to suppress unwanted thoughts. The WBSI demonstrates good construct validity and adequate internal consistency ($\alpha = .89$) (Muris, Merckelbach, & Horselenberg, 1996). Cronbach’s alpha in the present sample was adequate ($\alpha = .91$).

Experimental Visual Analogue Scales. Each Experimental Visual Analogue Scale (VAS; Wolpe, 1958) consists of six statements assessing subjective units of distress. Participants place a mark on a 100-mm line with polar statements at the 0-mm and 100-mm points. Scores were generated by measuring the distance in millimeters from the 0-mm endpoint. Participants rate their level of distress ($0 = \text{not at all distressed} \text{ to } 100 = \text{extremely distressed}$), intensity of bodily reactions ($0 = \text{very mild} \text{ to } 100 = \text{extremely intense}$), perceived control over bodily reactions ($0 = \text{complete control} \text{ to } 100 = \text{absolutely no control}$), degree of fear ($0 = \text{not at all fearful} \text{ to } 100 = \text{extremely afraid}$), willingness to have sensations/feelings without acting on them ($0 = \text{extremely willing} \text{ to } 100 = \text{completely unwilling}$), and struggle to reduce physical sensations, feelings, and thoughts ($0 = \text{no struggle} \text{ to } 100 = \text{extremely struggling}$). These six VAS variables are herein referred to as Distress, Intensity, Control, Fear, Willingness, and Struggle, respectively. Note that higher scores on Control indicate lower sense of control. Further, higher scores on Willingness indicate lower willingness (i.e., greater unwillingness).
Diagnostic Symptoms Questionnaire. The Diagnostic Symptoms Questionnaire (DSQ; Rapee, Sanderson, McCauley & Di Nardo, 1992) is a 16-item measure of the presence and intensity of 13 somatic and three cognitive DSM-5 (APA, 2013) panic symptoms. Participants rank intensity for each symptom on a 9-point Likert scale from 0 (not at all) to 8 (very strongly felt). Participants also rate their perceived control, safety, and anxiety on a 9-point Likert scale from 0 (not at all) to 8 (completely). Finally, participants indicate if they experienced 6 catastrophic and 6 positive thoughts (e.g. “I feel relaxed.” “I feel like I might be dying.” “There is nothing to fear.” “Something is wrong.”). Participants complete the DSQ immediately after each trial.

Psychophysiological Indices. Heart rate was measured using a finger probe attached to the participant’s non-dominant index finger which led to a NovaMetrix CO2SMO Model No. 7100 capnograph. A research assistant recorded heart rate each minute of each trial. Breath rate was measured using a capnostat sensor attached to a Hans Rudolph Inc. 7940 series breathing mask. The capnostat sensor was connected to the capnograph described above. Breathing rate and heart rate were sampled continuously and averaged in 10-sec intervals. A research assistant recorded heart and breathing rate each minute of each trial.

Validity Check and Other Post-Experiment Questions. Following completion of the trials, participants answered several questions serving as a validity check, and others probing experience with meditation. Participants were asked if they used the guided audio as instructed, how effective the strategy they were asked to use was (on a 9-point Likert scale from 1 = not at all effective to 9 = completely effective), clarity of instructions (on a 9-point Likert scale from 1 = not at all clear to 9 = completely clear), likelihood of recommending the strategy to a friend (on a 9-point Likert scale from 1 = not at all recommend to 9 = completely recommend), and
willingness to repeat experiment (on a 9-point Likert scale from 1 = not at all willing to 9 = completely willing).

**Procedures**

Participants were first screened for eligibility and then provided informed consent. Participants completed pre-experiment VAS ratings and were informed that they will complete several VAS rating sheets throughout experiment. Participants then completed the pre-experimental battery which included demographics, the AAQ-II, ASI, BAFT, STICSA State and Trait, DERS, DTS, FMI, PANAS, and WBSI. Thereafter, participants were led to a dimly lit, sound-attenuated experiment room and seated up-right in a comfortable recliner. Participants were fitted with a finger probe to measure heart rate. Participants placed a nose clip on their nose to inhibit nose breathing. Next, participants were fitted with a breathing mask and apparatus to assess respiration rate. Immediately thereafter, participants completed the pre-experimental VASs a second time.

Participants were told to rest for five minutes to allow for acclimation to the mask and recording devices. After five minutes, participants listened to pre-recorded instructions describing when to fill out the VAS ratings. Instructions also reminded participants of the transient effects of breathing CO₂-enriched air, including increased heart rate, dizziness, sweatiness, anxiety, trembling, or a smothering sensation. Finally, participants were told that they may discontinue a trial at any time if they experience significant distress. Participants were encouraged only to signal to end a trial if they felt that they could not go on. Participants were then asked to open an envelope and read condition specific instructions on how to use the guided meditation audio. Experimenters were blind to the contents of the envelopes and hence the participants’ assigned condition.
Participants randomized to the meditation+control-agenda (MedCntrl) condition were given the following instructions:

“In a few minutes, you may start to experience some of the effects of breathing the CO₂-enriched air. These sensations may include increased heart rate, dizziness, sweatiness, anxiety, and feeling panicky. The purpose of the guided audio you are about to hear is to minimize the effects of the CO₂-enriched air. It should allow you to better control, manage, and reduce the effects of the CO₂. The guided audio provides you with a helpful strategy so that you can experience less anxiety and other negative effects of the CO₂-enriched air. The guided audio is designed to make the negative effects of the CO₂-enriched air go away. Please keep this in mind as you listen and follow along with the guided audio.”

Participants in the meditation+acceptance-agenda (MedAccept) condition were given the following instructions:

“In a few minutes, you may start to experience some of the effects of breathing the CO₂-enriched air. These sensations may include increased heart rate, dizziness, sweatiness, anxiety, and feeling panicky. The purpose of the guided audio you are about to hear is to allow you to open up to and accept the effects of the CO₂-enriched air. The guided audio should allow you to experience the effects of the CO₂ for what they are, without struggling or resisting them or trying to make the sensations go away. The guided audio is not necessarily designed to make the effects go away, but as a strategy for you to be more open and accepting to experiencing them. Please keep this in mind as you listen to and follow along with the guided audio.”
Participants completed three experimental trials (see Figure 1 for trial progression). Trial 1 involved meditation while breathing normal room air. The purpose of this trial, unbeknownst to the participant, was to have the participant practice implementing the assigned condition instruction. Participants completed the first set of VAS ratings (VAS 1) at the beginning of the trial, which served as a pre-trial baseline. After two minutes, they were asked to complete the second set of VAS ratings (VAS 2). The guided meditation started immediately after participants completed VAS 2. After five minutes, participants completed a third set of VAS ratings (VAS 3). After another five minutes, at the conclusion of the guided meditation, participants completed the fourth set of VAS ratings (VAS 4). At each minute, heart rate and respiratory rate (breaths per minute) were recorded. At the conclusion of each trial, participants were instructed to complete the DSQ. Participants then rested for five minutes before beginning the second trial. Before the start of the second trial, participants were asked to reread the condition instructions.

Trials 2 and 3 were identical (see Figure 1). After completing VAS 1 (i.e., pre-trial baseline), experimenters switched the 3-way valve from normal room air to CO₂-enriched air. After two minutes, participants completed VAS 2. Participants then listened to the guided audio and breathed CO₂-enriched air for five minutes, which was followed by VAS 3. Upon completion of VAS 3, participants were returned to breathing normal room air. Participants listened to the guided meditation for another five minutes. Participants then completed VAS 4. The DSQ was completed after each trial. At each minute, heart rate and respiratory rate (breaths per minute) were recorded. Baseline heart rate and respiratory rate were recorded before the start of the trials. Minutes were kept using a stopwatch, which began after completion of VAS 1. The stopwatch and the CO₂ began at the same time. Thus, in the event of drop out, gas exposure time
was recorded in minutes:seconds. A five-minute break was included between Trial 2 and 3. Before Trial 3, participants were asked to reread the condition instructions as in previous Trials.

If participants signaled to end the procedures during Trial 2, they were given the option to attempt Trial 3. At the end of Trial 3, the experimenter announced the end of the procedure, removed the mask and sensors, and escorted participants to a computer in an adjacent room to complete the post-experimental assessments. Participants were then debriefed.

**Data Reduction and Statistical Analyses**

Owing to the small sample size, the study was significantly underpowered. Thus, the analyses and results should be considered exploratory and interpreted with caution. Several reasons for the small sample size exist, chief among them being that numerous participants discontinued one or both trials involving the CO\textsubscript{2}-enriched air. This further reduced power in repeated-measures analyses that required participants to complete the entirety of the trials (e.g., VAS assessments). Given the reduced power and exploratory nature of the study, observed \( p \) values are reported for all tests rather than using any Bonferroni correction.

In analyses using repeated measures analysis of variance (ANOVA), Greenhouse-Geisser degrees of freedom (\( F_{GG} \)) adjustments were applied to correct for violations of sphericity. Follow-up single degree of freedom contrasts and pairwise \( t \)-tests were used to clarify significant interactions.

Partial eta squared (\( \eta^2 \)) was used as an index of effect size to evaluate approximate variance accounted for by experimental manipulation with the following ranges: small effects \( \eta^2 = .02 \) to \( .12 \), medium effects \( \eta^2 = .12 \) to \( .44 \), and large effects \( \eta^2 > .44 \) (Cohen, 1988). The small sample size introduced numerous issues regarding violation of assumptions inherent to particular
statistical analyses, namely univariate normality. Specific issues, data reduction, and analytic strategies are discussed in the following sections.

**Pre-experiment assessments.** Each calculated pre-experimental measure satisfied the homogeneity of variance assumption based on insignificant Levene’s Tests. Normality assumptions were violated on the WBSI in the Med$_{Ctrl}$ group and the STICSA-State in the Med$_{Accept}$ group. No outliers were found. To evaluate group equivalence prior to the experimental procedure, pre-experimental individual difference (e.g., AAQ-II) variables were tested by condition using one-way ANOVA.

