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Clarifying the Associations between Mindfulness Meditation and Emotion: Daily High- and Low-arousal Emotions and Emotional Variability

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Background: Research examining the effects of mindfulness meditation (MM) on emotion seldom considers differences by arousal level or emotion variability. **Methods:** In the present study, 115 participants (64% Female, 72% White, M_{age} = 19.03) were randomly assigned to a brief MM intervention condition (n = 60) or a wait-list control condition (n = 51). Participants in the MM condition were trained in MM and instructed to practice MM daily for one week. All participants provided daily diary reports of both higher- and lower-arousal positive (PE) and negative (NE) emotions. Emotions were weighted by valence and arousal. Multilevel modeling was used to examine valence, arousal, and their interaction; multivariate regression was used to examine emotional variability. **Results:** More time spent meditating (but not the MM condition itself) was associated with increased lower arousal emotions, and exhibited a significant effect on the interaction between valence and arousal. Examination of individual emotion items suggested that more time meditating significantly predicted increased feelings of quiet and calm and marginally increased relaxation and sleepiness among participants, but did not predict any other emotions assessed in daily life. MM was not associated with emotional variability. **Conclusion:** These results may suggest that PE should be separated by arousal when examining the effects of MM interventions.

Keywords: daily diary, emotion, emotional arousal, emotion variability, mindfulness meditation, negative emotion, positive emotion

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INTRODUCTION

The past two decades have seen a surge in research examining the benefits of mindfulness meditation (MM). Results broadly suggest that MM reduces pain, decreases anxiety and depression, and promotes well-being (Eberth & Sedlmeier, 2012; Marchand, 2012). A number of mechanisms have been proposed to elucidate how MM promotes health and well-being, with stress (Creswell & Lindsay, 2014), emotion regulation (Grecucci, Pappaianni, Siugzdaite, Theuninck, & Job, 2015), negative emotion (NE; Sedlmeier et al., 2012), and positive emotion (PE; Garland et al., 2010) all identified as potential pathways. However, there are theoretical inconsistencies in the literature regarding associations between MM and PE; some theories suggest that MM should promote PE whereas others suggest that MM should attenuate high-arousal emotions regardless of whether they are positive or negative in valence (Garland et al., 2010; Goyal et al., 2014; Kabat-Zinn, 1990). Similarly, there are discrepant empirical findings regarding the association between MM and PE (Arch & Craske, 2006; Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008), although these may be due, in part, to methodological differences (such as the style of meditation and duration of the study). One purpose of the present research is to determine whether such discrepancies may be due in part to studies not accounting for differences in the arousal level of PE items (namely, the distinction between "high-arousal PE", as captured by adjectives like excited and joyful, vs. "low-arousal PE" as captured by adjectives like calm and satisfied). In addition, few studies consider emotion dynamics, such as how much emotion varies from one time to the next. Emotion variability has been associated with better health and well-being (Gruber, Kogan, Quoidbach, & Mauss, 2013; Human et al., 2015). Therefore, another goal of the present research is to help clarify the relationship between MM and emotion by examining the effects of MM training on emotional variability.

Theory vs. Empirical Evidence in Mindfulness Meditation and Emotion

Buddhist and Hindu traditions from which MM is broadly derived warn against over-engagement with high-arousal emotions, purporting that highly arousing negative *and* positive emotions (e.g. anger and anxiety vs. joy and excitement, respectively) can cloud judgment (for an overview of Buddhist and Hindu approaches see Sedlmeier et al., 2012). Detachment from high-arousal emotions is therefore often practiced in MM, and this detachment may facilitate the ability to downregulate high-arousal PE and NE (Chiesa, Serretti, & Jakobsen, 2013; Kabat-Zinn, 1990). Given the supposition that MM promotes regulation of high-arousal emotions, theoretical arguments from this perspective suggest that MM may result in decreased high-arousal PE and high-arousal NE (Chambers, Gullone, & Allen, 2009; Kabat-Zinn, 1990).

