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Focused Attention vs. Open Monitoring: An Event-Related Potential Study of Emotion Regulation by Two Distinct Forms of Mindfulness Meditation

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FOCUSED ATTENTION VS. OPEN MONITORING: AN EVENT-RELATED POTENTIAL STUDY OF EMOTION REGULATION BY TWO DISTINCT FORMS OF MINDFULNESS MEDITATION

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

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Abstract

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This study investigated the effects of two novel forms of 8-week mindfulness meditation training, focused attention (FA) and open monitoring (OM), relative to an established training, mindfulness-based cognitive therapy (MBCT), on early emotional reactivity to negative emotional images as assessed by electroencephalography (EEG). Data on the late-positive potential (LPP) were analyzed to address whether the three mindfulness interventions attenuated the LPP from pre- to post-intervention, and if significant differences existed between groups in LPP at post-intervention. Rather than an attenuation, results indicated an average increase in LPP amplitude from pre- to post-intervention. No significant differences were found in the LPP between the training conditions at post-intervention. These results provide preliminary evidence that mindfulness training in novice practitioners may heighten initial emotional reactivity. Further, well-designed research is needed to examine a wider range of neural responses to better understand emotion regulation process effects of different forms of mindfulness training.

Focused Attention vs. Open Monitoring: An Event-Related Potential Study of Emotion Regulation by Two Distinct Forms of Mindfulness Meditation.

In the last two decades, research on mindfulness has been rapidly increasing, with results indicating a wide variety of psychological and physical benefits associated with mindfulness training programs. Much previous research on mindfulness has focused on the benefits associated with the mindfulness-based stress reduction course (MBSR) and derivatives of it, particularly mindfulness-based cognitive therapy (MBCT; Segal, Williams, & Teasdale, 2002). Created by Jon Kabat-Zinn (1990), the MBSR course consists of a variety of mindfulness meditation exercises, including sitting meditation, body scan meditation, walking meditation, as well as yoga, stretching, and group discussions, and has demonstrated effectiveness for a variety of populations ranging from college students, to cancer survivors, to older adults. Benefits of the MBSR course include increased psychological well-being (Singleton et al., 2014), decreased stress (Khoury, Sharma, Rush, & Fournier, 2015), decreased anxiety (Hofmann, Sawyer, Witt, & Oh, 2010), and improved physical health outcomes (Creswell et al., 2012). Moreover, the enhanced attentional allocation and control fostered by mindfulness training has been found to improve emotion regulation skills (Holzel et al., 2011), a key underpinning of psychological and physical health (Gross & Thompson, 2007). For example, enhanced attentional allocation, reduced attentional avoidance, and positive redirection of attention may explain the benefits of MBSR for reducing symptoms in individuals with social anxiety disorder (Goldin & Gross, 2010). MBCT is a newer clinical application of mindfulness training modeled after the MBSR course, and was developed specifically for the treatment of chronic major depressive disorder (MDD; Segal et al., 2002). The 8-week MBCT course combines components of mindfulness training seen in MBSR with preexisting aspects of Cognitive Behavioral Therapy (CBT), with the aim to prevent relapse of MDD. MBCT has exhibited beneficial effects for clinical depression (Lenz, Hall, & Smith, 2016), anxiety disorders (Kim et al., 2009), and suicidal ideation (Chesin et al., 2016).

Canonically, mindfulness concerns a "receptive attention to and awareness of present events and experience" (Analayo, 2003; Brown, Ryan, & Creswell, 2007). There are a variety of means, most concerning some form of meditation, in which to train and embody mindfulness, and mindfulness research has yet to fully distinguish benefits between different types of mindfulness meditation. Both MBSR and MBCT involve instruction in different forms of meditation, and research examining these courses and other, related forms of secular mindfulness training have done little to pinpoint which types of meditation are most effective in garnering improved mental and physical health outcomes.

As a theoretical starting point for understanding different types of meditation, Lutz, Slagter, Dunne, and Davidson (2008) defined two common styles or forms of meditation: focused attention (FA) meditation and open monitoring (OM) meditation. FA meditation involves voluntarily sustaining one's attention on a chosen perceptual object (e.g. sensations of breathing), whereas OM meditation entails broadened, receptive attention to all salient sensory, kinesthetic, emotional, and cognitive experience from moment to moment. A fundamental difference between these two techniques involves the distribution of attention. For FA, the meditation practitioner is focusing attention on a single object, and via meta-awareness, monitoring the quality of that attention by ignoring distractions and maintaining one's focus on the chosen object. The focus of attention on a specific perceptual object results in a narrow field of attention (Lutz, Jha, Dunne, & Saron, 2015). Therefore, during FA meditation, the practitioner is mostly inattentive to other internal and external stimuli in the present environment. During

OM, there is no specific focus of attention, but rather all salient internal and external perceptual stimuli are attended to receptively from moment to moment. In this sense, OM concerns a broadening of attention to a variety of ongoing perceptual events and experiences. As with FA meditation, meta-awareness is crucial for successful OM, as the trainee must monitor the ongoing state of attention to maintain the receptive attentiveness characteristic of mindfulness and, by implication, to avoid attentional capture by discursive thought (Lutz et al., 2015). Moreover, as described by Lutz and colleagues (2015) OM meditation requires heightened background awareness, such that the individual is attentive to and aware of objects and experiences that may currently be outside of his or her primary focus.

This delineation of different forms of mindfulness meditation has, to date, not resulted in empirical research to investigate whether they have different effects on emotion regulation and the mental and physical health outcomes that to greater or lesser degrees depend on efficient and effective emotion regulation. However, there is incipient research supporting their different attentional processes. Much of this early work has examined neural and neurocognitive markers of attention, which provide a temporally fine-grained analysis of rapidly unfolding attention processes. Evidence indicates that these two techniques indeed have different neural and neurocognitive correlates. Functional magnetic resonance imaging (fMRI) studies have shown that among experts in FA meditation (individuals with > 10,000 hours of practice), changes in neural activation are seen in areas of the brain associated with engaged attention and attentional orienting (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007). Behavioral research on both novice and experienced meditators supports these fMRI results. Novice meditators who completed a 20-minute FA meditation induction exhibited enhanced performance on the Stroop Task, an assessment of implicit attention (Wenk-Sormaz, 2005).

Among Tibetan monks with between 5 and 54 years of meditation practice, those who performed a brief FA meditation during a binocular rivalry task maintained prolonged periods of perceptual stability, with only one of the two images coming to awareness (Carter et al., 2005).

In contrast, preliminary research indicates that OM meditation training correlates with activation in areas of the brain associated with monitoring interoceptive stimuli to homeostatic activity (Farb et al., 2007). These neurological differences between OM meditation and FA meditation likely translate into different behavioral consequences, and initial research supports these distinct outcomes. Results from one study indicated that in comparison to FA meditators, OM meditators exhibited enhanced performance on a sustained attention task for unexpected stimuli, but no significant differences were found for expected stimuli (Valentine & Sweet, 1999). Moreover, research indicates that OM meditation fosters habituation to stimuli, unlike FA meditation (Perlman, Salomons, Davidson, & Lutz, 2010). This initial evidence supports the theoretical differences between these techniques as OM meditators are aware of all momentary salient stimuli (thereby facilitating habituation), whereas FA meditators are focused on only a single object and therefore, unable to habituate to other stimuli. These differences in attention, awareness, and habituation between FA and OM meditation are likely to affect perception and experience of emotional events, as emotion regulation processes are strongly affected by attentional processes (Goldin & Gross, 2010).