**VAS assessments.** Due to trial discontinuation and drop-out, the sample included in this set of analyses was $n = 12$ in the Med$_{Ctrl}$ group and $n = 9$ in the Med$_{Accept}$ group. Initially, Trial 1 was included in analyses. However, Trial 1 scores were highly correlated with each other, leading to issues with singularity/multicollinearity and an inability to conduct Box’s M test of homogeneity of variance-covariance matrices. To solve this issue, Trial 1 was removed from analyses. To control for Trial 1 scores, Trial 1 VAS scores were subtracted from the corresponding VAS on Trial 2 and 3 (e.g., Trial 2 VAS 1 – Trial 1 VAS 1, Trial 2 VAS 2 – Trial 1 VAS 2, etc.).

Assumption tests were conducted on calculated variables (i.e., after controlling for Trial 1). Distress, Intensity, Fear, Control, Willingness, and Struggle met linearity assumptions based on visual analysis of scatterplots. Box’s M test of homogeneity of variance-covariance matrices did not reach statistical significance ($p$’s > .001) for Distress, Control, Fear, or Struggle suggesting that these variables met homogeneity of variance-covariance assumption. Box’s M test was significant ($p$’s < .001) for Intensity and Willingness. The following variables failed the normality assumption in the Med$_{Ctrl}$ condition: Trial 2 VAS 4 Distress, Trial 3 VAS 4 Distress,
Trial 2 VAS 1 Control, Trial 2 VAS 4 Fear, Trial 3 VAS 4 Fear, Trial 3 VAS 1 Fear, Trial 3 VAS 4 Fear, Trial 2 VAS 1 Willingness, Trial 3 VAS 4 Willingness, Trial 2 VAS 1 Struggle, Trial 2 VAS 3 Struggle, and Trial 3 VAS 1 Struggle. The following variables failed normality assumption in the MedAccept condition: Trial 2 VAS 4 Distress, Trial 3 VAS 4 Distress, Trial 2 VAS 1 Intensity, Trial 2 VAS 3 Intensity, Trial 2 VAS 4 Intensity, Trial 3 VAS 4 Intensity, Trial 2 VAS 4 Control, Trial 3 VAS 4 Control, Trial 2 VAS 4 Fear, Trial 2 VAS 1 Willingness, Trial 3 VAS 4 Willingness, Trial 2 VAS 4 Struggle, Trial 3 VAS 1 Struggle, and Trial 3 VAS 4 Struggle. Given the small sample size and the exploratory nature of the study, transformations were not conducted. No univariate or multivariate outliers were found.

VAS ratings were analyzed using a one-way 2 (Condition: MedAccept vs. MedCntrl) x 2 (Trial: Trial 2 vs. Trial 3) x 4 (Time: VAS 1 – VAS 4) repeated-measures ANOVA.

**DSQ ratings of panicogenic symptoms.** All participants who discontinued a trial completed a DSQ. Thus, all participants are included in the DSQ analyses. Nine participants did not attempt Trial 3 and were excluded from this set of analyses. Severity of cognitive and somatic panicogenic symptoms were calculated by averaging the severity ratings of endorsed symptoms. Symptoms that were not endorsed were not included in calculations.

Each of the DSQ calculated variables (i.e., cognitive severity, somatic severity, overall number of symptoms, frequency of catastrophic thoughts, and frequency of positive thoughts) met linearity assumptions. Further, insignificant Box’s M ($p > .001$) indicated satisfaction of homogeneity of variance-covariance matrices. The following variables failed the normality assumption in the MedCntrl condition: Trial 1 Cognitive Severity, Trial 1 Catastrophic Thoughts, and Trial 2 Positive Thoughts. The following variables failed the normality assumption in the
MedAccept condition: Trial 1 Cognitive Severity, Trial 1 Number of Symptoms, and Trial 1 Catastrophic Thoughts. No univariate or multivariate outliers were found.

DSQ ratings were analyzed using a one-way 2 (Condition: MedAccept vs. MedCtrl) x 3 (Trial: Trial 1 - Trial 3) repeated-measures ANOVA.

Psychophysiological indices. Due to trial discontinuation and dropout, the analyses were conducted on the 12 participants in the MedCtrl group and 9 participants in the MedAccept group. The baseline score for each was subtracted from each minute in the trial. Thus, heart rate and respiratory rate reflects change over corresponding trial baseline. Average heart rate and breathing rate change scores were calculated to correspond with each trial stage, yielding three data points for each trial. For example, the first two minutes wherein participants breathed CO2-enriched air only, the five minutes of combined CO2-enriched air and meditation, and the final five minutes of meditation only were averaged separately and are referred to as Time 1, Time 2, and Time 3, respectively.

Calculated heart rate and respiratory rate variables appeared to meet assumption of homogeneity of variance covariance, Box’s M (p’s > .001). Variables appeared to satisfy assumptions of normality. No univariate or multivariate outliers were found.

Heart and respiratory rates were analyzed using one-way 2 (Condition: MedAccept vs. MedCtrl) x 2 (Trial: Trial 2 vs. Trial 3) x 3 (Time: Time 1 – Time 3) repeated measures ANOVA.

Post-experimental assessments. Each of the variables appeared to satisfy normality assumptions. No outliers were found. Insignificant Levene’s Tests suggest no issues with homogeneity of variance. The homogeneity of residuals assumption in the linear regression appeared satisfied. Analyses of post-experiment assessments were conducted using a one-way
ANOVA. Pre-experiment STICSA scores were entered as a covariate in analyses using the STICSA.

**Results**

**Participant Characteristics - Pre-Experimental Assessment**

Table 1 illustrates means and standard deviations of responses to the pre-experimental questionnaires as a function of experimental condition. As can be seen, pre-experimental individual difference variables did not discriminate between conditions.

Six participants indicated that they had prior meditation experience. Of these, five participants were in the MedCntrl group and one participant was in the MedAccept group. A chi-square test of independence was not significant ($\chi^2 (1, N = 47) = 2.51, p = .11$) indicating that conditions did not differ on meditation experience.

**VAS Assessments**

The following set of analyses relate to hypotheses one and two. The analyses tests interactions and main effects from the 2 (Condition: MedAccept vs. MedCntrl) x 2 (Trial: Trial 2 - Trial 3) x 4 (Time: VAS 1 - VAS 4) repeated-measures ANOVA.

Table 2 displays means and standard deviations for the VAS difference scores in Trial 2 and Trial 3 over VAS scores at Trial 1.

**Distress.** The main effect and interactions involving condition were not significant.

Reported distress on Trial 2 ($M = 17.17, SE = 4.25$) was significantly greater than Trial 3 ($M = 5.30, SE = 4.56$), as supported by the significant main effect of Trial ($F(1,19) = 15.73, p < .001, \eta^2 = .45$).

The main effect of Time was significant ($F_{GG}(2.46,57) = 18.92, p < .001, \eta^2 = .50$). Reported distress was quadratic in nature and increased after the onset of the CO₂-enriched air
(VAS 1 \[M = -9.13, SE = 3.52\] to VAS 2 \[M = 28.49, SE = 5.97\]), remained stable after the meditation began (VAS 2 \[M = 28.49, SE = 5.97\] to VAS 3 \[M = 26.29, SE = 6.24\]), and then decreased during the recovery meditation period (VAS 4 \[M = -.72, SE = 6.24\]) \((F(1,19) = 46.41, p < .001, \eta^2 = .71)\).

The reduced distress on Trial 3 compared to Trial 2 depended on levels of Time as supported by a significant two-way Trial x Time interaction \((F_{GG}(2.64,57) = 6.93, p = .001, \eta^2 = .27)\). To clarify the nature of the two-way interaction, simple main effects of Trial were examined. Distress on VAS 1 \((F(1,19) = 1.36, ns, \eta^2 = .07)\) did not discriminate between Trials. However, participants reported reduced distress on Trial 3 compared to Trial 2 on VAS 2 \((F(1,19) = 15.15, p = .001, \eta^2 = .44)\), VAS 3 \((F(1,19) = 9.23, p < .01, \eta^2 = .33)\), and VAS 4 \((F(1,19) = 7.91, p = .01, \eta^2 = .29)\).

**Intensity.** Though the main effect of condition was not significant \((F(1,19) = .72, p = .41, \eta^2 = .04)\), participants did report greater intensity of bodily sensations on Trial 2 \((M = 19.80, SE = 2.84)\) compared to Trial 3 \((M = 6.89, SE = 3.51)\) as supported by the significant Trial main effect, \((F_{GG}(1,19) = 28.02, p < .001, \eta^2 = .60)\).

The main effect of Time was also significant \((F_{GG}(2.75,57) = 18.43, p < .001, \eta^2 = .49)\). As with distress ratings, the pattern of reported intensity of bodily sensations was quadratic such that intensity ratings increased from VAS 1 \((M = -5.17, SE = 2.67)\) to VAS 2 \((M = 27.97, SE = 5.34)\), remaining stable at VAS 3 \((M = 27.36, SE = 5.04)\), before decreasing at VAS 4 \((M = 3.22, SE = 4.48)\) \((F(1,19) = 53.00, p < .001, \eta^2 = .74)\).

Time varied by condition over trials as supported by a significant three-way Condition x Trial x Time interaction \((F_{GG}(2.40,57) = 3.12, p < .05, \eta^2 = .14)\). To further clarify the nature of
the three-way interaction, simple two-way Condition x Time interactions were examined at levels of Trial.