MM theories posit that low-arousal PE (e.g. calm, relaxed, satisfied) increases with MM practice, because engagement in MM is thought to naturally facilitate feelings of calm and relaxation as stress and high-arousal NE decline (Kabat-Zinn, 1990, 1994; Koopmann-Holm, Sze, Ochs, & Tsai, 2013; Sedlmeier et al., 2012). Moreover, a recent review examining the topic of equanimity in MM, which is defined as a state of calmness and composure toward experiences regardless of how pleasant or unpleasant those experiences may be, suggests that equanimity is developed with MM practice (Desbordes et al., 2014). Despite the theoretical assumption that MM increases low-arousal PE, few studies separately examine high- and low-arousal PE items. Theoretical assertions are less clear regarding how MM should influence "low-arousal NE" (that is, emotional states as captured by adjectives like sad and depressed). It seems plausible, however, that if MM promotes low-arousal PE, low-arousal NE will either decrease or remain stable.

Although most empirical studies examining the effects of MM on emotion have not focused on the distinction of high- and low-arousal emotions, some MM studies have incorporated measurement of both high- and low-arousal NE items. Results generally suggest that MM reduces NE (Sedlmeier et al., 2012); in contrast, results from empirical research examining the effects of MM on PE are more inconsistent. The majority of studies suggest that MM either has no effect on PE (Goyal et al., 2014; Koopmann-Holm et al., 2013; Mongrain, Komeylian, & Barnhart, 2016), or increases PE (Fredrickson et al., 2008; Sedlmeier et al., 2012), although a few studies report that MM decreases PE (Arch & Craske, 2006; Lalot, Delplanque, & Sander, 2014). Thus, studies capable of clarifying the associations between MM and PE are needed.

Despite theoretical and empirical justification for the argument that MM may differentially influence emotion by arousal, to our knowledge only two studies to date have examined emotion differentiated by arousal in an MM intervention. In one of these, Lalot et al. (2014) used a repeated-measures design to determine whether 45 participants responded differently to film clips designed to elicit high- or low-arousal PE (NE was not elicited). Participants engaged in a control, a reappraisal, an expression suppression, and a mindful attention condition. While in the mindful attention condition, participants reported less PE overall, but the manipulation of PE arousal was not statistically significant (participants reported more high-arousal PE in both the high- and low-arousal PE condition), so it was unclear whether mindful attention differentially influenced high- and low-arousal PE (Lalot et al., 2014). In separate research, Koopmann-Holm et al. (2013) examined both high- and low-arousal PE and NE with MM across a series of three studies. All three studies suggested that MM did not influence actual emotion, but rather influenced "ideal emotion" reported by participants (that is, what participants indicated that they would like to feel rather than what they actually felt), and particularly increased the reported ideal levels of low-arousal PE. The authors note that MM may be more effective in changing the personal value of emotions rather than actual emotions experienced. An alternative perspective is that the technique used to assess emotion in these studies—global recall of emotion—may not have adequately captured the experience of emotion given recall difficulties inherent to this type of assessment, but rather drew more strongly on top-down processes (e.g. personal values regarding emotional states; Conner & Barrett, 2012). Because emotional experience is transient in nature, ecologically valid assessment techniques (e.g. momentary or daily assessments; Smyth & Heron, 2012) may be better suited to capture the effects of MM on emotion over relatively short time periods.

Few MM studies examine emotion on a momentary or daily basis, and those that do frequently aggregate data to the between-person level (e.g. Fredrickson et al., 2008). Thus, it is unclear whether the effects of MM on daily high- and low-arousal PE and NE will be similar to those seen in studies assessing global emotion. Similarly, the question of whether MM will be differentially associated with daily high- and low-arousal PE and NE remains unclear.

Mindfulness Meditation and Emotional Variability

To further elucidate mechanisms by which MM may promote health and well-being, it may be useful to distinguish the effects of MM on high- and low-arousal emotions from emotional variability, which is often conflated with person-mean emotion. Emotion variability captures the degree to which individuals vary on average in their emotions over time (Ram & Gerstorf, 2009). Emotional variability may be important to examine because, as noted by Gruber et al. (2013), two people may have the same mean emotion across time, but one may report being very happy some days and much less happy on others whereas another person may be more stable in their daily happiness. The emotional experiences of these two people differ greatly, yet these differences are missed when examining only mean emotion. It may therefore be important to incorporate variability in emotion to determine whether MM promotes stability in emotional experience.