Emotion Regulation: The Role of Attention

Individuals engaging in emotion regulation have the goal to influence which emotions they are experiencing at a particular moment, how they are experiencing them, and/or how they are expressing those emotions (Gross, 2015). The Process Model of emotion regulation (Gross, 1998), highlights emotion regulation strategies across different points within the emotion-generative process. As Figure 1 shows, the four major points along this model are: Situation, Attention, Appraisal, and Response. Figure 1 also shows that a variety of emotion regulation strategies can be employed at each point of this process and include situation selection and modification, attention deployment, cognitive change (reappraisal), and response modulation.

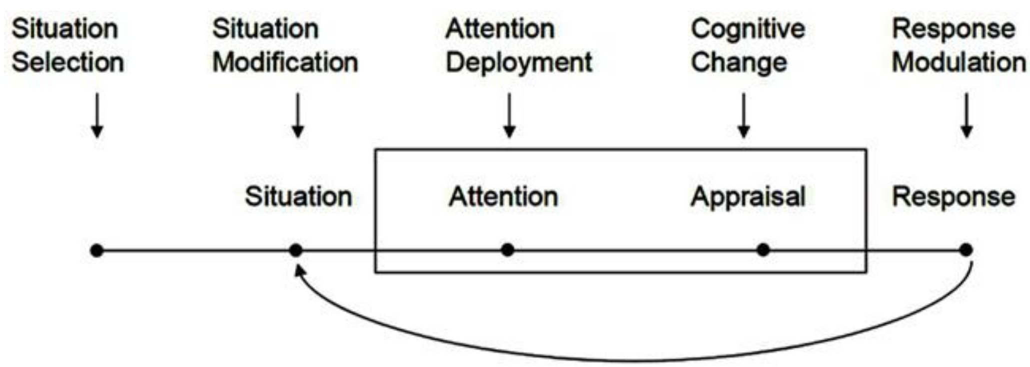

Figure 1: Process Model of emotion regulation

Research on emotion regulation divides the type of emotion regulation strategies into two distinct categories: Antecedent-focused and response-focused (Gross, 1998). Antecedent-focused strategies (including attention deployment and cognitive reappraisal) tend to be deployed prior to the completion of the emotional experience, thereby altering the subsequent emotional reaction and response. On the other hand, response-focused strategies (including emotional suppression) are deployed after an emotional experience has already unfolded, and aim to alter one's already present affective response to the stimulus.

Specific emotion regulation strategies of both the antecedent-focused and response-focused types have been examined for their effectiveness in modulating emotional reactions and responses. Suppression is a well-studied response-focused emotion regulation strategy, and involves purposefully inhibiting an emotional response to an emotion-eliciting stimulus, and appears to be both psychologically and physically detrimental (Webb, Miles, & Sheeran, 2012). Individuals who engage in more emotional suppression report higher rates of depressive symptoms (Gross & John, 2003), reduced well-being (Haga, Kraft, & Corby, 2009), and increased activation of the sympathetic nervous system (Gross & Levenson, 1997).

Perhaps the most intensively studied antecedent-focused strategy is cognitive reappraisal. During cognitive reappraisal, the individual attempts to either change the meaning of the stimulus (often to decrease the experience of a negative emotion), or attempts to make the situation less personally relevant and subsequently, less emotionally arousing. Indeed, this strategy has proven psychologically beneficial, leading to decreased negative emotionality and enhanced well-being (McCrae, Jacobs, Ray, John, & Gross, 2012; Gross & John, 2003). Moreover, reappraisal has been related to enhanced health outcomes such as improved cardiovascular stress responses (Jamieson, Nock, & Mendes, 2012), healthier heart-rate variability profiles (Denson, Grisham, & Moulds, 2011), and reduced inflammatory response (Appleton, Buka, Loucks, Gilman, & Kubzansky 2013).

Despite the success of reappraisal in modulating emotional reactions (Webb et al., 2012), it is a cognitively effortful strategy and appears to be less effective at higher levels of arousal (Gross, 2015). Research has emerged investigating the role of attention deployment in emotion regulation, which offers the promise of greater ease of deployment in terms of both economy of cognitive effort and speed of access. Much of the research on attention deployment has focused on distraction. When employing distraction as an emotion regulation strategy, the individual diverts attention away from the emotionally salient (usually unpleasant) event (Thiruchselvam, Blechart, Rydstrom, & Gross, 2011). Due to this diversion of attention, the individual fails to fully process the meaning of the emotional event, and this has been related to positive emotional outcomes in the short-term (Webb et al., 2012), including reduced negative affect in adults with major depressive disorder (Smoski, Labar, & Steffens, 2014). However, distraction is likely ineffective as a long-term emotion regulation strategy, as emotional stimuli illicit stronger affective responses upon re-exposure (Thiruchselvam et al., 2011). It may also be that distraction is a maladaptive strategy when a difficult situation demands attention (an upset spouse). This suggests that distraction may have limited value for adaptive processing of emotional stimuli.

Overall, research indicates that emotion regulation strategies have differential costs and benefits. Emotional suppression appears to be detrimental to well-being, while reappraisal and distraction confer well-being benefits. Yet, reappraisal appears to be a costly strategy in terms of cognitive effort, whereas distraction is not effective long-term. Thus, an emotion regulation strategy that enhances well-being without requiring costly cognitive effort is desirable. One such superior emotion regulation strategy may be mindfulness.

Mindfulness as an Emotion Regulation Strategy

Emerging research suggests mindfulness meditation may have important benefits for emotion regulation. For example, patients with social anxiety disorder who complete the MBSR program have shown reduced emotional reactivity and reduced negative affectivity, likely the result of changes in attention processes fostered by mindfulness (Goldin & Gross, 2010), as indicated already. Completion of the MBSR program has also led to a reduced avoidance of emotions (Robins, Keng, Ekblad, & Brantley, 2012). Moreover, research suggests that emotion regulation is an important mediator of the relation between mindfulness and improved psychological health outcomes (Holzel et al., 2011; Prakash, Hussain, & Schirda, 2015).

Interestingly, research indicates that mindfulness may be superior to reappraisal for emotion regulation. Research comparing mindfulness and reappraisal as emotion regulation strategies has found that although both strategies lead to similar levels of heightened well-being, reappraisal incurs greater cognitive costs, resulting in reduced subsequent emotion regulation abilities (Parvaz, Moeller, Goldstein, & Proudfit, 2015), and reduced executive functioning (Keng et al., 2013). Therefore, further exploration of mindfulness as an emotion regulation strategy is needed. Moreover, the studies discussed thus far focus on either behavioral measures or self-reports of emotion regulation ability, without investigating the neural correlates of such strategies. Assessment of neural activity can provide objective data on rapidly occurring emotion-relevant processes in real time. To understand how mindfulness training may affect neural processes underlying emotion regulation, let us turn to a neural marker of attention and appraisal called the late positive potential.