The simple two-way Condition x Time interaction was significant for Trial 2 ($F_{GG}(2.9,57) = 3.90$, $p = .01$, $\eta^2 = .17$) but not Trial 3 ($F_{GG}(2.43,57) = .60$, $p = .58$, $\eta^2 = .03$). To clarify further, interaction contrasts were examined. The between group difference in change from VAS 2 to VAS 3 was significant in Trial 2 such that participants in the Med_Cntrl group reported an increase in intensity of bodily sensations whereas participants in the Med_Accept group reported a decrease in intensity; however, participants in both groups reported lower stable intensity ratings across VAS 2 and VAS 3 on Trial 3. This is supported by a significant simple two-way Condition x Time interaction contrast of VAS 2 and VAS 3 on Trial 2 ($F(1,19) = 7.78$, $p = .01$, $\eta^2 = .29$), but not on Trial 3 ($F(1,19) = .20$, $ns$, $\eta^2 = .01$). Further, participants in the Med_Cntrl condition reported greater intensity of bodily reactions on VAS 3 of Trial 2 compared to their counterparts as supported by a simple main effect of condition ($F(1,19) = 9.71$, $p < .01$, $\eta^2 = .34$). Conditions did not differ on VAS 3 on Trial 3, nor did conditions differ at the conclusion (VAS 4) of Trial 2 or Trial 3.

Participants in the Med_Cntrl condition reported significant reductions in intensity of bodily sensations from Trial 2 to Trial 3 on VAS 2 ($M_{Diff} = 18.50$, $SE = 8.13$, $t(19) = 2.28$, $p = .04$), VAS 3 ($M_{Diff} = 31.50$, $SE = 6.90$, $t(19) = 4.57$, $p < .001$), and VAS 4 ($M_{Diff} = 10.58$, $SE = 4.48$, $t(19) = 2.36$, $p = .03$). In contrast, participants in the Med_Accept condition only reported significant reduction in intensity from Trial 2 to Trial 3 on VAS 2 ($M_{Diff} = 29.33$, $SE = 9.39$, $t(19) = 3.12$, $p < .01$).

**Fear.** Interactions and the main effect involving condition were not significant.
Participants reported greater levels of fear during Trial 2 ($M = 15.52$, $SE = 4.66$) compared to Trial 3 ($M = 5.28$, $SE = 5.52$), as supported by the significant Trial main effect, $(F(1,19) = 10.20, p < .01, \eta^2 = .35)$.

The main effect of Time was also significant $(F(2.40,57) = 16.66, p < .001, \eta^2 = .47)$ and again quadratic in nature $(F(1,19) = 33.52, p < .001, \eta^2 = .64)$. Participants reported increasing fear from VAS 1 ($M = -7.92$, $SE = 3.48$) to VAS 2 ($M = 22.74$, $SE = 6.81$), stability through VAS 3 ($M = 22.97$, $SE = 6.40$), and decreasing fear in VAS 4 ($M = 3.79$, $SE = 6.00$).

In general, participants reported less fear on Trial 3 compared to Trial 2 dependent on level of Time, supported by a significant two-way Trial x Time interaction $(F_{GG}(2.41,57) = 4.07, p = .02, \eta^2 = .18)$. To clarify the nature of the interaction, simple main effects of Trial were examined at levels of Time. Participants reported similar levels of fear across trials on VAS 1 $(F(1,19) = .27, ns, \eta^2 = .01)$. Conversely, participants reported statistically greater fear in Trial 2 compared to Trial 3 on VAS 2 $(F(1,19) = 7.43, p = .01, \eta^2 = .28)$, VAS 3 $(F(1,19) = 6.55, p = .02, \eta^2 = .26)$, and VAS 4 $(F(1,19) = 9.58, p < .01, \eta^2 = .36)$.

**Control.** Main effects and interactions involving condition were not significant.

Not surprisingly, participants reported an overall greater sense of control on Trial 3 ($M = 9.69$, $SE = 3.39$) compared to Trial 2 ($M = 19.72$, $SE = 3.10$) as evidenced by a significant main effect of Trial $(F(1,19) = 14.00, p = .001, \eta^2 = .42)$.

The main effect for Time was also significant $(F_{GG}(2.56,57) = 16.46, p < .001, \eta^2 = .46)$ and again appeared quadratic $(F(1,19) = 32.40, p < .001, \eta^2 = .63)$. Participants reported a reduced sense of control from VAS 1 ($M = -2.02$, $SE = 2.23$) to VAS 2 ($M = 32.09$, $SE = 5.11$), stability through VAS 3 ($M = 26.48$, $SE = 5.48$), and an increasing sense of control by VAS 4 ($M = 2.77$, $SE = 5.10$).
The two-way Trial x Time interaction was not significant \( (F_{GG}(1.69,57) = 2.84, \text{ ns}, \eta^2 = .13) \).

**Willingness.** Main effects and interactions of both Condition and Trial were not significant.

In general, participants reported increasing unwillingness from VAS 1 \((M = -5.90, SE = 5.00)\) to VAS 2 \((M = 18.31, SE = 7.03)\), stability through VAS 3 \((M = 21.17, SE = 6.29)\), and improved willingness scores on VAS 4 \((M = 3.91, SE = 5.93)\). This is supported by a significant main effect for Time \( (F_{GG}(1.69,57) = 5.26, p = .01, \eta^2 = .22) \). Further, the quadratic pattern was significant \( (F(1,19) = 6.59, p = .02, \eta^2 = .26) \).

**Struggle.** The main effect and interactions involving Condition were not significant.

The main effect of Trial was significant \( (F(1,19) = 9.14, p < .01, \eta^2 = .33) \). Participants reported greater levels of struggle on Trial 2 \((M = 21.75, SE = 2.15)\) compared to Trial 3 \((M = 10.75, SE = 4.03)\).

The main effect of Time was also significant \( (F_{GG}(2.47,57) = 30.51, p < .001, \eta^2 = .62) \) and quadratic in shape \( (F(1,19) = 53.28, p < .001, \eta^2 = .74) \). Similar to the patterns observed previously, participants reported increasing struggle from VAS 1 \((M = -9.16, SE = 2.65)\) to VAS 2 \((M = 36.51, SE = 5.14)\), stability at VAS 3 \((M = 34.69, SE = 5.31)\), and attenuation of struggle at VAS 4 \((M = 2.96, SE = 4.29)\).

Participants, regardless of condition, reported less struggle on Trial 3 compared to Trial 2 dependent on level of Time as supported by a significant two-way Trial x Time interaction \( (F_{GG}(2.88,57) = 4.40, p = .01, \eta^2 = .19) \). Extent of struggle did not discriminate between Trial 2 and Trial 3 on VAS 1 \( (F(1,19) = .45, \text{ ns}, \eta^2 = .02) \) and VAS 4 \( (F(1,19) = 2.17, \text{ ns}, \eta^2 = .10) \).
Attenuation of struggle occurred on Trial 3 compared to Trial 2, but only on VAS 2 \( F(1,19) = 12.30, p < .01, \eta^2 = .39 \) and VAS 3 \( F(1,19) = 4.69, p = .04, \eta^2 = .20 \).

**DSQ Panicogenic Symptom Assessments**

The following analyses evaluated the impact of condition on DSQ panic domains using a series of one-way repeated measures ANOVAs, with condition serving as the between subjects factor and Trial as the within-subjects repeated measures factor with 3 levels. These analyses relate to hypothesis three. See Table 3 for means and standard deviations for DSQ response domains for Trials 1, 2, and 3.

**Number of panicogenic symptoms.** The top five symptoms endorsed across conditions were the same for Trial 2 and Trial 3: pounding or racing heart (Trial 2: 93.6%; Trial 3: 78.9%), breathlessness or a smothering sensation (Trial 2: 91.5%; Trial 3: 73.7%), sensation of panic or fear (Trial 2: 91.5%; Trial 3: 57.9%), dizziness, lightheadedness, or unsteadiness (Trial 2: 87.2%; Trial 3: 78.9%), and sweatiness (Trial 2: 76.6%, Trial 3: 63.2%).

The number of endorsed panic symptoms did not vary by condition. However, total symptoms endorsed did vary by Trial \( F_{GG}(1.65,36) = 36.29, p < .001, \eta^2 = .50 \). Overall, participants endorsed more symptoms on Trial 2 compared to Trial 1 \( M_{Diff} = -6.36, SE = .64, t(37) = -9.94, p < .001 \), and fewer symptoms on Trial 3 compared to Trial 2 \( M_{Diff} = 2.40, SE = .69, t(37) = 3.51, p = .001 \).

**Severity of cognitive panicogenic symptoms.** Severity of cognitive panicogenic symptoms did not discriminate between conditions, but it did differ across Trials, \( F_{GG}(1.94,36) = 24.46, p < .001, \eta^2 = .41 \). As one might expect, participants reported more severe cognitive panicogenic symptoms on Trial 2 compared to Trial 1 \( M_{Diff} = 3.27, SE = .43, t(37) = 7.67, p < .001 \) and
and less severe cognitive symptoms on Trial 3 compared to Trial 2 ($M_{\text{Diff}} = -1.41$, $SE = .49$, $t(37) = -2.88$, $p < .01$).

**Severity of somatic panicogenic symptoms.**

Severity of somatic panicogenic symptoms did not discriminate between conditions, but it did differ across Trials, ($F_{GC}(1.83,36) = 42.44$, $p < .001$, $\eta^2 = .54$). Again, participants reported more severe somatic panicogenic symptoms on Trial 2 compared to Trial 1 ($M_{\text{Diff}} = 3.22$, $SE = .29$, $t(37) = 11.10$, $p < .001$) and less severe somatic symptoms on Trial 3 compared to Trial 2 ($M_{\text{Diff}} = -1.27$, $SE = .37$, $t(37) = -3.43$, $p < .01$).

**Frequency of catastrophic thoughts.** Again, frequency of catastrophic thoughts did not discriminate between conditions, but it did vary by Trial, ($F_{GC}(1.67,36) = 33.57$, $p < .001$, $\eta^2 = .48$). Participants reported more catastrophic thoughts on Trial 2 compared to Trial 1 ($M_{\text{Diff}} = 3.03$, $SE = .33$, $t(37) = 9.18$, $p < .001$) and fewer catastrophic thoughts on Trial 3 compared to Trial 2 ($M_{\text{Diff}} = -1.28$, $SE = .33$, $t(37) = -3.88$, $p < .001$).