To our knowledge, no studies have examined the effects of MM on the variability of high- and low-arousal emotion. Related empirical work suggests that associations between MM and emotional variability might differ from associations between MM and person-mean emotion. For example, those with higher trait mindfulness exhibited lower emotional variability in both high- and low-arousal PE and NE (Hill & Updegraff, 2012). Other studies have suggested that MM may decrease emotional reactivity. Taylor et al. (2011) found that when both experienced meditators and novice meditators viewed positive, negative, and neutral pictures, they reported less emotional reactivity regardless of picture valence compared to non-meditators. Other studies report findings consistent with this perspective, suggesting that MM practitioners may have less high-arousal PE and NE reactivity (Chiesa et al., 2013; Lutz et al., 2014). In keeping with the theoretical concept of equanimity, which holds that MM should promote feelings of calm and reduce emotional reactivity to highly arousing stimuli (Desbordes et al., 2014), and because lower emotional reactivity should relate to less emotional variability, it is plausible that MM would decrease variability in emotion overall.

The Present Research

The purpose of the present research was to examine the effects of MM on daily emotion by arousal and valence and to examine the effect of MM on emotional variability, in a naturalistic daily diary study. We examined these associations during an MM intervention (instead of at pre-test and post-test as is frequently done), which is a strategy well suited to elucidating mechanistic processes. Based on the theory that MM dampens high-arousal emotions and facilitates feelings of calm and relaxation, we expected that MM would be associated with decreases in daily high-arousal PE items and high-arousal NE items and with higher daily low-arousal PE items. We further expected that MM would be associated with decreased low-arousal NE items in daily life, as previous experimental evidence suggests that MM decreases feelings of sadness and depression (Sedlmeier et al., 2012). Regarding emotional variability, we hypothesised that MM would be associated with decreased emotional variability.

METHODS

One hundred and fifteen students located at a university in the Pacific Northwest were recruited as part of a larger study examining the effects of MM on coping flexibility over a three-week time period. Exclusion criteria included previous training with an MM instructor or having a diagnosis of clinical depression or anxiety disorders. Participants were predominantly female (64%) and Caucasian (72%), with a mean age of 19.03. Prior to beginning the study, participants were pre-screened for previous practice with MM or yoga. Seven participants had familiarity with and/or had practiced MM previously to some extent, although they did not report any official training. Likewise, 16 participants regularly participated in yoga, which is a traditional component of MM. To ensure that those familiar with MM and yoga were not differentially placed into one group, participants were assigned to the MM condition ($n = 64$) or the waitlist control condition ($n = 51$) using stratified random assignment by previous experience with informal MM or yoga practice.

Data were collected in three waves. A check on randomisation to condition across all three waves of data collection indicated that baseline stress was statistically different between conditions ($t(110) = 2.31$, $p = .023$; $M_{\text{Control}} = 2.59$, $M_{\text{MM}} = 2.89$) but there were no other significant baseline differences. Thus, results were examined covarying for baseline stress. Also, examination of the data prior to any formal hypothesis testing using Mahalanobis distance analysis revealed that two participants assigned to the control condition began engaging in MM, and reported over 90 minutes of practice during the week of daily data collection, although they had no previous experience in the practice. These two individuals were removed from the dataset prior to analyses.

Over the course of the study, 11 participants dropped out (Figure 1). Follow-up with these participants indicated that they dropped out due to illness and busy schedules (e.g. sports, exams); one participant specifically reported not realising that the study required three weeks of participation. Two additional participants were missing some baseline measures. There were no significant differences in attrition by condition, gender, age, or pre-test variables (e.g. dispositional mindfulness, stress).