The Late Positive Potential (LPP)

As described in the process model of emotion (see Figure 1) attention and appraisal are early processes in the unfolding of emotion, and often occur very quickly. For example, appraisals of stimuli typically occur within a second after initial stimulus contact (Giner-Sorolla, Garcia, & Bargh, 1999). Such rapidity requires measurement with very high temporal resolution. Brain imaging techniques can provide such resolution and neural markers of attention and appraisal in the unfolding of emotion have been well-specified. Electroencephalography (EEG) is considered an ideal method for assessing the unfolding of temporal events in brain activation. Time-locked measurements of temporal brain activity that occur around specific events are event-related potentials (ERPs; Hajcak, MacNamara, & Olvet, 2010). These ERPs are direct reflections of electrocortical processes linked to specific events, and can be used to assess electrical activity in the cortex associated with attention, appraisal, and other cognitive processes (Hajcak & Olvet, 2008).

One particular ERP of interest to studies of emotion and emotion regulation is the late positive potential (LPP), which indexes attentional deployment to, and initial appraisals of motivationally salient, emotion-relevant stimuli. Therefore, the LPP is a marker of early emotion generation processes. A great deal of research investigating the LPP has involved the presentation of emotionally salient photographic images of a positive nature (e.g. smiling people, erotica), a negative nature (mutilated bodies, pollution), and for control purposes, neutral images (e.g., household items). Many studies of this kind draw from the well-validated International Affective Picture System (IAPs; Lang, Bradley, & Cuthbert, 2005) and other photographic image sets. Hajcak and Olvet (2008) found the LPP to be heightened from 300ms to 1000ms after the offset of positive and negative emotional stimuli in comparison to neutral photographic stimuli. Results from this study also indicated that the LPP response lasted longer following a negative emotional stimulus than a positive emotional stimulus. Additional research has supported this conclusion, with enhanced, prolonged positivity of the LPP amplitude observed following presentation of high arousal negative emotional stimuli (Hajcak et al., 2010; Olofsson, Nordin, Sequeira, & Polich, 2008).

Given the association of the LPP response to emotional stimuli, research has examined how the LPP amplitude varies during use of emotion regulation strategies. Researchers have found reappraisal effective in significantly attenuating the LPP response from 700ms to 1500ms following the presentation of negative emotional images (Thiruchselvam et al., 2011; Paul, Simon, Kniesche, Kathmann, & Endrass 2013). In comparison, both suppression and distraction attenuate the LPP much earlier, at 300ms (Paul et al., 2013). This research suggests that distraction, reappraisal, and suppression may attenuate the psychological experience of emotion in response to evocative images. However, further investigations have shown that their benefits are not equal. Although distraction attenuates the LPP earlier than reappraisal upon the first viewing of an emotionally salient image, these effects may not hold upon repeated exposure (Thiruchselvam et al., 2011). Those authors found that when re-exposed to images, individuals who initially employed distraction as an emotion regulation strategy exhibited an increased LPP response, whereas individuals who employed reappraisal during the initial viewing had a significantly reduced LPP response during re-exposure. Although no known research has investigated the effect of emotional suppression upon repeated exposure of emotional images, there is evidence that distraction and suppression may be useful short-term emotion regulation strategies; but to date, research suggests that reappraisal may incur greater benefits in the long-run.

Although much less extensively investigated, initial evidence suggests that mindfulness and mindfulness meditation may be similarly effective in reducing the LPP response. Brown, Goodman, and Inzlicht (2012) found trait mindfulness, as assessed by self-report, to be related to reduced LPP amplitudes in response to both high arousal positive and negative emotionally arousing images. Additional research found a brief mindfulness meditation exercise effective in significantly attenuating the LPP response to the presentation of negative stimuli (Lin, Fisher, Roberts, & Moser, 2016). Finally, one study comparing long-term mindfulness meditators to controls found that long-term meditators exhibited significantly reduced LPP responses to negative emotional stimuli (Sobolewski, Holt, Kublik, & Wrobel, 2011). These results suggest that mindfulness may have an effect on a key neural response implicated in emotional reactivity.

However, research has yet to disentangle the effects of specific mindfulness practices, including FA and OM meditation, on the LPP response.

FA vs. OM in Emotion Regulation

Researchers have just begun to examine how FA and OM meditation affect the LPP response. In one study, adult participants with minimal prior mindfulness meditation experience completed an IAPS viewing task consisting of three different conditions: attentive viewing (pay attention to details of image), mindful viewing (pay attention to all arising thoughts and sensations), and distraction (divert attention away from stimuli by counting backwards from 566) (Uusberg, Uusberg, Talpsep, & Paaver, 2016). The mindful viewing condition involved OM meditation instructions, which included asking participants to pay attention to all arising thoughts and bodily sensations. In comparison to the attentive viewing and the distraction conditions, during the mindful viewing condition participants displayed an enhanced LPP amplitude upon initial viewing, but exhibited an attenuated LPP with re-exposure, indicating a process of extinction in emotional reactivity (Uusberg et al., 2016). According to those authors, OM works by reducing habitual emotional responses. This conclusion is supported by the framework of de-automatization of mindfulness proposed by Kang, Gruber, and Gray (2013). In this framework, OM reduces habitual emotional responding by fostering exposure to stimuli and non-judgmental acceptance that "enables individuals to observe their automatic reactivity to mental events without judging, which can open a gateway to discontinued undesirable automatized behaviors" (Kang et al., 2013, p. 198). Therefore, such openness to and nonjudgment of experience may foster reduced emotional reactivity to negative stimuli.

FA meditation may have similar effects on habitual emotional response, although potentially through different mechanisms. Lutz et al. (2008) explain that the enhanced levels of concentration fostered by FA meditation may be related to reduced emotional reactivity. They argue that by maintaining mindfully focused attention, one is more likely to inhibit automatic emotional responses to emotionally salient stimuli, thereby reducing automatic emotional reactivity. In fact, Menezes et al. (2013) reported that a 6-week FA meditation training resulted enhanced concentrated attention and reduced automatic emotional reactivity to negative stimuli. Despite such apparent benefits of FA meditation for emotional reactivity, only one known study has investigated the effects of FA meditation on LPP response. Eddy, Brunye, Tower-Richardi, Mahoney, and Taylor (2015) found no significant effect of a 15-minute audio-recorded FA meditation induction on LPP response. However, this study suffered from a small sample size (only 24 participants) and it is likely that any effects of the induction on reduced emotional reactivity were highly ephemeral, resulting in no detected effect. Aside from this study, no known additional research exists specifically examining FA meditation and LPP response, nor has any research compared the effects of FA and OM meditation on neural markers of emotion regulation. Therefore, there is a need for research of larger samples to investigate the effects of FA and OM mindfulness training programs on the LPP response.

Current Study

To date, no known literature has directly compared FA and OM meditation techniques on emotional response processes as assessed by the LPP. This will be an important stepping stone to understanding the different benefits associated with types of meditative practice on emotion regulation. Chiesa, Serretti, and Jakobsen (2013) note that much meditation research has focused on training that combines both of these two main types of meditative practice, thereby failing to determine which types of meditation effect (greater) change in neural markers of emotion regulation. The current study is designed to do so. Prior research has shown that without intervention the LPP amplitude is heightened following the onset of both positive and negative emotional images (particularly those previously rated as highly arousing); however, this increased amplitude persists longer for negative images (Hajcak & Olvet, 2008). Arguably, regulation of negative emotions has a broader range of consequences for psychosocial and physical health than the regulation of positive reactions (with reactions to addictive stimuli being one notable exception). Therefore, this current study will investigate the differences in LPP amplitude during the viewing of negative emotional images (relative to neutral images) between trainees of two novel treatment programs, OM and FA, in comparison to trainees of an established treatment program, MBCT.