**Frequency of positive thoughts.** Number of positive thoughts did not differ between conditions. However, participants reported fewer positive thoughts on Trial 2 compared to Trial 1 ($M_{\text{Diff}} = -2.67$, $SE = .30$, $t(37) = -8.90$, $p < .001$), and more positive thoughts on Trial 3 compared to Trial 2 ($M_{\text{Diff}} = 1.06$, $SE = .24$, $t(37) = 4.42$, $p < .001$), as supported by the significant main effect for Trials, ($F_{GC}(1.55,36) = 36.74$, $p < .001$, $\eta^2 = .51$).

**Psychophysiological Indices**

The following set of analyses evaluated the impact of condition on psychophysiological indices (heart rate and respiration rate) in a one-way 2 (Condition: MedAcpt vs. MedCnt) x 2 (Trial: Trial 2/Trial 3) x 3 (Time: Time 1 – Time 3) repeated measures ANOVA, with Trials and Time serving as within-subject factors. These analyses relate to hypothesis three.
Table 4 displays means and standard deviations for heart rate and respiratory rate change over baseline.

**Heart rate.** Though the main effect for condition was not significant ($F(1,19) = .10, ns, \eta^2 = .01$), the main effect of trial was significant ($F(1,19) = 8.89, p < .01, \eta^2 = .32$). Participants reported a significantly greater increase in heart rate over baseline in Trial 2 ($M = 14.02, SE = 2.49$) compared to Trial 3 ($M = 8.28, SE = 1.72$) ($M_{diff} = 5.74, SE = 1.93, t(20) = 2.98, p < .01$).

Heart rate changed significantly across Time as supported by a significant main effect of Time ($F_{GG}(1.97,38) = 4.83, p = .01, \eta^2 = .20$). The pattern of change was quadratic such that heart rate increased after the onset of the guided meditation + CO2-enriched air (i.e., Time 2) and subsequently decreased during meditation + room air (i.e., Time 3) ($F(1,19) = 9.22, p < .01, \eta^2 = .33$).

Condition appeared to effect the pattern of heart rate change as supported by a significant two-way Condition x Time interaction ($F_{GG}(1.97,38) = 4.95, p = .01, \eta^2 = .21$). To clarify the nature of the interaction, single degree of freedom contrasts were examined. Participants in the MedCtrl group showed an increase in heart rate after the onset of the meditation + CO2 (i.e., Time 1 [$M = 8.72, SE = 2.31$] to Time 2 [$M = 15.16, SE = 2.36$]) and a decrease in heart rate during meditation + room air (i.e., Time 3 [$M = 11.39, SE = 2.47$]). In contrast, participants in the MedAccept group showed no differences in change in heart rate after the onset of the meditation + CO2 (i.e., Time 1 [$M = 12.93, SE = 2.67$] to Time 2 [$M = 12.16, SE = 3.88$]) and a decrease in heart rate after returning to breathing normal room air during meditation (Time 3 [$M = 6.53, SE = 2.85$]). The difference in pattern is supported by a significant two-way Condition x Time linear interaction contrast ($F(1,19) = 7.95, p = .01, \eta^2 = .30$). This is further supported by the simple main effect of Time within Condition in which the pattern of heart rate change was
quadratic in the MedCntrl group ($F(1,19) = 9.88, p < .01, \eta^2 = .34$), whereas for the MedAccept group the change in heart rate showed a decreasing linear trend over time ($F(1,19) = 6.93, p = .02, \eta^2 = .27$).

Heart rate increased significantly from Time 1 to Time 2 in the MedCntrl group ($M_{Diff} = 6.44, SE = 1.99, t(11) = 3.23, p < .01$); however, heart rate change from Time 2 to Time 3 was not significant ($M_{Diff} = 3.77, SE = 1.88, t(11) = 2.01, ns$). Even after the flow of CO$_2$-enriched air ceased (i.e., Time 3), participants in the MedCntrl group did not evidence heart rate change that was different from when they were only breathing the CO$_2$ air (Time 1) ($M_{Diff} = 2.67, SE = 2.10, t(11) = 1.27, ns$).

The stability in heart rate change in the MedAccept group after the onset of the guided meditation is supported by a nonsignificant pairwise comparison of Time 1 and Time 2 ($M_{Diff} = .77, SE = 2.30, t(8) = .33, ns$). The decrease in heart rate during the meditation only portion (Time 3) was significant ($M_{Diff} = -5.63, SE = 2.17, t(8) = 2.60, p = .02$). Participants in the MedAccept group showed a significantly lower heart during the meditation only portion (Time 3) when compared to only breathing CO$_2$-enriched air (Time 1) ($M_{Diff} = -6.40, SE = 2.43, t(8) = 2.63, p = .02$). Finally, groups did not differ in heart rate change over baseline at Time 1, Time 2, or Time 3.

No other effects were significant.

**Respiration rate.** Main effects and interactions involving Condition were not significant. Though the main effect of Trial was not significant, there was a significant Time main effect, ($F_GG(1.44,38) = 6.76, p < .01, \eta^2 = .26$). Overall, respiration rate increased in a linear fashion, as supported by a significant linear contrast of Time ($F(1,19) = 10.60, p < .01, \eta^2 = .36$).
No other effects were significant.

**Trial Discontinuation and Drop Out**

This set of analyses relate to the fourth hypothesis. The rate of discontinuation during one or more trials was high. No participants discontinued Trial 1. In Trial 2, 12 participants (48%) in the MedCntrl group discontinued; 9 participants (41%) in the MedAccept group discontinued. During Trial 3, four participants (16%) in the MedCntrl group refused to attempt the trial and five participants (20%) discontinued the trial. For this group, three participants who refused Trial 3 had discontinued Trial 2. In addition, four participants who discontinued Trial 2 completed Trial 3 in its entirety.

Concerning the MedAccept group in Trial 3, five participants (23%) did not attempt the trial and six (27%) discontinued the trial. Two of the participants who did not attempt Trial 3 had discontinued Trial 2. Further, two participants who discontinued Trial 2 completed Trial 3 in its entirety. Finally, one participant who completed Trial 2 discontinued Trial 3.

The range of times for discontinuation in the MedCntrl group in Trial 2 was 0:44 sec to 6:35 min. The mean time of discontinuation in this group was 2:37 min for Trial 2, coinciding with the completion of VAS 2, before the guided meditation began. The range of times for discontinuation in the MedAccept group in Trial 2 was 1:00 to 5:07 min. The mean time of discontinuation for Trial 2 was 2:26 min, occurring at or just before the completion of VAS 2 and before the guided audio began.

The range of time for discontinuation of Trial 3 in the MedCntrl group (not including those who refused Trial 3) was 1:10 to 5:50 min with a mean time of 3:31 min. The average discontinuation time coincides with having listened to the guided audio for approximately 45-55 seconds before discontinuing. The range of time for discontinuation of Trial 3 in the MedAccept
group (not including those who refused Trial 3) was 0:57 sec to 3:55 min with a mean time of 2:45 min. The average time of discontinuation for this group coincided just before, or a few seconds into, the guided audio.

A chi-square test of independence was performed to examine the relation between treatment group and discontinuation/drop out in Trial 2, Trial 3, and overall (discontinuation/drop out of one or both trials). The relation between treatment group and discontinuation of Trial 2 was not significant ($\chi^2(1, N = 47) = .24, p = .63$). Additionally, the relation between treatment group and discontinuation and refusal of Trial 3 was not significant ($\chi^2(1, N = 47) = .94, p = .33$). Overall, the relation between treatment group and discontinuation/drop out of one or both trials was not significant ($\chi^2(1, N = 47) = .24, p = .63$).

Groups did not differ on time of discontinuation in Trial 2 ($F(1,15) = .04, ns, \eta^2 = .00$) or Trial 3 ($F(1,10) = .74, ns, \eta^2 = .07$).

As a follow-up set of analyses, a series of linear regressions were conducted with the pre-experiment measures predicting time of CO$_2$-enriched air exposure. None of the pre-experiment measures predicted amount of time exposed to CO$_2$-enriched air.

**Post-Experiment Assessments**

The following analyses tests hypothesis five.

**State anxiety (STICSA-State).** After controlling for pre-experiment levels of anxiety, participants in the Med$_{Ctrl}$ group ($M = 40.08, SD = 11.68$) did not differ from participants in the Med$_{Accept}$ group ($M = 37.68, SD = 11.98$) on overall post-experiment anxiety ($F(1,46) = .09, ns, \eta^2 = .00$).

Further, participants in the Med$_{Ctrl}$ group did not differ in post-experimental levels of somatic ($M = 22.44, SD = 7.04$) or cognitive anxiety ($M = 17.64, SD = 5.71$) compared to their
MedAccept counterparts (somatic: $M = 21.50$, $SD = 9.47$; cognitive: $M = 16.18$, $SD = 5.58$) after controlling for pre-experiment levels (somatic: $F(1,46) = .05$, $ns$, $\eta^2 = .00$; cognitive: $F(1,47) = .04$, $ns$, $\eta^2 = .00$).

**Effectiveness of meditation.** Though participants in the MedAccept group ($M = 5.09$, $SD = 2.33$) rated the guided audio as slightly more effective than their MedCntrl group counterparts ($M = 3.84$, $SD = 2.29$), the difference was not significant ($F(1,46) = 3.45$, $ns$, $\eta^2 = .07$).

**Clarity of instructions.** On average, both groups reported that the condition-specific instructions were at least “very clear” (MedCntrl: $M = 7.40$, $SD = 2.20$; MedAccept: $M = 8.05$, $SD = 1.43$). The difference was not statistically significant ($F(1,46) = 1.38$, $ns$, $\eta^2 = .03$).

**Ease of following guided meditation.** Participants in the MedAccept group ($M = 5.77$, $SD = 1.82$) found the guided audio slightly easier to follow compared to their counterparts in the MedCntrl group ($M = 5.00$, $SD = 2.22$). However, the difference was not statistically significant ($F(1,46) = 1.67$, $ns$, $\eta^2 = .04$).