Procedure

This study was approved by the ethics review board at the university where the research was conducted. Participants provided informed consent, received class credit for participation, and those who completed at least 90 per cent of

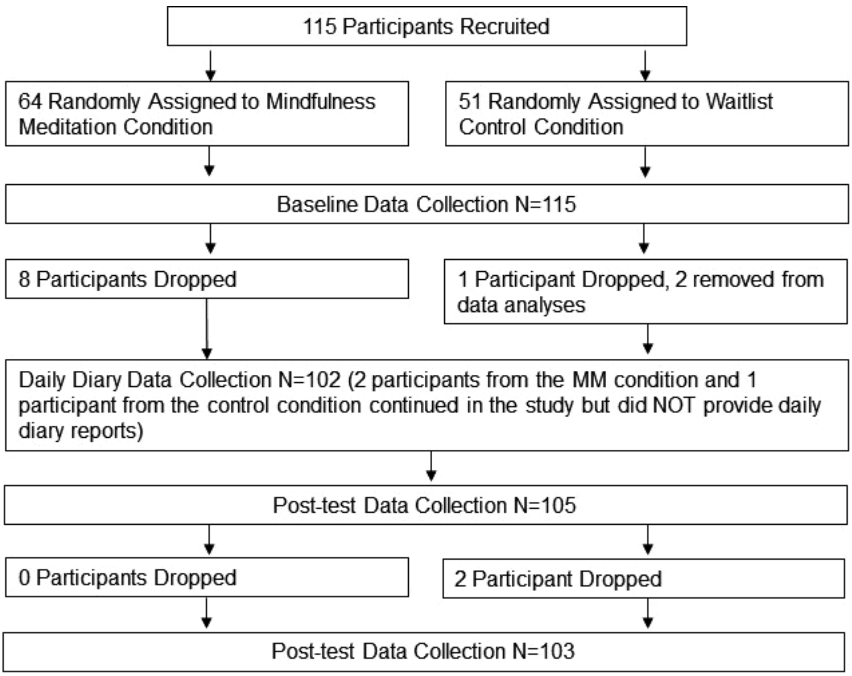

FIGURE 1. Consort diagram of study recruitment and attrition.

assessments were entered into a raffle to win $25. The study took place over a three-week period. On the first day, participants provided demographic and pre-test assessments (psychological measures such as dispositional mindfulness and stress, as well as coping measures). On day two, participants in the MM condition received 2.5 hours of MM training (one hour of actual practice time in MM) from an instructor certified to teach Mindfulness Based Stress Reduction. At the end of the MM training session, participants in the MM condition were provided with guided meditation recordings on a compact disc recorded by the same instructor. Participants in the MM condition were asked to meditate each day for six subsequent days (days 3–8 of the study). Each day (days 2–8), participants in both conditions were emailed an online questionnaire and were asked to provide reports of time spent meditating, PE, and NE for that day. During this time, those in the control condition were not instructed to engage in any particular activity. On day 9, participants returned for post-test assessment and began engaging in the physiological portion of the study. Participants then returned two weeks after the intervention (day 21) for a follow-up assessment of baseline measures. Although participants continued in the larger study after the daily diary assessment, for the purposes of this paper only pre-test assessments and the daily dairy portion (days 1–8) of the study were used.

MM Intervention. Two practices integral to Mindfulness Based Stress Reduction (MBSR) were utilised for this study: sitting meditation and a body scan. Participants were trained in both practices, and the guided recordings for at-home practice also utilised these two practices. Participants in the MM condition received MM training from a certified MBSR instructor with prior experience in leading MM courses to diverse audiences (e.g. lay people, researchers, health professionals). Participants practiced in classes of approximately 20–25 people. Training began with an overview of MM, including its origins in Buddhism and its implementation in the United States. Participants were instructed on breathing techniques and sitting positions for sitting meditation. Participants then practiced guided sitting meditation for 30 minutes. This meditation instructed participants to focus their attention on their breath and guided them to notice whether their attention had wandered and, if it had, to gently bring back their attention to their breath. Moreover, in this practice, participants were directed to breathe from their stomachs and to focus on their breath, noticing the physical sensations associated with breathing and where the sensations of breathing were strongest (e.g. back of throat, chest). After the meditation, participants engaged in a reflection of their experience during this practice and were encouraged to share their experience with the group. These discussions were focused on the emotional experience of MM as well as anything they found particularly beneficial or difficult. Following the sitting meditation practice, participants were given a short break.