In this study, adult participants completed an 8-week MBCT, FA, or OM meditation training and completed an adapted version of the Emotion Reactivity and Regulation Task (ERRT; Jackson, Malmstadt, Larson & Davidson, 2000) at both pre- and post-intervention assessment. During the task, EEG activity was recorded, which allows for the comparison of participants' LPP response to emotional negative and neutral images. Given the exploratory nature of this study, hypotheses will not be proposed. Rather, this study will seek to investigate two main research questions:

Research Question 1: Do MBCT, FA, and OM meditation training result in attenuation of LPP amplitude to unpleasant images? As previously mentioned, research suggests that emotion regulation strategies are successful in reducing LPP amplitude to emotional images. Given the purported benefits of mindfulness for emotion regulation, participants completing 8 weeks of MBCT, FA-based, or OM-based mindfulness training may show attenuation in the LPP response between pre- and post-assessment.

Research Question 2: Following completion of the 8-week training period, do significant differences exist between the MBCT, FA, and OM groups on the amplitude of LPP response to unpleasant images? As reviewed already, previous literature suggests that FA and OM meditation recruit different brain regions that may have differing emotion regulation outcomes. Therefore, the second aim of the study is to investigate if any significant differences exist between training conditions in the amplitude of the LPP response when viewing negative emotional images.

Answers to these research questions will provide important evidence on the effects of different types of meditative practice on a key neural marker of early emotional response, which can have significant "downstream" impacts on the generation of negative emotions implicated in psychological and physical health.

Method

Participants

The larger study from which the current study is drawn was conducted between November 2012 and March 2016 at the Clinical and Affective Neuroscience Laboratory at Brown University in Providence, Rhode Island, USA. Participants were a community sample recruited through a variety of methods including informational posters, flyers at primary care clinics, and announcements made at community events. Recruitment also occurred through electronic advertisements on social media websites, as well as on yoga and meditation-related websites.

All eligible participants were required to be English-speaking and between the ages of 18 and 65 years. To determine eligibility, participants first underwent a phone screening before being invited to the lab for additional screening. During the phone screening, participants were excluded if they reported any lifetime history of bipolar disorder, psychotic disorders, persistent antisocial behavior, self-harm behaviors, borderline personality disorder, organic brain damage, or regular meditation practice. If participants were eligible for the study following the initial phone screening, they came into the lab for additional assessments where they were considered ineligible if they presented with severe depression or any Axis I personality disorder (as determined by DSM-IV criteria), obsessive compulsive disorder, post-traumatic stress disorder, panic disorder, eating disorder, or substance abuse disorder. Following all screening procedures, participants read and signed an informed consent form approved by the Institutional Review Board at Brown University. In this larger study, a total of 506 participants were initially screened, but many did not meet inclusion criteria, declined to participate in the study, or were excluded from participation for other reasons. A power analysis conducted for the parent study indicated that a sample of 105 participants (35 for each intervention) would be sufficient to detect a small-medium effect ($d = .33$) at a power greater than .80 ($\alpha = .05$) with a 3 (condition) x 2 (pre-post intervention) mixed factorial ANOVA. See Figure 2 for an overview of participant flow during the course of the study. Thirty-six participants were randomly assigned to each of the novel treatment conditions, FA and OM. Thirty-two participants were randomized to an MBCT condition, which constituted the established treatment group.

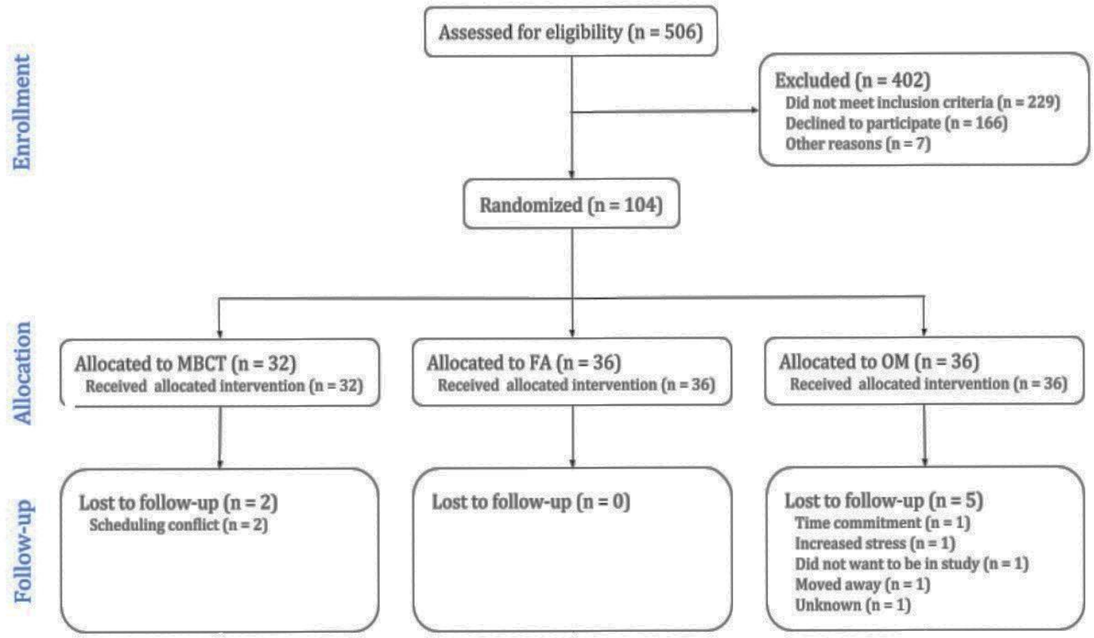

Figure 2: CONSORT participant-flow diagram (from Kriedler, 2016)

Procedure

Full details on the methods of this study can be found in Kriedler (2016). Following the phone screening, eligible participants visited the lab to complete informed consent and a baseline (pre-intervention) assessment with the ERRT (see Measures/Materials below). Participants were first fit with an EEG cap to assess neural activity throughout the ERRT task. The ERRT involves passive viewing of photographic images appearing on the computer screen without looking away during the period of stimulus presentation. The ERRT consisted of a total of five blocks of photographic image presentation, with 25 pictures in each block. Participants received a brief break between each block. During the task, participants passively viewed each presented image for 4 seconds, during which time their electrocortical activity was recorded.

Following baseline assessments, participants were randomized into one of the three intervention conditions: OM and FA, which constituted the novel treatment conditions, or

MBCT, which was an established treatment condition. Due to the nature of participant flow into the study across the 3.5 year study period, group randomization was used rather than individual randomization. Group randomization took the form of randomly allocating each set of 4-16 participants who visited the lab for baseline assessments into one of the three interventions arms. This was done nine different times until desired sample sizes for each intervention were obtained. Once 4-16 participants were allocated to a given intervention class, that course began. For the next 8 weeks, participants underwent their meditation training and then returned to the lab for post-intervention ERRT assessment, following the same procedure discussed above.

Interventions

MBCT. MBCT is a standardized and manualized, 8-week group-based course that emphasizes mindful attention in a client-centered format, by incorporating aspects of both MBSR and CBT (Teasdale et al., 2000). During the course, individuals are asked to complete at-home meditations for homework by following along with guided meditations. The MBCT program consists of both FA and OM meditations, and this intervention was dismantled to develop the additional training programs, with each focusing on cultivating separate kinds of attentional practices, as explained in the sections below.