**Recommend strategy to a friend.** On average, participants in the MedAccept group ($M = 5.82$, $SD = 1.94$) indicated that they were slightly more likely to recommend their condition-specific strategy to a friend when compared to participants in the MedCntrl group ($M = 4.72$, $SD = 1.84$). However, this difference was not significant ($F(1,46) = 3.96$, $ns$, $\eta^2 = .08$).

**Willingness to repeat experiment.** On average, participants in the MedAccept group ($M = 3.55$, $SD = 2.60$) were slightly more willing to repeat the experimental procedures compared to participants in the MedCntrl group ($M = 3.24$, $SD = 2.45$). However, the difference was not statistically significant ($F(1,46) = .17$, $ns$, $\eta^2 = .00$).

**Exploratory Analyses**
The following set of analyses were conducted due to the low power of the study. Between group pairwise t-tests were examined on difference scores to explore specific hypotheses.

**Contribution of meditation.** The following analyses examine the contribution of meditation on the subjective experience of inhaling the CO$_2$-enriched air. To achieve this aim, VAS 2 (i.e. the period of only breathing CO$_2$-enriched air) was subtracted from VAS 3 (i.e. combined meditation and CO$_2$-enriched air). A t-test was then conducted separately for each VAS rating to evaluate between group differences on change from VAS 2 to VAS 3. Trial 2 and Trial 3 were tested separately.

Because the three-way Condition x Trial x Time interaction and related contrasts were significant with the Intensity variable (see above), analyses of this variable are not repeated here.

**Distress.** On Trial 2, condition appeared to impact subjective distress elicited by the CO$_2$-enriched air after the meditation began. Participants in the Med$_{Accept}$ group reported a reduction in distress after the meditation began ($M_{Diff} = -20.00$, $SD = 32.40$). In contrast, participants in the Med$_{Cntrl}$ group reported an increase in distress ($M_{Diff} = 6.92$, $SD = 18.01$). This difference in differences was significant ($t(19) = 2.43$, $p = .03$).

On Trial 3, groups did not differ on change in distress between VAS 2 and VAS 3 (Med$_{Accept}$: $M_{Diff} = 2.11$, $SD = 15.90$; Med$_{Cntrl}$: $M_{Diff} = 2.17$, $SD = 16.31$; $t(19) = .01$, ns).

**Fear.** On Trial 2, participants in the Med$_{Accept}$ group reported a reduction in fear after the meditation began ($M_{Diff} = -7.11$, $SD = 27.28$) and participants in the Med$_{Cntrl}$ ($M_{Diff} = 2.92$, $SD = 21.69$) reported a slight increase; however, the difference in differences was not significant ($t(19) = .94$, ns).
On Trial 3, participants in both groups reported a slight increase in fear after the meditation began (MedAccpt: \( M_{\text{Diff}} = 3.00, SD = 15.02 \); MedCntrl: \( M_{\text{Diff}} = 2.17, SD = 20.24 \)). The difference in differences was not significant (\( t(19) = -.10, ns \)).

**Control.** On Trial 2, participants in the MedAccpt group (\( M_{\text{Diff}} = -16.22, SD = 39.53 \)) reported a greater sense of control after the meditation began. Participants in the MedCntrl group reported a small decrease in control after the onset of the meditation began (\( M_{\text{Diff}} = -1.83, SD = 37.74 \)). However, the difference in differences was not significant (\( t(19) = .85, ns \)).

On Trial 3, participants in MedAccpt group (\( M_{\text{Diff}} = -5.22, SD = 17.47 \)) reported a greater sense of control after the onset of meditation. Participants in the MedCntrl reported stable sense of control after the onset of meditation (\( M_{\text{Diff}} = .83, SD = 15.52 \)). The difference in differences was not significant (\( t(19) = .84, ns \)).

**Willingness.** On Trial 2, participants in the MedAccpt group (\( M_{\text{Diff}} = -23.78, SD = 36.17 \)) reported greater willingness after on the onset of the meditation, whereas participants in the MedCntrl (\( M_{\text{Diff}} = 20.08, SD = 23.20 \)) reported less willingness. The difference in differences was significant (\( t(19) = 3.39, p < .01 \)).

On Trial 3, both groups reported increases in willingness scores after the onset of the meditation (MedAccpt: \( M_{\text{Diff}} = 13.58, SD = 35.46 \); MedCntrl: \( M_{\text{Diff}} = 1.56, SD = 16.12 \)). The difference in differences was not significant (\( t(19) = .94, ns \)).

**Struggle.** On Trial 2, participants in the MedAccpt group (\( M_{\text{Diff}} = -14.78, SD = 36.44 \)) reported a reduction in struggle after the onset of the meditation. In contrast, their control counterparts reported a slight increase in struggle (\( M_{\text{Diff}} = 2.00, SD = 27.83 \)). However, the difference in differences was not significant (\( t(19) = 1.20, ns \)).
On Trial 3, participants in the MedAccpt group reported an increase in struggle after the meditation began ($M_{\text{diff}} = 1.44, SD = 16.68$). Participants in the MedCntrl group also reported an increase in struggle ($M_{\text{diff}} = 4.08, SD = 24.99$). The difference in differences was not significant ($t(19) = .27, ns$).

**Group differences in rate of recovery.** The following set of analyses examine group differences in recovery from the effects of the CO$_2$-enriched air. VAS 1 was subtracted from VAS 4 to calculate difference scores. The difference scores represent change from baseline. $T$-tests were conducted to explore between group differences on recovery over baseline.

All six VAS variables were included in this set of analyses.

**Distress.** On Trial 2, participants in the MedAccpt group reported a greater reduction in distress from baseline ($M_{\text{diff}} = 9.33, SD = 27.10$) compared to the MedCntrl group ($M_{\text{diff}} = 24.25, SD = 38.48$). However, the difference was not significant ($t(1,19) = .99, ns$).

A similar pattern emerged on Trial 3. Participants in the MedAccpt group showed a greater reduction in distress ($M_{\text{diff}} = -4.78, SD = 46.86$) compared to the MedCntrl group ($M_{\text{diff}} = 4.83, SD = 31.55$). However, this difference was not statistically significant ($t(19) = .56, ns$).

**Intensity.** On Trial 2, participants in the MedAccpt group reported less intense bodily sensations at the end of the trial ($M_{\text{diff}} = 7.56, SD = 25.37$) compared to participants in the MedCntrl group ($M_{\text{diff}} = 16.67, SD = 38.61$). However, the difference was not significant ($t(19) = .61, ns$).

On Trial 3, a similar pattern emerged. The MedAccpt group reported lower intensity of bodily sensations ($M_{\text{diff}} = 2.89, SD = 19.76$) compared to the MedCntrl group ($M_{\text{diff}} = 6.42, SD = 26.14$). The difference was not significant ($t(19) = .34, ns$).
Fear. Participants in both groups reported similar levels of fear at the end of Trial 2 (MedAccept: $M_{Diff} = 16.44, SD = 34.48$; MedCntrl: $M_{Diff} = 20.83, SD = 31.43$). The difference was not significant ($t(19) = .30, ns$).

On Trial 3, participants in the MedAccept reported a greater reduction in fear from baseline ($M_{Diff} = -5.11, SD = 29.46$) compared to participants in the MedCntrl group ($M_{Diff} = 14.67, SD = 15.39$). Nonetheless, the difference was not significant ($t(19) = 2.00, ns$).

Control. Participants in the MedAccept group reported a greater sense of control on Trial 2 ($M_{Diff} = 3.11, SD = 26.87$) compared to participants in the MedCntrl group ($M_{Diff} = 13.33, SD = 25.59$). However, the difference was not significant ($t(19) = .89, ns$).

On Trial 3, participants in both groups evidenced similar levels of control (MedAccept: $M_{Diff} = -1.44, SD = 21.28$; MedCntrl: $M_{Diff} = 4.17, SD = 22.56$). The difference was not significant ($t(19) = .58, ns$).

Willingness. On Trial 2, participants in the MedAccept group reported more willingness ($M_{Diff} = -6.44, SD = 24.25$) compared to those in the MedCntrl group ($M_{Diff} = 28.25, SD = 31.74$). The difference was statistically significant ($t(19) = 2.73, p = .01$).

A similar pattern emerged on Trial 3. Participants in the MedAccept group reported significantly greater willingness scores ($M_{Diff} = -7.33, SD = 27.44$) compared to those in the MedCntrl group ($M_{Diff} = 24.75, SD = 25.31$) ($t(19) = 2.72, p = .01$).

Struggle. On Trial 2, participants in the MedCntrl group reported significantly greater struggle with experience at the end of the trial ($M_{Diff} = 30.25, SD = 26.79$) compared to those in the MedAccept group ($M_{Diff} = 4.22, SD = 26.79$) ($t(19) = 2.20, p = .04$).

A similar pattern emerged on Trial 3 (MedCntrl: $M_{Diff} = 13.00, SD = 25.20$; MedAccept: $M_{Diff} = 1.00, SD = 26.62$). However, the difference was not statistically significant ($t(19) = 1.05, ns$).
Discussion

As practicing mindfulness meditation has gained popularity in Western culture and psychotherapeutic interventions, a focus on the benefits of practice may result in the use of mindfulness meditation as a strategy to avoid or control unwanted private events. A large body of research in thought control and emotion science tell us that attempts to suppress or control unwanted experiences may result in more unwanted experiences; thus, application of mindfulness meditation as a strategy to control unwanted private events may have iatrogenic consequences. In fact, emerging research suggests mindfulness meditation may not be beneficial for all, resulting in adverse effects. The current study is the first of its kind to explore the issue of how meditation is used. This study examined the effects of manipulating a rationale for using a standardized mindfulness meditation while undergoing a panicogenic provocation. Participants were meditation-naïve and randomized to either a control-based context group or an acceptance-based context group. Groups did not differ on assessed demographics and individual difference variables that are known to covary with anxiety-related distress (e.g., experiential avoidance, anxiety sensitivity). A small initial sample size and subsequent attrition rate rendered the study underpowered, thus precluding robust tests of the main study hypotheses. Because of this, results should be interpreted with caution.