After the break, participants returned and received instructions regarding a body-scan meditation. The body-scan meditation also lasted 30 minutes. During this meditation, participants were instructed to lie comfortably on a mat and begin attending to their breath. Over the course of 30 minutes, participants attended to various portions of their bodies, focusing on the bottom of their feet and slowly moving their attention through their body to the top of their head. Participants were encouraged to note any particular sensations they felt without judgment. For example, if they experienced mild pain, they were encouraged to not view this pain as negative, but simply accept that this was their experience in that part of their body at that moment. Following this practice, participants engaged in another debriefing session regarding their experience. Once both meditation practices were complete, participants were given a compact disc with a recording of the same two guided meditation activities led by the same instructor, for at-home practice. Participants were instructed to practice meditating for a minimum of 30 minutes per day and to alternate between the sitting and body-scan meditations.

Measures

Stress. The Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) was used to measure baseline stress. The PSS includes 10 items, with Likert-type scale ranges from "never" (0) to "very often" (4). For the purposes of this study, instructions directed participants to rate how much stress they had experienced in the previous week. Examples from the scale include, "In the last week, how often have you been upset because of something that happened unexpectedly?" and "In the last week, how often have you felt nervous and 'stressed'?" The PSS exhibited good internal consistency ($\alpha = .89$).

Emotion. The Circumplex Model of Affect (Feldman, 1995) was used to assess daily emotion. This model incorporates 16 items designed to assess emotion by valence and/or arousal. Emotion items included disappointed, sad, sluggish, afraid, nervous, sleepy, still, quiet, relaxed, calm, satisfied, happy, enthusiastic, peppy, aroused, and surprised. Instructions were altered to access daily rather than global emotion: Instead of rating emotion over the past few weeks, participants were asked to indicate the extent to which they experienced each of the emotion items *that day*. Emotion was rated on a slider scale from 1 to 10, with 10 indicating more of that particular emotion. This format has been used in previous studies (Lehman & Conley, 2010) and has demonstrated adequate internal consistency. Internal consistency estimates were conducted according to specifications by Cranford et al. (2006) for multilevel models and can be interpreted similarly to Cronbach's alpha. All emotion items demonstrated acceptable internal consistency (above .86) at the person level. From these emotion items, we created three measures of emotion: valence, arousal, and an interaction between valence and arousal based on Feldman's (1995) breakdown of emotion items and using a similar rational to Smyth, Zawadzki, Juth, and Sciamanna (2017). To create valence, we weighted each item by its degree of positivity or negativity. For positively valenced items, we multiplied individual scores by 1 (emotion items: peppy, enthusiastic, happy, satisfied, calm, relaxed), for moderately valenced items we multiplied individual scores by 0 (emotion items: aroused, surprised, quiet, still), and for negatively valenced items we multiplied scores by −1 (sleepy, sluggish, sad, disappointed, nervous, afraid). To create arousal, we weighted each item by its degree of arousal. For high-arousal items, we multiplied individual scores by 1 (emotion items: aroused, surprised, peppy, enthusiastic, nervous, afraid), for moderately arousing items we multiplied individual scores by 0 (emotion items: happy, satisfied, sad, disappointed), and for low-arousal items we multiplied individual scores by −1 (emotion items: calm, relaxed, quiet, still, sleepy, sluggish). The interaction term was created by multiplying valence and arousal.

Emotional Variability. To calculate emotional variability, we calculated each individual's average for emotion items based on all available daily diary ratings of emotion. Then we calculated each individual's average deviation (*iSD*) from their own mean level of emotion and averaged these to create one overall measure of emotion variability for all emotion items.

Time Spent Meditating. Participants reported whether they spent time meditating that day and, if so, how many minutes they engaged in MM that day. For analyses with emotional variability measures, we summed time spent meditating across the entire week of the study to obtain the total time spent meditating.

Data Analysis

Data were cleaned and prepared for analysis in SAS 9.4. Multilevel modeling was used for models with valence, arousal, and their interaction as the outcome variables, while multiple regression was used to examine emotional variability. All models covaried for baseline stress. Condition was dummy coded (MM = 1, control = 0). Daily valence, arousal, their interaction, and time meditating were tested at Level 1; condition, total time meditating, grand-mean centered baseline stress, person-mean emotion, and emotional variability comprised Level 2. All multilevel models exhibited significant variability in within-person emotion (see Table 1).