Focused Attention. This newly adapted course derived from MBCT included training on meditation techniques to foster focused attention. These techniques included training on focusing attention on a chosen object through the use of body scan meditation and focused breathing. The foundation of the FA meditation practice was the use of 6 anchors of attention: feet, hands, breath at belly, breath at chest, breath at nostrils, and sound. Individuals were instructed to maintain their attention on their chosen anchor, to recognize when attention wandered, and to redirect attention back to anchor upon noticing mind-wandering. This process of anchoring was used throughout the variety of FA meditations, including walking meditation, in which the participants were asked to pay attention to their feet as they lifted upwards and forward with each step.

Open Monitoring. This intervention was similarly adapted from MBCT, but included training in acceptance of internal and external events with an open awareness rather than object selection. Participants were trained in open monitoring meditation as well as mountain/lake meditations, which involved visualization of natural scenes. As discussed in Krieder (2016), the OM training emphasized the Mahasi tradition's practice of noting experience across 6 dimensions: seeing, hearing, feeling, tasting, smelling, and thinking. Participants first began by labeling their experience out loud, and over time, noted them mentally, until finally they could note experiences wordlessly. Participants completed many of the same meditation practices as in FA meditation, including walking and movement meditation, but the OM training instructed participants to be aware of all things that arose in consciousness, rather than focusing on sensations in specific body regions.

Intervention Similarities. All training programs were structurally equivalent; consisting of 8 weeks of training, with 3 hours of class each week, and a 1-day silent retreat either during the 6th or 7th week. The first four weeks of training were centered around providing proper instruction on the specific meditation techniques, with the last four weeks focused on applying the learned techniques to regulate negative affect. Participants in all training programs were also asked to complete 45 minutes of formal, guided meditation practice (either FA meditation, OM meditation, or both as determined by their assigned treatment arm) as homework during each day of the intervention. The individual classes for the trainings were also structurally equivalent, with each class session beginning with meditation practice in a variety of postures (sitting, lying down, walking), followed by discussion of experiences during meditation and a review of the homework from the week prior. The class content varied each week and often involved the introduction, training in, and discussion of a new meditation technique. Lectures on depression and stress were also given. Content for the lectures was the same for each program, with changes only made in the material to focus on one training practice or the other. At the end of each class period, homework for the upcoming week was assigned and explained.

Each treatment program had two meditation instructors: one male and one female. The female instructor led all MBCT, FA, and OM intervention groups, was trained in MBSR and MBCT, and had taught 25 MBSR or MBCT courses. One male instructor co-led all FA intervention groups and had an extensive background in concentration training in the Theravada Buddhist tradition. Another male instructor co-led all OM trainings and also had an extensive background in Theravadin meditation practice (and specifically the Mahasi tradition). A third male instructor co-led all MBCT trainings and was trained in MBSR and Zen Buddhism as well. Each instructor had over 20 years of personal meditation practice experience.

Measures/Materials

Demographics: Demographic information on age, gender, race, and ethnicity were collected and included in analyses as covariates. Research indicates that emotion regulation and emotion reactivity can differ by age and gender, with older adults exhibiting enhanced emotion regulation skills (Renfroe, Bradley, Sege, & Bowers, 2016; Roalf, Pruis, Stevens, & Janowsky, 2009), and men displaying a positivity bias in LPP response (Syrjanen & Wiens, 2013). Moreover, research has found cultural differences in emotion regulation strategies (Kwon, Yoon, Joorman, & Kwon, 2013), suggesting that analyses should statistically control for race and ethnicity. Therefore, age, gender, race, and ethnicity were included as covariates in the preliminary analyses to check for any significant main or interaction effects.

Depression, Anxiety, Stress Scale (DASS). Previous research indicates depression and anxiety can negatively impact emotion regulation processes (D'Avanzato, Joormann, Siemer, & Gotlib, 2013; McLaughlin, Mennin, & Farach, 2007). Therefore, baseline scores on the depression and anxiety subscales of the DAAS were included as covariates. The DAAS is a 42-item self-report scale that asks participants to rate the extent each statement applied to them over the past week (Lovibond & Lovibond, 1995). Scale responses range from 0 = "did not apply to me at all" to 3 = "applied to me very much, or most of the time." Example items include "I couldn't seem to get any enjoyment out of the things I did" and "I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)." Items are summed to obtain three separate subscale scores for depression, anxiety, and stress.

Emotion Reactivity and Regulation Task (ERRT). The ERRT is commonly used to assess initial emotional reactivity to arousing images, as well as the ability to regulate emotional response to those images. For this current study, only the initial emotional reactivity as seen in the LPP window of 500-900ms after stimulus onset will be analyzed, as this window of the LPP response is supported by previous mindfulness research (Brown et al., 2012). During the ERRT, participants are first shown a fixation cross on the computer screen for 3s. Then, participants are presented with a photographic image for 4s, followed by presentation of the photographic image with FA-based or OM-based instructions to regulate their emotional response (10s). Finally, participants are given 10s to provide a self-report of their affective response to the image. The next round of image presentation begins after participants either complete their affective response, or after the 10s period in which to provide that response has ended. Figure 3 illustrates the order of experimental presentation.

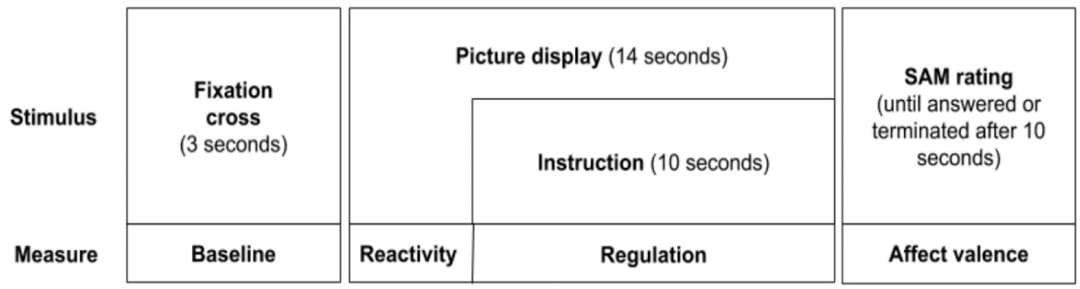

Figure 3: ERRT experimental trial timeline (from Kriedler, 2016)

Photographic images shown to participants consisted of 125 positive, neutral, and negative emotional color images (75 negative, 25 neutral, and 25 positive) from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2008). All images were digitized and presented on a computer screen with DMDX software (Forster & Forster, 2003). Stimulus presentation consisted of 5 blocks, each with 25 images (positive, negative, and neutral). Each 25-image block contained five subsets of images, each with 3 negative, 1 positive, 1 neutral image. The images in each subset were pseudorandomized in presentation, such that negative images were never presented back-to-back in each subset; each negative image was always followed by either a positive or neutral image. This current study focused on analyses of data from the negative images only, as prior research has highlighted the importance and strength of emotion regulation of reactions to negatively valenced stimuli (e.g., Brown et al., 2012; Thiruchselvam et al., 2011).

EEG. EEG recording was made with 19 gold electrodes placed according to the 10-20 system, with a forehead ground and two references, one on the left mastoid and one on the right. Continuous EEG was collected using a Comet AS40 amplifier (Grass Technologies Astro-Med, Inc., RI) at a sampling rate of 400 Hz. EEG data was pre-processed for analysis using EEGLAB 14.0 (Delorme & Makeig, 2004) and Matlab (Mathworks, www.mathworks.com). Previous research has indicated that the LPP is largest along central electrode sites (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Schupp et al., 2000). Therefore, to simplify data analyses, three sensors were separately investigated and used to quantify the LPP response: Fz, Cz, and Pz.