Summary of Main Findings

Consistent with evidence supporting the use of acceptance-based strategies with anxiety and related forms of distress (e.g. Arch & Craske, 2006; Feldner et al., 2006; Levitt et al., 2004), including work highlighting acceptance as an integral component to mindfulness-based practices (e.g. Eifert & Forsyth, 2013; Kabat-Zinn, 1994; Roemer & Orsillo, 2009) we hypothesized that participants given an acceptance rationale for mindfulness meditation during an experience of
acute panicogenic distress would report lower distress, fear and anxiety, and struggle with experience, greater willingness and sense of control, and no difference in intensity of bodily sensations compared to those using mindfulness as an experiential control strategy. This hypothesis was not supported.

Condition did not discriminate responses to the CO₂-enriched air based on nonsignificant interactions or main effects of condition across most of the assessed VAS ratings. The only exception to this general observation was for intensity of bodily reactions to the enriched air.

Participants who practiced meditation with a control agenda reported an increase over baseline in how they perceived the intensity of their bodily sensations during enriched-air inhalation in Trial 2 (i.e., the segment that included CO₂-enriched air inhalation and meditation). In contrast, participants who practiced meditation with an acceptance rationale reported a decrease over baseline in intensity of bodily sensations during the same epoch. Nonetheless, this pattern was not replicated on Trial 3.

The results differ from previous studies showing decreases in fear and anxiety in acceptance-based rationales compared to suppression or other control strategies (Ainsworth et al., 2015; Eifert & Heffner, 2003; Levitt et al., 2004). Further, previous research suggests acceptance strategies lead to reduced distress compared to suppression (Marcks & Woods, 2005; Masedo & Esteve, 2006).

The current results are consistent with previous research in emotion suppression literature suggesting that suppression of negative emotions does not reduce negative affect (Gross 1998; Gross & Levenson, 1993, 1997; John & Gross, 2004). However, the main effect of time, with a quadratic pattern, on the VAS measures combines both conditions. One possibility is, despite being given an acceptance rationale, participants attempted to suppress responses without
success. Unfortunately, we did not evaluate use of such strategies explicitly. Yet, the extant literature suggests that participants are able to use and adapt an acceptance rationale when instructed to do so in a laboratory context (Ainsworth et al., 2015; Eifert & Heffner, 2003; Levitt et al., 2004). Nonetheless, applying acceptance in the context of a highly aversive emotional event requires skillful use of acceptance-strategies, and thus more practice may be needed for effects of practice to be realized. As such, the benefits of acceptance may not emerge after a session or two of practice. Yet another possible explanation is the manipulation may have overshadowed any benefits of acceptance and the known iatrogenic effects of suppression. Thus, any distinction between strategies used during mindfulness may have been eclipsed by the highly aversive nature of the CO₂-enriched air challenge itself. Indeed, the trial and time main effects show robust potentiation in distress at the first trial of CO₂ exposure, and thereafter some habituation by the second inhalation trial. Moreover, the high dropout/discontinuation rate in the current sample may serve as evidence that the manipulation was too potent. Here again, it is important to be mindful that the study was too under powered to detect differences, and thus such alternative explanations ought be held lightly awaiting further research.

The increase in reported intensity of bodily reactions in the control agenda group and the decrease in reported intensity in the acceptance agenda group during the combined enriched air and meditation on Trial 2 differs from previous research suggesting no differences in self-reported intensity of physical reactions (Eifert & Heffner, 2003). The discrepancy in results between this study and that of Eifert & Heffner (2003) may be a function of differences in acceptance strategies between the two studies. In Eifert and Heffner’s (2003) study, participants in the acceptance group were taught a common ACT experiential exercise using a Chinese finger trap. The function of this exercise is to show that leaning into and accepting experience creates
the necessary space to experience aversive private events without fighting them. While an acceptance-based rationale for mindfulness meditation is similar with regards to resisting fighting experience, the rationale in the current study also encouraged participants to observe their bodily reactions. The additional instruction to observe may facilitate a defused perspective of the self as a context in which bodily sensations occur, leading to a more dispassionate stance towards experience. Instruction to lean into and accept experience may not facilitate a more distant perspective, but rather focuses more generally on the acceptance of experience. Thus, a more distant perspective (i.e., defused, view of self-as-context; see Hayes et al., 2012) may lead to participants perceiving panicogenic bodily sensations as less intense than those instructed to lean into and accept bodily sensations. The discrepancy may also be due to differences in measuring perceived intensity of bodily sensations. Eifert and Heffner (2003) measured self-reported intensity of physical reactions using the DSQ after the trial. The current study measured intensity using a single VAS measure during the experiment, though the DSQ was also included.

Nonetheless, the current findings add to the literature supporting the use of mindfulness as an acceptance strategy. Mindful observation of unwanted bodily sensations may facilitate a dispassionate stance towards experience of the sensations, reducing their perceived importance and threat-evoking functions. If individuals perceive unwanted private events as less intense, they may be less likely to engage in strategies aimed at altering their form. As such, individuals may be more likely to behave flexibly in the presence of unwanted private events. As observed in the current study, the reduction in intensity of bodily sensations in the acceptance group compared to the control-agenda group during meditation supports this claim.

The second hypothesis was not supported. Participants in the control-based group did not show delayed recovery in psychological indices of distress at the end of each trial compared to
the acceptance-based group, nor did the control-context group evidence a rebound effect. Previous research suggests that individuals who suppress internal experience exhibit a slower recovery, indicated by elevated post-experiment measures (Campbell-Sills et al., 2006b; Matthies et al., 2014; Tull et al., 2010), and show a rebound in emotional responding following suppression (Cioffi & Holloway, 1993; Masedo & Esteve, 2006). Though the means were higher for the control-context group compared to the acceptance group on distress and intensity on Trial 2, and distress and fear on Trial 3, indicating slower recovery, the current study simply may have been too underpowered to detect reliable differences.

Overall, VAS scores on Trial 3 were lower compared to Trial 2, regardless of condition. The significant reduction of scores in several variables on Trial 3 is perplexing in the context of potentiated responding to the first CO2-exposure (i.e., Trial 2) and given the pattern of partial trial discontinuations and dropouts. Though evidence from this study supports the panicogenic properties of the CO2 challenge itself, the pattern of attenuated responding from Trial 2 to Trial 3 suggests habituation. Previous research has suggested that participants do not habituate to inhalations of CO2-enriched air within a single experimental session but do tend to habituate to CO2-enriched air across multiple experimental sessions over time (Forsyth, Lejuez, & Finlay, 2000). Of note, the present study used half the level carbon dioxide-enriched air for a prolonged period of time. The difference in concentration and time exposure may explain the apparent habituation effects observed in the current study. Nonetheless, previous research suggests that suppression inhibits habituation to unwanted thoughts (Gold & Wegner, 1995; Wegner, 1994). Further research may aim to clarify within-session habituation of various concentrations and exposure times to CO2-enriched air.
The third hypothesis was partially supported. Groups did not differ on severity of somatic panic symptoms or overall number of panic symptoms as assessed using the DSQ. This finding is consistent with previous research comparing an acceptance-based strategy with a control-based strategy during a carbon dioxide-enriched air inhalation challenge (Eifert & Heffner, 2003; Levitt et al., 2004).

Contrary to expectation and previous research (e.g., Eifert & Heffner, 2003), groups did not differ on number or severity of cognitive symptoms of panic or frequency of catastrophic thoughts. While participants in the acceptance condition reported less severe cognitive symptoms of panic compared to their control-context counterparts, the nonsignificant result may be a function of low statistical power.

Moreover, number of positive thoughts failed to discriminate between groups, despite research suggesting that mindfulness meditation leads to positive affect (Brockman et al., 2017). However, relations between positive affect and meditation appear limited to responses following a film clip selected to induce positive affect (Erisman & Roemer, 2010). To date, no studies have evaluated whether mindfulness increases positive affect, including frequency of positively valanced thoughts, following aversive stimuli. Though the present study did not assess positive affect per se (e.g., as assessed with the PANAS), it did evaluate frequency of positive thoughts (e.g., the DSQ item “I am safe”). Acknowledging that positive thoughts are related to positive affect but not synonymous with positive affect, future research of this type ought to assess positive affect in relation to aversive emotional events. This would be worthwhile in evaluating the utility of mindfulness-based strategies when individuals are faced with aversive emotional events.
Evaluation of physiological indices of arousal were consistent with expectation, albeit with caveats. Overall, groups did not differ on heart rate change from baseline at each static time point (e.g., between group comparisons on VAS 3); an observation that is consistent with previous research (Eifert & Heffner, 2003; Erisman & Roemer, 2010; Levitt et al., 2004). However, group differences emerged in the unfolding of heart rate changes over time. On Trial 2, participants in the acceptance-based group had slightly elevated heart rate response after breathing the CO2-enriched air. Thereafter, heart rate remained stable during the combined CO2-enriched air + meditation period, and thereafter declined notably during the period when participants returned to breathing normal room air while also listening to the meditation. In contrast, participants in the control-based group had a lower heart rate after the onset of gas and experienced a significant increase in heart rate after 5 minutes of CO2-enriched air + meditation. Further, heart rate did not significantly decrease after returning to normal room air for those in the control-agenda meditation group.

Overall, participants in the acceptance-based group showed heart rate stability during the meditation, whereas those in the control-based group experienced elevated heart rate during this same period. This result is consistent with previous studies that show acceptance may lead to increased or stable heart rate, but suppression that generally leads to a greater increase in heart rate (Campbell-Sills et al., 2006b; Hofmann, Heering, Sawyer, & Asnaani, 2009; Tull et al., 2010; Wolgast et al., 2011). These findings, in turn, are not attributable to group differences in respiration rate. In fact, respiration rate failed to discriminate between groups.