We tested whether being in the MM condition or time spent meditating was associated with valence, arousal, and their interaction, respectively. Below is an example equation used to examine whether the MM condition or time meditating predicted valence, arousal, and their interaction, after covarying out baseline stress. For the equations below, emotion_{ij} is valence, arousal, or the interaction between valence and arousal for person j on day i; β_{0j} is the intercept for emotion; β_{01ij} is the effect of b time spent meditating for person j on day i; e_{ji} is error

TABLE 1
Condition and Time Spent Meditating Predicting Emotion, with Baseline Stress as a Covariate

Arousal	*Mindfulness Meditation Condition Coefficient (SE)*		*Time Spent Meditating Coefficient (SE)*	
Intercept	−0.554^***	(.079)	−0.450^***	(.064)
Stress	0.148^{Ɨ}	(.076)	0.130^{Ɨ}	(.075)
Mindfulness Meditation Condition	0.016	(.108)	–	–
Time Spent Meditating	–	–	−0.005**	(.002)
Valence	*Mindfulness Meditation Condition Coefficient (SE)*		*Time Spent Meditating Coefficient (SE)*	
Intercept	0.639^***	(.107)	0.776^***	(.088)
Stress	−0.821***	(.101)	−0.857***	(.100)
Mindfulness Meditation Condition	0.250^{Ɨ}	(.145)	–	–
Time Spent Meditating	–	–	<0.001	(.003)
Interaction between Arousal and Valence	*Mindfulness Meditation Condition Coefficient (SE)*		*Time Spent Meditating Coefficient (SE)*	
Intercept	−0.269^*	(.111)	−0.207^*	(.090)
Stress	0.542***	(.105)	0.538***	(.102)
Mindfulness Meditation Condition	−0.148	(.150)	–	–
Time Spent Meditating	–	–	−0.008**	(.003)

Note: ^Indicates random slope or intercept. Degrees of freedom: within-person = 362, between-person = 98. Ɨ$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

for person j on day i; π_{00} the fixed effect for no time meditating at average levels of stress; π_{10} is the grand mean of stress; π_{11} is the effect of stress on the outcome variable. Equations took the following form:

$$\text{Level 1: Emotion}_{ij} = \beta_{0ij} + \beta_{01ij}\ (\text{Time Spent Meditating}) + e_{ji}$$

$$\text{Level 2: } \beta_{0ij} = TT_{00}$$
$$\beta_{01ij} = TT_{01} + TT_{11}\ (\text{Stress})$$

We next tested whether being in the MM condition or total time meditating was associated with decreases in emotion variability, while statistically covarying person-mean emotion and baseline stress.

RESULTS

Compliance and Descriptive Statistics

Participants provided 496 daily assessments of emotion over the course of seven days. Means and standard deviations of each emotion measure can be found in Table 2. Overall, compliance was modest. Twenty-two per cent of participants provided four or fewer (of seven) days of daily diary assessments. The number of daily dairy reports provided did not differ by condition ($t(104) = .35$, $p = .728$), indicating that those in the MM condition were not more or less compliant in providing daily assessments than those in the control condition. Compliance in providing daily diary assessments also did not differ by gender, age, baseline stress, or other baseline measures. There were no associations between number of daily diary reports and any emotion measure, nor were any of our results attenuated when covarying number of daily dairy reports provided. Total time meditating varied greatly in the MM condition ($M = 170.52$, $SD = 83.42$, range: 60, 450), with some participants reporting no at-home practice and others reporting that they had spent over an hour each day meditating.