Data Analysis

LPP Window Selection

Visual inspection of the ERP waveforms across the three electrode sites of interest (Fz, Pz, and Cz) for all training conditions revealed that the LPP occurred on average from 500ms to 900ms after stimulus onset (see Figure 4). This signal window is generally consistent with previous studies on LPP response to IAPs images (e.g., Brown et al., 2012; Schupp et al., 2000). To better preserve within-subject variability in LPP response, the selected window was broken down into two separate, but equal length windows. Window 1 was defined as 500-700ms after stimulus onset, and window 2 was defined as 700-900ms after stimulus onset. This methodology is in line with previous work by Brown et al. (2012), and accommodates for individual variability in the LPP response over time.

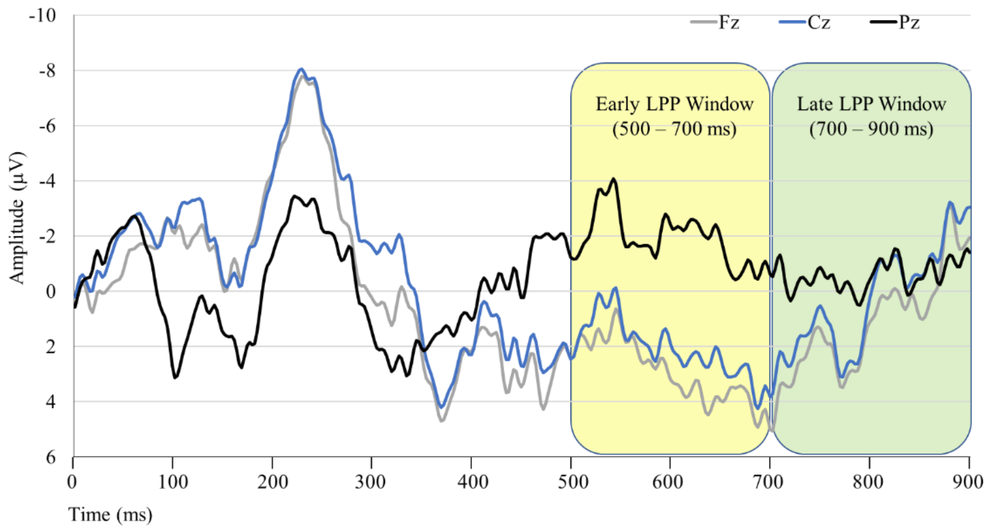

Figure 4: Grand means of LPP response across channels Fz, Cz, and Pz.

Data Analysis Plan

Prior to performing analyses, normality of the LPP data was checked by examining skewness and kurtosis statistics, and deviations from normality were corrected by winsorizing or through data transformations, as appropriate (Tabachnick & Fidell, 2007). Preliminary analyses were first conducted to assess significant effects of covariates (depression, anxiety, age, race, gender, ethnicity) using a mixed-methods 3 (condition; MBCT, OM, FA) x 3 (electrode channel; Fz, Cz, Pz) x 2 (session; pre-, post-intervention) x 2 (LPP window; 500-700ms, 700-900ms) ANCOVA. This preliminary analysis was used to trim nonsignificant covariates from subsequent analyses. Moreover, the preliminary analysis indicated at which channel the LPP response was maximal, and subsequent analyses focused on that channel alone.

To address research question 1, a mixed-methods 3 (condition; MBCT, OM, FA) x 2 (session; pre-, post-intervention) x 2 (LPP window; 500-700ms, 700-900ms) ANCOVA was conducted to determine effects of intervention condition on LPP response at the maximal channel over time while controlling for participant age and race. Intervention assignment was entered as the between-subjects factor, and pre- and post-intervention LPP amplitude and window were entered as within-subjects factors. Pairwise comparisons further investigated any significant main and interaction effects. To address research question 2, a repeated measures ANCOVA was conducted controlling for baseline differences in LPP amplitude. All analyses were performed with an alpha level of .05 and were conducted using SPSS 24 software (SPSS Inc., Chicago, IL).

Results

Preliminary Analyses

Preliminary ANCOVA analyses tested the role of the covariates of interest: depression, anxiety, age, race, gender, and ethnicity. The assumption of sphericity was violated (Mauchley's $W = .48$, $p < .001$), with a Greenhouse-Geisser episilon of .66, and a Huynd-Feldt episilon of .74. The Greenhouse-Geisser correction is a more conservative correction for degrees of freedom, and it is often recommended for use over the more liberal Huynd-Feldt correction when the estimated episilon is less than .75. Thus, the Greenhouse-Geisser correction was used. There were no main effects of any of the entered covariates; however, significant interaction effects were found for age and race. Results indicated a statistically significant 3-way interaction between age, channel, and session, $F(1, 90.84) = 5.09$, $p < .05$, partial $\eta^2 = .068$, and a statistically significant interaction between session and race, $F(1, 70) = 5.55$, $p < .05$, partial $\eta^2 = .073$. These significant interaction terms were carried forward into the main model. Preliminary analyses also revealed LPP amplitude to be maximal at Fz ($M = .655$, $SD = 1.11$) in comparison to Cz ($M = .558$, $SD = 1.14$) and Pz ($M = -.372$, $SD = 0.91$), so all subsequent analyses were conducted on Fz alone.

Research Question 1: Do MBCT, FA, and OM meditation training result in attenuation of LPP amplitude to unpleasant images? Analyses revealed a significant main effect of session, $F(1, 75) = 8.64$, $p < .05$, partial $\eta^2 = .103$. Pairwise comparisons indicated that mean LPP at session 2 ($M = .957$, $SD = 1.52$) was significantly higher than mean LPP at session 1 ($M = .395$, $SD = 1.59$), $p < .05$. Therefore, averaged across all conditions, there was an increase in LPP response from baseline to post-intervention. Table 1 displays the main effects and interaction terms from this model.

Table 1. ANCOVA results showing predictions of change in LPP response at Fz from pre- to post-intervention.

Effect	*df*	*F*	*p*
Session	(1, 75)	8.64	<0.01
Session x Age	(1, 75)	5.19	<0.05
Session x Race	(1, 75)	6.28	<0.05
Session x Condition	(2, 75)	0.51	0.884
Window	(1, 75)	0.28	0.598
Window x Age	(1, 75)	0.59	0.443
Window x Race	(1, 75)	0.01	0.906
Window x Condition	(1, 75)	0.32	0.724
Session x Window	(1, 75)	0.01	0.942
Session x Window x Age	(1, 75)	0.13	0.724
Session x Window x Race	(1, 75)	0.01	0.945
Session x Window x Condition	(2, 75)	0.34	0.713

Notes. Race was coded 0 = Asian, 1 = White; Session was coded 0 = pre-intervention, 1 = post-intervention; Condition was coded 0 = MBCT, 1 = OM, 2 = FA.