Collectively, these findings suggest that control and acceptance do not confer any discernable advantage with regard to panicogenic symptoms or physiological response. The one exception was the pattern of heart rate change observed across sampling epochs. While between
group differences in heart rate observed in the current study is inconsistent with results observed in Eifert and Heffner (2003) and Levitt and colleagues (2004), this may be due to methodological differences in heart rate measurements between the studies. For example, in Eifert and Heffner (2003), heart rate was sampled more frequently (i.e., 10 times a second). In the current study, heart rate was a rolling average of the previous 10 seconds, recorded once a minute, and then averaged to correspond with each trial epoch. Nonetheless, the current study offers evidence that using suppression in a mindfulness context may be physiologically taxing.

The fourth hypothesis, that more participants in the control-based context would discontinue a trial or drop-out altogether compared to participants the acceptance-based context, was not supported. Statistically equivalent percentages of participants in both groups dropped out of one or both trials involving enriched air, resulting in a dropout rate of 36-59%. In contrast, Eifert and Heffner (2003) reported no attrition in the acceptance group, and 20% drop-out in the control-context group. Of note, in the current study average trial discontinuation occurred several minutes after onset of CO₂-enriched air, and before the start of the meditation audio. Contrary to expectation, the findings of the current study suggest that the context for practicing meditation did not impact attrition.

Indeed, attrition rates were unusually high in the present study, particularly in comparison to previous work using a similar dose of CO₂ in both healthy non-clinical and clinically anxious samples (Ainsworth et al., 2015; Eifert & Heffner, 2003; Levitt et al., 2004). In fact, previous work suggests that healthy undergraduate samples generally experience a 10% CO₂-enriched air challenge as aversive, and nonetheless (with few exceptions) complete the inhalation trials. Given the high rate of attrition, evaluation of the main study hypotheses was severely limited. Thus, the present findings can only be viewed as preliminary.
Though there may be several possible explanations for the attrition rates observed in the present study, here we will focus on cohort effects. The present study, and that conducted by Eifert and Heffner (2003), differ by 16 years. In that time, there has been increased concern that the current generation of undergraduates differ in terms of their level of emotional distress (APA, 2018; Bland, Melton, Welle, & Bigham, 2012; Nash et al., 2015). Along these lines, it is possible that the current cohort of undergraduates may be more prone to EA. In one study, undergraduates ($M_{\text{age}} = 20.1$ years, range: 18 – 29 years) had significantly higher EA ($M_{\text{AAQ-II}} = 22.56, SD = 9.40$) than older adults ($M_{\text{age}} = 71.8$ years, range: 60 – 86 years; $M_{\text{AAQ-II}} = 16.80, SD = 9.39$) (Mahoney, Segal, & Coolidge, 2015). The shift in experiential avoidance may be a function of media and modern culture encouraging avoidance of aversive experiences coupled with a world that is filled with emotionally difficult material, which is easily accessible via the internet, news channels, and smartphones, creating a culture of “feel-goodism” (Boulanger et al., 2010). Of note, the grand mean on the AAQ-II in the current study ($M = 19.23, SD = 7.04$) appears comparable to that of undergraduates reported by Mahoney and colleagues (2015). Further, the mean in the current study is more similar to that of first year undergraduates who reported a diagnosis of alcohol abuse or dependence in their lifetime ($M = 19.09, SD = 7.07$), than those who reported no history of alcohol use disorders ($M = 15.90, SD = 6.95$) (Levin et al., 2013).

In recent years, the current cohort of undergraduates and young adults have pushed to create “safe spaces” on campuses and elsewhere. Additionally, according to popular press, “trigger warnings” seem increasingly common (Wilson, 2015) and numerous debates over the potential benefits or detriments have emerged (Boysen, 2017; Boysen, Wells, & Dawson, 2016; Care, Franklin, Fisher, & Bostaph, 2019). Further, the current cohort of undergraduates appears
to be more stressed, anxious, and depressed than previous generations. For example, the rate of college students reporting a diagnosis of depression has risen from 10% in 2000 to 18% in 2008 (Mackenzie et al., 2011). Other research shows that between 2008 and 2013 college campus counseling center visits have increased 231% and total number of yearly clients has increased 173% (Nash et al., 2015). The results observed in the current study provide some evidence of a pervasive pattern of emotional distress, and perhaps EA, in undergraduate nonclinical samples. Collectively, this line of work presents notable challenges for research that aims to use undergraduate samples to evaluate psychologically relevant processes in an experimental context, especially if the aim of such research is to provide a normative baseline from which to clarify the function of putative psychological processes in healthy samples before expanding to clinical populations. Future research should explore if intergenerational differences in EA and other indices of distress exist. If between cohort differences exist, research should examine correlates and possible causes for the shift.

Pre-experimental individual differences variables were evaluated in relation to time and duration of CO₂-exposure in an effort to clarify the high rates of attrition observed in the present study. Surprisingly, none of the pre-experimental measures predicted exposure time to the CO₂-enriched air. Consistent with previous research and theory, we anticipated that participants who terminated a CO₂-inhalation prematurely, or opted out of an inhalation altogether, would report greater EA, lower distress tolerance, and more difficulties with emotion regulation. The data, however, suggest that this was not the case. Rather, the pattern was one of desynchrony between self-reported psychosocial measures and behavior. This topic warrants more research.

Lastly, the acceptance-based group was expected to rate their particular strategy as more effective, report more willingness to repeat the experiment again, and report being more likely to
recommend the strategy to a friend compared to their control-based counterparts. Though the pattern of means was consistent with expectation, none were statistically significant. This is not surprising given problems with attrition that rendered the analyses underpowered.

Data from the present study are inconsistent with previous research showing that those in an acceptance condition are more willing to repeat experiments again involving a carbon dioxide inhalation challenge, watching aversive pictures, or studies utilizing a pain induction task (Arch & Craske, 2006; Eifert & Heffner, 2003; Gutierrez et al., 2004; Levitt et al., 2004). One possibility is that the meditation-naïve sample did not have enough practice with the strategy to benefit in the face of a highly aversive biological challenge. In the study conducted by Eifert and Heffner (2003), participants and researchers had face-to-face conversations about the experimental rationales. In the current study, participants simply read instructions. The instructions may not have been robust enough to foster an effective acceptance stance, or a control stance for that matter. As numerous mindfulness meditation smartphone applications and other media publications exist, future research should focus on if simply reading instructions on how to practice mindfulness is equally effective as being taught the practice by and in the presence of a trained instructor.

In summary, results of the main analyses suggest practicing mindfulness meditation as an acceptance strategy may lead to perceiving unwanted bodily sensations as less intense when compared to practicing as a control strategy. Whether mindfulness is practiced with an acceptance or a control agenda did not appear to impact rate of recovery or rebound of unwanted private experiences. Further, no between group differences were observed in somatic or cognitive symptoms of panic, or frequency of catastrophic or positive thoughts. However, practicing mindfulness as a control strategy may lead to increased heart rate when faced with
noxious stimuli compared to practicing mindfulness with acceptance. Groups did not differ on rates of dropout or discontinuation of trials. Finally, participants in the acceptance group did not report the strategy as more effective, nor did they reported more willingness to repeat the experiment again. Unfortunately, low initial sample size and subsequent attrition rendered the analyses underpowered. Because of low power, exploratory analyses were conducted, which will be discussed in the next section.

**Exploratory Analyses**

Exploratory analyses were conducted to examine group differences regarding the contribution of mindfulness meditation during exposure to CO2-enriched air and on recovery using VAS ratings. Given the exploratory nature of the analyses, results should be interpreted with caution.

**Contribution of meditation.** To explore possible group differences in the contribution of meditation, *t*-tests were performed on the difference between the combined meditation and CO2-enriched air exposure (VAS 3) and the period of exposure to the CO2-enriched air only (VAS 2). Because the significant three-way Condition x Trial x Time interaction was significant for the Intensity VAS variable, it was not included in this series of exploratory analyses.

Participants who received the acceptance-based rational reported reduced distress and greater willingness on Trial 2, and greater willingness on Trial 3 compared to their control-agenda counterparts. Groups did not differ on fear, struggle, or control as measured by the VAS.

The results differ from previous studies showing decreases in fear and anxiety in acceptance-based groups compared to suppression or other control strategies (Ainsworth et al., 2015; Eifert & Heffner, 2003; Levitt et al., 2004). Nonetheless, participants who practice the meditation in an acceptance-context reduced distress but not fear. This suggests that while they
were comparably fearful after the meditation began, they were not as distressed. This supports the rationale underlying acceptance: to take what is offered as it is, without struggle or resistance. Participants in the acceptance condition may have been experiencing equal levels of fear after five minutes of meditation, but more accepting of the fear that was present. The acceptance of fear may explain the reduction in distress. That is, acceptance practice may increase tolerance for unwanted private events (e.g., Arch & Craske, 2006; Coffey & Hartman, 2008; Eifert & Heffner, 2003; Gutierrez et al., 2004).

Consistent with previous research, exploratory analyses suggest that participants who meditated in an acceptance-based context reported increased willingness to experience the effects of the gas compared to those in the control-based context (Arch & Craske, 2006; Eifert & Heffner, 2003; Levitt et al., 2004).

Although participants reported lower fear, struggle, and control on Trial 2, the nonsignificant group difference again may be attributed to the small sample size.

Taken together, these exploratory results suggest that participants were equally fearful, but appeared more willing and less distressed by the effects of the CO₂-enriched air when using meditation in an acceptance versus a control context. Other group differences were in hypothesized directions; however, differences were not statistically reliable. Placed in a larger context, these results suggest that the intention of practicing mindfulness meditation may be an important consideration. If individuals practice mindfulness meditation with the intention of acceptance, they may be more willing to experience unwanted private events. Further, they may be less distressed by these aversive events. As such, individuals can shift focus from attempting to control their internal experience to expanding behavioral repertoires that lead to a meaningful life and greater wellbeing.
**Recovery.** To explore possible group differences in recovery from the effects of the CO₂-enriched air, t-tests were performed on the difference between the end of trial measurement (VAS 4) and beginning of trial measurement (VAS 1).