TABLE 2
Descriptive Statistics of All Emotion Measures

Emotion variable	*N*	*Mean*	*Standard deviation*
Valence	497	0.79	1.20
Arousal	497	−0.52	0.73
Valence × Arousal	497	−0.35	1.16
Disappointed	496	3.37	2.41
Sad	494	3.30	2.26
Sluggish	497	4.43	2.56
Afraid	495	2.61	2.17
Nervous	495	4.06	2.64
Sleepy	495	5.62	2.61
Still	495	4.76	2.19
Quiet	495	5.62	2.30
Relaxed	495	5.85	2.31
Calm	495	6.12	2.21
Satisfied	495	6.44	2.29
Happy	496	6.73	2.23
Enthusiastic	497	5.87	2.38
Peppy	495	5.06	2.52
Aroused	496	3.38	2.44
Surprised	496	3.02	2.30

MM and Daily Emotion

To examine whether MM was associated with decreases in higher-arousal PE, higher-arousal NE, and lower-arousal NE, and increases in lower-arousal PE (all at Level 1), we conducted multilevel regression analyses predicting valence, arousal, and their interaction from MM condition and time meditating (in separate analytic models), using baseline stress (Level 2) as a covariate. Results are shown in Table 1; effect sizes (percentage of variance accounted for) are shown in Table 3. Being in the MM condition (Level 2) was not significantly associated with arousal, valence, or their interaction. Daily time spent meditating (Level 1) significantly predicted lower arousal emotions. Time spent meditating was also significantly associated with the interaction between valence and arousal. To examine the interaction, we individually tested time spent meditating predicting each emotion item. More time spent meditating was significantly associated with increased feelings of quiet (b = .02, SE = .01, p < .001) and calm (b = .02, SE = .01, p = .002) and marginally increased feelings of being relaxed (b = .01, SE = .01, p = .065) and sleepy (b = .01, SE = .01, p = .068). Time spent meditating was not significantly associated with any other emotion items (i.e. disappointed, sad, sluggish, afraid, nervous, still, satisfied, happy, enthusiastic, peppy, aroused, and surprised).

MM and Emotional Variability

To examine whether MM was associated with emotional variability, we conducted multiple regression analyses predicting person-level emotional variability

TABLE 3
Proportion of Variance Accounted for in Multilevel Models Predicting Emotion by Condition and Time Spent Meditating, with Baseline Stress as a Covariate

Outcome variable	*Between-person variance explained by Mindfulness Meditation Condition*	*Within-person variance explained by Mindfulness Meditation Condition*
Valence	2.20%	0.47%
Arousal	0.00%	0.00%
Valence × Arousal	0.00%	0.28%
Outcome variable	*Between-person variance explained by Time Spent Meditating*	*Within-person variance explained by Time Spent Meditating*
Valence	0.00%	2.65%
Arousal	0.00%	0.11%
Valence × Arousal	0.00%	0.13%

from being in the MM condition and total time spent meditating, covarying person-mean emotion and baseline stress. There were no statistically significant associations between being in the MM condition and emotion variability ($b = -.03$, $SE = .06$, $p = .589$) or between total time spent meditating and any emotion variability measure ($b < .01$, $SE < .01$, $p = .244$).

DISCUSSION

This study examined the association of an MM intervention on experienced emotion in daily life, with a focus on differentiating emotions by valence and arousal, as well as exploring the effects of MM on emotional variability. To our knowledge, only two studies have examined the effect of an MM intervention on emotions by arousal and valence, and no other studies have examined the effect of MM on emotion variability in daily life. Based on limited empirical findings and theory, we predicted that MM would increase low-arousal PE items but could decrease higher-arousal PE, higher-arousal NE, and lower-arousal NE items. We examined the effects of the MM condition, and of daily time spent meditating on emotion weighted by arousal, emotion weighted by valence, and the interaction of arousal and valence. More daily time spent meditating was associated with lower arousal emotions, and with the interaction between arousal and valence. To better understand these effects, we examined each emotion item individually and found that more daily MM practice was significantly associated only with increased feelings of quiet and calm, and was marginally associated with increased feelings of being relaxed and sleepy. We interpret these results to indicate that MM practice promoted daily low-arousal PE. In contrast to our hypothesis, however, MM training exhibited no significant effects on daily high-arousal PE, high-arousal NE, or low-arousal NE items. Based largely on theory and related empirical findings, we also predicted that MM training would be associated with less emotional variability regardless of valence or arousal. However, MM was not significantly associated with emotional variability. Overall, the present study provides preliminary evidence demonstrating the importance of separating emotion by arousal when examining the effects of MM interventions, particularly for PE.