Research Question 2: Following completion of the 8-week training period, do significant differences exist between the MBCT, FA, and OM groups on the amplitude of LPP response to unpleasant images? To address this question, it was first important to establish if any significant differences in LPP existed between the groups at baseline. An initial graph of the LPP response indicated that the conditions may differ at baseline (see Figure 5), and a follow-up one-way ANOVA revealed that at session 1, statistically significant differences did exist at window 1 (500-700ms), $F(2, 89) = 3.90$, $p < .05$. A post-hoc Tukey test revealed that the average LPP amplitude in the early (first) window among OM participants was significantly higher ($\Delta M = 1.06$, $p < .05$) than that of the MBCT participants. No significant differences were found between MBCT and FA ($p = .745$), or between OM and FA ($p = .105$).

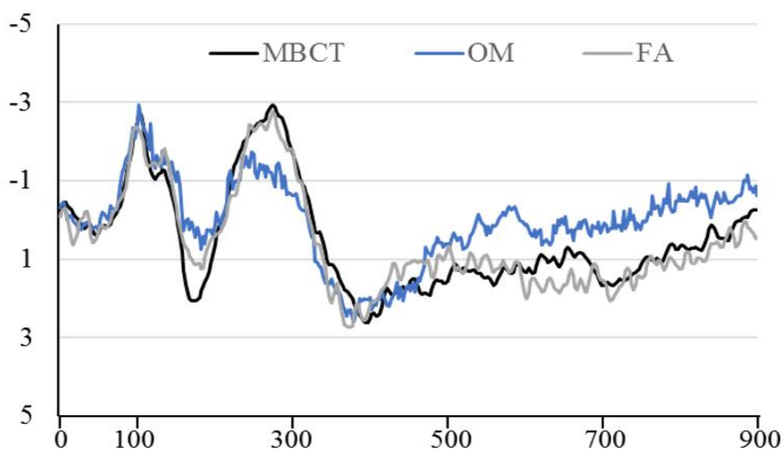

Figure 5: Fz channel LPP at baseline for each intervention condition

Following determination of baseline differences, significant differences at post-intervention were tested by controlling for baseline LPP response, as well as age and race interaction terms that were revealed to be significant in the preliminary analyses. Results revealed no main effect of condition at post-intervention, $F(2,73) = 1.97$, $p = .148$. Thus, there were no significant differences in LPP response between conditions at post-intervention after controlling for baseline condition differences in LPP amplitude (see Figure 6). Remaining model predictors were also not significant and are displayed below in Table 2 and Table 3.

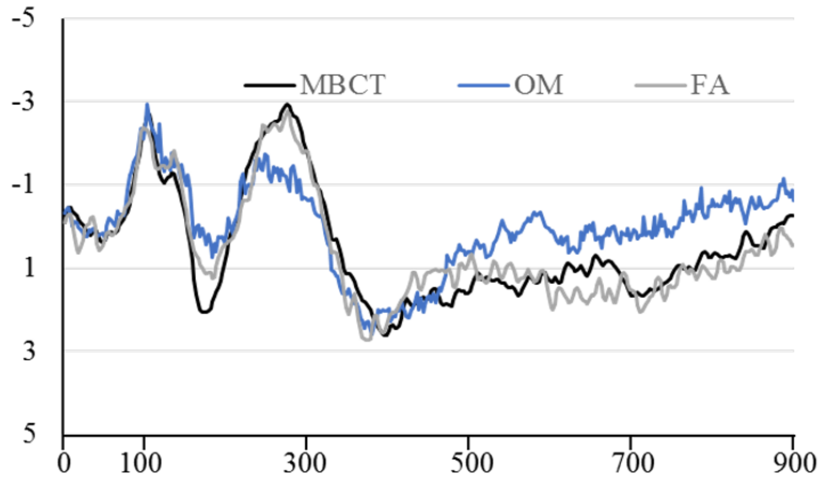

Figure 6: Fz channel LPP response by intervention condition at post-intervention

Table 2. ANCOVA results showing within-subjects effects on LPP response at Fz at post-intervention.

Effect	*df*	*F*	*p*
Window	(1, 73)	0.18	0.673
Window x Fz.S1.W1	(1, 73)	0.03	0.858
Window x Fz.S1.W2	(1, 73)	0.34	0.563
Window x Age	(1, 73)	0.89	0.348
Window x Race	(1, 73)	0.06	0.806
Window x Condition	(2, 73)	1.16	0.320

Notes. Race was coded 0 = Asian, 1 = White; Session was coded 0 = pre-intervention, 1 = post-intervention; Condition was coded 0 = MBCT, 1 = OM, 2 = FA.

Table 3. ANCOVA results showing between-subjects effects on LPP response at Fz at post-intervention.

Effect	*df*	*F*	*p*
Fz.S1.W1	(1, 73)	0.37	0.545
Fz.S1.W2	(1, 73)	0.05	0.832
Age	(1, 73)	3.31	0.073
Race	(1, 73)	3.94	0.051
Condition	(2, 73)	1.97	0.148

Notes. Race was coded 0 = Asian, 1 = White; Session was coded 0 = pre-intervention, 1 = post-intervention; Condition was coded 0 = MBCT, 1 = OM, 2 = FA.

Discussion

This study was the first to directly compare the effects of different forms of 8-week mindfulness trainings on emotional reactivity, as assessed by electrocortical (LPP) response. The specific novel aim of this study was to elucidate LPP differences that may exist between two novel treatments, FA and OM meditation training, in comparison to a standardized and established treatment, MBCT. FA and OM meditative practices emphasize different types of attention deployment, and understanding their effects on the LPP, a key neural marker of early emotion regulation – whether those effects are similar or different - will have implications for enhancing psychological and physical health, both of which commonly depend on effective emotion regulation (Gross, 2015). The results of the study indicated no significant differences between FA, OM, and the MBCT conditions at post-intervention. It is possible that the three trainings may have equal effects, but specific limitations of this study could also have prevented the discovery of significant differences. Such limitations will be discussed later.

The results did, however, reveal a significant main effect of session, indicating that LPP response across all conditions was greater at post-intervention than at baseline. This finding conflicts with initial previous research showing that mindfulness training attenuates the LPP response to negative emotional images (Lin et al., 2016). Still, the effect of mindfulness training programs on the LPP has not been extensively studied to date so the results obtained from this thesis may indicate that meditation training in novice practitioners heightens awareness of and sensitivity to emotional stimuli. This speculation is in line with Teper, Segal, and Inzlicht's (2013) conceptualization of mindfulness as not attenuating one's initial emotional reactivity, but as effective in decreasing continued negative emotionality throughout the emotion-generative process. Research supports this speculation, as an open monitoring meditation induction has been found to initially amplify the LPP response in novice practitioners, before eventually attenuating the LPP after repeated exposure to stimuli (Uusberg et al., 2016). Uusberg and colleagues (2016) theorize that the mindfulness induction led to initial sensitivity to one's emotional experience, but that the repeated experience with and acceptance of those initial reactions led to the eventual extinction of the amplified LPP response. Indeed, research supports that expert meditators (> 1300 hours of meditative practice) exhibit a reduced LPP in comparison to novice meditators in response to negative emotional stimuli (Sobolewski, Holt, Kublik, & Wrobel, 2011). Because this thesis did not involve repeated exposure to stimuli, nor were expert meditators studied, the finding of enhanced LPP at post-intervention may represent a heightened initial appraisal reaction due to meditative practice in novices. Therefore, the benefits of mindfulness training may be more pronounced at later points described in the process model of emotion regulation, and mindfulness training may have a greater effect on automatic emotional appraisals following several years of meditative practice.