Participants given the acceptance-based rationale reported significantly greater willingness at the end of Trial 2 and Trial 3, and lower struggle at the end of Trial 2, compared to participants in the control-agenda group. While participants in the acceptance group reported lower distress, intensity of bodily sensations, fear, and control than those in the control-agenda group, differences were nonsignificant. The nonsignificant results may be attributable, in large part, to the small sample size.

Previous research suggests that individuals who suppress internal experience exhibit a slower recovery, indicated by elevated post-experiment measures of emotional distress (Campbell-Sills et al., 2006b; Cioffi & Holloway, 1993; Feldner et al., 2006; Masedo & Esteve, 2006; Matthies et al., 2014). The current exploratory analyses failed to show this pattern, again likely due to low statistical power.

Interestingly, participants using meditation with a control-agenda were less willing to experience the effects of the gas and indicated ongoing struggle even after cessation of CO₂-enriched air compared to their acceptance counterparts. This suggests that use of emotion control strategies may backfire and yield more struggle and less willingness to experience aversive emotional events after an acute episode of anxiety. Conversely, use of an acceptance-rationale may foster opening up to experience, thus leading to greater willingness and reduced struggle with private experience. As previously suggested, greater willingness and reduced struggle may allow individuals to shift attention and other resources to engage in activities that increase their wellbeing and quality of life, regardless of their internal experience.
Limitations of the Current Study

Before concluding, several limitations of the present research are worth noting. First, the study was woefully underpowered given the initial sample size. Additionally, attrition was a significant issue. Almost half of the participants discontinued one or both trials. This further decreased the sample size, precluding the ability to test the main study hypotheses with confidence. On average, most participants discontinued a trial prior to the onset of the guided meditation.

Another limitation may be the trial progression. Exposure to the CO₂-enriched air for several minutes prior to the onset of the meditation was intended to mimic how one might use meditation as an emotion regulation strategy in the face of anxiety or panic. Nonetheless, beginning the meditation and the enriched air concurrently may yield better retention rates. Alternatively, participants could be exposed to a panicogenic dose of CO₂-enriched air before returning to normal room air at the onset of meditation. Future research may explore paradigms that alter the timing of enriched air delivery to better mimic anxiety and subsequent coping strategies.

Next, the context manipulation may not have been strong enough. The wording of the instructions appear somewhat passive. Instructions directing participants to use or apply the meditation in the context-specific method may reveal more robust results. For example, participants could be explicitly instructed to use and apply the guided audio as a way to minimize the effects of the enriched air to make them go away. In the current study, participants were simply told to “keep [the instructions] in mind while [they] listen and follow along.”

In a similar vein, one session of meditation may be insufficient to elicit beneficial effects of meditation practice (Thompson & Waltz, 2007). This point may be especially relevant when
presented with a highly aversive emotion provocation, such as inhaling CO₂-enriched air. Mindfulness is often likened to a muscle that needs to be strengthened with practice. Some programs, such as MBSR and MBCT, teach mindfulness skills over a course of several weeks, suggesting that a single session of mindfulness practice is insufficient to experience benefits (see also Johnson, Gur, David, & Currier, 2015). Other research suggest that meditation-naïve participants can experience benefits of mindfulness meditation after a single session (Erisman & Roemer, 2010; Feldman, Greeson, & Senville, 2010; Fennell, Benau, & Atchley, 2016; Rausch, Gramling, & Auerbach, 2006). However, even if the benefits of meditation emerge during a single session of practice, the aversive stimulus used in the current study may have been too potent, thus masking detection of such benefits. Some studies have employed longer exposure to lower concentrations of CO₂-enriched air. For example, in one study, healthy participants breathed 5.5% CO₂-enriched air for 15 minutes (Levitt et al., 2004). In another, healthy participants breathed 7.5% CO₂-enriched air for 20 minutes (Ainsworth et al., 2015). Future work in this area ought to evaluate lower concentrations of CO₂-enriched air and more training in meditation. However, reducing the strength of aversive stimuli to minimize attrition may negatively affect validity of research paradigms. Future research may also consider comparing a single session of meditation in response to an aversive stimulus in both a meditation-naïve sample and a meditation-experienced sample. Conversely, the procedure of the current study may be applied to a group with a strong background in meditation and compare to a group who endorses frequent suppression.

**Conclusion**

This study was the first of its kind to examine how using a mindfulness meditation may impact the experience of aversive private events. The study compared use of mindfulness
meditation as an acceptance strategy versus a control strategy on self-reported measures of experience and psychophysiological indices while participants breathed CO₂-enriched air. Unfortunately, the small sample size prohibited the detection of significant between group differences, which ultimately created difficulties testing the main study hypothesis hypotheses and offering reliable conclusions. However, group differences in favor of the acceptance-based group emerged in intensity of bodily reactions during Trial 2. Further, groups showed opposite patterns of heart rate after the meditation began. In general, scores were reduced on Trial 3 compared to Trial 2 suggesting possible habituation to the CO₂-enriched air during the experiment. The high attrition rate is concerning and may indicate an increase of experiential avoidance in college populations. Results of exploratory analyses suggest that participants meditating as an acceptance strategy may experience reduced distress and more willingness to experience aversive private events.

Taken together, results of the main and exploratory analyses warrant further attention in studying how individuals are meditating or using contemplative practices, and if the context of meditation influences subjective experiences. Because individuals with anxiety disorders are more likely to engage in control-based strategies including suppression or avoidance (Barlow et al., 2004; Campbell-Sills et al., 2006a), they may also be more likely to use mindfulness skills as another control strategy. Future research should examine how individuals generally use mindfulness or meditation (e.g., as a control strategy or to increase acceptance). Should evidence emerge showing that how one uses meditation does matter in relation to a range of health outcomes, this would have important implications for research, theory, and dissemination of mindfulness-based strategies in mental health practice. Given the dearth in research on adverse reactions in meditative practices (Baer et al., 2019) better understanding the impact of
how individuals are meditating or using contemplative practices may be crucial to clarifying the application of such strategies and their potential role in treatment failures and successes.
References


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Appendix A

Tables

Table 1.

*Means and Standard Deviations of Pre-Experimental Measures.*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Med\textsubscript{Cntrl} (n = 25)</th>
<th>Med\textsubscript{Accept} (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAQ-II</td>
<td>20.04 (SD = 6.50)</td>
<td>18.32 (SD = 7.65)</td>
</tr>
<tr>
<td>ASI</td>
<td>37.40 (SD = 9.81)</td>
<td>37.32 (SD = 9.56)</td>
</tr>
<tr>
<td>BAFT</td>
<td>55.76 (SD = 19.08)</td>
<td>51.91 (SD = 18.84)</td>
</tr>
<tr>
<td>DERS</td>
<td>82.72 (SD = 21.01)</td>
<td>84.45 (SD = 25.91)</td>
</tr>
<tr>
<td>DTS</td>
<td>3.21 (SD = 0.83)</td>
<td>3.53 (SD = 0.93)</td>
</tr>
<tr>
<td>FMI</td>
<td>85.64 (SD = 11.32)</td>
<td>82.64 (SD = 12.82)</td>
</tr>
<tr>
<td>PANAS-P</td>
<td>36.16 (SD = 6.10)</td>
<td>34.55 (SD = 7.77)</td>
</tr>
<tr>
<td>PANAS-N</td>
<td>22.08 (SD = 6.73)</td>
<td>21.32 (SD = 8.40)</td>
</tr>
<tr>
<td>STICSA-T</td>
<td>37.80 (SD = 10.23)</td>
<td>35.55 (SD = 10.65)</td>
</tr>
<tr>
<td>STICSA-S</td>
<td>32.04 (SD = 9.13)</td>
<td>29.77 (SD = 9.62)</td>
</tr>
<tr>
<td>WBSI</td>
<td>52.68 (SD = 10.89)</td>
<td>46.18 (SD = 13.40)</td>
</tr>
</tbody>
</table>

*Note.* Med\textsubscript{Cntrl} = Control-agenda meditation condition. Med\textsubscript{Accept} = Acceptance-agenda meditation condition. AAQ-II = Acceptance and Action Questionnaire – II. ASI = Anxiety Sensitivity Index. BAFT = Believability of Anxious Feelings and Thoughts Scale. DERS = Difficulties with Emotion Regulation Scale. DTS = Distress Tolerance Scale. FMI = Freiberg Mindfulness Inventory. PANAS P/N = Positive and Negative Affect Schedule – Positive Affect/Negative Affect, respectively. STICSA T/S = State-Trait Inventory for Cognitive and Somatic Anxiety – Trait/State, respectively. WBSI = White Bear Suppression Inventory.
Table 2.

Means and Standard Deviations of VAS Assessments Controlling for Trial 1.

<table>
<thead>
<tr>
<th></th>
<th>Trial 2</th>
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<th></th>
<th>Trial 3</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Distress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAS 1</td>
<td>-15.08</td>
<td>16.94</td>
<td>-6.11</td>
<td>16.69</td>
<td>-10.42</td>
<td>12.06</td>
</tr>
<tr>
<td>VAS 2</td>
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*Note.* Scores denote change from corresponding VAS on Trial 1. MedCtrl = Control-agenda meditation condition. MedAccept = Acceptance-agenda meditation condition. MedCtrl *n* = 12, MedAccept *n* = 9. Higher scores on control and willingness indicate lower sense of control and lower willingness, respectively.
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**Note.** MedCntrl = Control-agenda meditation condition. MedAccept = Acceptance-agenda meditation condition. Scores denote average change from baseline for each trial. Scores associated with each epoch correspond to the average change since the previous epoch. For example, heart rate change at Time 3 depicts the average change between Time 2 and Time 3.
Time 1 is the period of CO$_2$-enriched air only. Time 2 is the five minutes of CO$_2$-enriched air and meditation. Time 3 reflects five minutes of only meditation.

Appendix B

Figures

Figure 1. Trial progression for Trial 2 and Trial 3.

Note. Trial 1 progressed the same as Trial 2 and 3 only without CO$_2$-enriched air. Heart and respiratory rates were recorded each minute starting after the completion of VAS 1.