The failure to find significant differences in the LPP response between conditions at post-intervention may in part be due to the particular analytic strategy of this study. The LPP window was determined based upon visual inspection of the grand mean LPP amplitude for both pre- and post-intervention at each of the three channels of interest. Based upon the resulting graph for inspection, the selected window of clear LPP amplitude deflection was 500-900ms after stimulus onset. We chose to base the window upon pre- and post-intervention LPP to make sure the maximal LPP at both time points would be included in analyses. However, the peak or duration LPP amplitude may have differed between pre- and post-intervention assessments. Thus, averaging data from both time points to visually determine the LPP window for analysis may have erased differences in LPP amplitude between conditions across time points if the LPP response in fact had shifted over time. In addition, previous research has found the LPP response to continue up to 4s following stimulus onset (Paul, Kathmann, & Riesel, 2016), which opens the possibility that the current study failed to detect LPP differences across training conditions because such differences may appear later in an LPP response. However, it should be noted that there are benefits to a more restricted LPP window. If the LPP window had been lengthened, it would likely introduce additional noise into the data (e.g. muscle artifacts, eyeblinks, etc.). Therefore, limiting the LPP window to a 400ms timeframe better preserved the quality of the data.

Limitations and Future Research

There are a few limitations to the current study which should be discussed. First, the design of the ERRT task may have introduced confounds into our assessment of emotional reactivity. During the ERRT, participants were shown an image for 4 seconds before being provided with instructions on how to regulate their emotional response for an additional 10 seconds. Therefore, the expectation of regulating their emotions as instructed may have altered participants' attention and initial reaction to the images. By using a task which tracks emotional reactivity and emotion regulation, there may be difficulty in accurately isolating and understanding initial emotion-relevant reactions. Likewise, the emotion regulation portion of the ERRT involved the presentation of three possible instructions for all participants, regardless of condition: "breath," "label," or "watch." The breath condition instructed participants to pay attention to the sensation of their breath (focused attention), while the label condition asked participants to mentally label their emotional experience (open monitoring). The watch condition simply asks participants to continue watching the image as they normally would. Therefore, the instructions may have conflicted with, and interfered with the 8-week training received, thereby washing out any differences that may have occurred if participants only practiced the regulatory strategy they learned in their training.

Second, although anxiety and depression were not found to be significant predictors of LPP amplitude, assessment of these variables was based on self-report instruments. As with any self-report measure, there is a risk that participants are unwilling or unable to accurately report their true internal experience. Because of this, significant differences in baseline emotion regulation abilities may have been present, and this is supported by the finding that the participants in the OM group had significantly different baseline LPP amplitudes compared to the other two groups. Although we attempted to statistically control for these differences, this may have been an insufficient approach. Participants in conditions that were inequivalent in LPP response and possibly psychological status at baseline may have confounded the efficacy of the individual treatment programs, as research indicates certain forms of mindfulness training to be more effective for some individuals than for others. For example, Chiesa and Serretti (2010) stated that MBCT is most efficacious for preventing depression relapse in patients who have had at least three episodes of major depressive disorder, while MBSR is better suited for non-clinical populations or those with physical impairments. It is quite possible that FA and OM are differentially beneficial for specific populations as well, a question that deserves investigation.

Finally, the quality of the EEG data in this study was less than optimal. EEG data is always imperfect, given the nature of this scalp recording approach to studying brain activity, and visual inspection of the data indicated several instances of “bad” (poor recording) channels that required extensive data cleaning and some data deletion. Baseline trial-by-trial data were lost from three participants, and post-intervention trial-by-trial data were lost from 8 participants due to poor data quality (or corrupted data files). Data from one participant were deleted completely due to poor quality EEG. These issues may have contributed, however indirectly, to the failure to find significant condition differences in LPP response.

Future research should employ methodologies that attempt to attenuate or eliminate the study design and data quality limitations discussed above. In particular, studies should focus on disentangling the effects of early emotion reactivity processes from later emotion regulation processes. For example, future research could examine differences in LPP response between FA and OM through the use of IAPs image presentation without the emotion regulation component (to “label” or “breathe” for example). Moreover, future work should study additional ERP components to investigate how different forms of mindfulness training may impact early attention processes (the N200 and P300 components, for example) or later emotion regulation processes separately. Such research would elucidate the temporal effects of different forms of mindfulness training during both early and late emotion regulation processes.

Conclusions

Although the present study was unable to identify any significant differences in LPP response between FA, OM, and MBCT training programs at post-intervention, there were several limitations that may have accounted for this and should be addressed in future work. Nonetheless, the finding of increased LPP amplitude at post-intervention offers an interesting point of consideration for the study of mindfulness training and emotion regulation processes. Moving forward, it will be important for future studies to evaluate the time-course effects of different mindfulness training programs during emotion regulation, as understanding the effects of different kinds of meditative practice is important for furthering our understanding of their nature and emotional consequences.

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Appendix

Depression, Anxiety, and Stress Scale (DASS)
Please read each statement and choose a number 0, 1, 2 or 3 that indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

0 = *did not apply to me at all*
1 = *applied to me to some degree, or some of the time*
2 = *applied to me to a considerable degree, or a good part of time*
3 = *applied to me very much, or most of the time*

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1 I found myself getting upset by quite trivial things

2 I was aware of dryness of my mouth

3 I couldn't seem to experience any positive feeling at all

4 I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)

5 I just couldn't seem to get going

6 I tended to over-react to situations

7 I had a feeling of shakiness (eg, legs going to give way)

8 I found it difficult to relax

9 I found myself in situations that made me so anxious I was most relieved when they ended

10 I felt that I had nothing to look forward to

11 I found myself getting upset rather easily

12 I felt that I was using a lot of nervous energy

13 I felt sad and depressed

14 I found myself getting impatient when I was delayed in any way (eg, elevators, traffic lights, being kept waiting)

15 I had a feeling of faintness

16 I felt that I had lost interest in just about everything

17 I felt I wasn't worth much as a person

18 I felt that I was rather touchy

19 I perspired noticeably (eg, hands sweaty) in the absence of high temperatures or physical exertion

20 I felt scared without any good reason

21 I felt that life wasn't worthwhile

22 I found it hard to wind down

23 I had difficulty in swallowing

24 I couldn't seem to get any enjoyment out of the things I did

25 I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)

26 I felt down-hearted and blue

27 I found that I was very irritable

28 I felt I was close to panic

29 I found it hard to calm down after something upset me

30 I feared that I would be "thrown" by some trivial but unfamiliar task

31 I was unable to become enthusiastic about anything

32 I found it difficult to tolerate interruptions to what I was doing

33 I was in a state of nervous tension

34 I felt I was pretty worthless

35 I was intolerant of anything that kept me from getting on with what I was doing

36 I felt terrified

37 I could see nothing in the future to be hopeful about

38 I felt that life was meaningless

39 I found myself getting agitated

40 I was worried about situations in which I might panic and make a fool of myself

41 I experienced trembling (eg, in the hands)

42 I found it difficult to work up the initiative to do things

Vita

Tarah Lynn Raldiris is an American citizen born on November 9, 1988, in Palm Beach Gardens, Florida. She graduated from South Fork High School in Stuart, Florida in 2007. She received a Bachelor of Arts with a concentration in Psychology from Harriet L. Wilkes Honors College at Florida Atlantic University, Jupiter, Florida in 2011. In 2014, she received a Master of Arts in Applied Psychological Research from Pennsylvania State University, Harrisburg, Pennsylvania.