Most studies examining the effects of MM on PE have focused on high-arousal PE, with inconsistent results (e.g. as to the directionality of the effects). However, the few studies that have used primarily low-arousal PE items suggest that MM may increase feelings of peace (Bower et al., 2015), hope (Sears & Kraus, 2009), and other low-arousal positive emotions (Fredrickson et al., 2008). We found that more time spent meditating led to greater low-arousal PE in daily life, but did not influence high-arousal PE. These results highlight the importance of examining low-arousal PE separately from high-arousal PE. This is particularly important because increased low-arousal PE may be a potential mechanism of MM in promoting health and well-being. Mechanistic theories suggest that MM may exhibit beneficial effects in part by mitigating physiological stress responses and that PE plays a critical role in this mitigation (Creswell & Lindsay, 2014; Garland et al., 2010). High-arousal PE is sometimes associated with increased sympathetic arousal (e.g. heart rate, blood pressure; Pressman & Cohen, 2005), whereas low-arousal PE may be more likely to dampen sympathetic responses. Although speculative, the results of this study, together with theory and extant evidence, suggest that the promotion of low-arousal PE may be an important mechanism by which MM can exert salubrious effects.

MM did not decrease high-arousal PE (which included feelings of peppiness, enthusiasm, or happiness) in the present research. This is in contrast to most theoretical perspectives (e.g. Chambers et al., 2009; Hayes & Feldman, 2004) and two studies which suggested that MM might decrease high-arousal PE (Arch & Craske, 2006; Lalot et al., 2014). Both of the latter interventions were very brief, and examined elicited emotions (that is, participants provided emotional responses to pictures or videos). Thus, it is possible that MM is effective in down-regulating high-arousal PE only immediately following meditation. This pattern may be especially true in Western societies, where high-arousal PE may be more idealised and where the experience of high-arousal PE may be higher (Koopmann-Holm et al., 2013; Tsai, Knutson, & Fung, 2006).

Negative Emotion

There are robust theoretical expectations that MM should decrease over-engagement in high-arousal emotions (Chambers et al., 2009; Hayes & Feldman, 2004). As such, our finding that high-arousal NE items (assessed by the adjectives nervous and afraid) were not reduced by MM training was unexpected, and inconsistent with our predictions. There are several reasons for the finding that this MM intervention did not influence high-arousal NE items. First, it could be that it takes more time and practice for MM practitioners to develop the ability to down-regulate responses to events that elicit fear or anxiety (Adele & Greg, 2004). Second, most participants in the present study reported relatively low levels of high-arousal NE, raising concerns about floor effects. Indeed, the most frequent responses were not feeling afraid or nervous at all that day (49% and 22% of days, respectively). Our study specifically targeted those without a recent history of depression or anxiety. As noted by Creswell and Lindsay (2014), MM may be more effective in reducing high-arousal NE for those who more frequently experience these emotions, such as in clinical samples. Finally, our measurement of high-arousal NE was narrow (i.e. nervous, afraid), and did not include other high-arousal negative emotion items (e.g. anger). It may be that MM exhibits more robust effects on broader conceptualisations of high-arousal NE.

We also did not observe the decrease in low-arousal NE (assessed by adjectives such as sluggish, sad, and disappointed) that we expected based on past research, which has suggested that MM may decrease sadness and depression (Sedlmeier et al., 2012). MM theory has previously focused on high-arousal emotions; theoretical predictions are ambiguous as to whether MM should in fact decrease low-arousal NE or whether it merely increases acceptance of low-arousal NE (see Koopmann-Holm et al., 2013). Additionally, some researchers have suggested that MM exhibits stronger ameliorative benefits in clinical or high-stress populations (Creswell & Lindsay, 2014). Overall, our findings with NE are consistent with a growing body of literature which suggests that MM may not decrease NE in healthy samples (Creswell & Lindsay, 2014; Hofmann, Sawyer, Witt, & Oh, 2010). More work is this area is necessary before definitive claims can be made.

Emotional Variability

In the present study, MM was not associated with decreases in emotional variability. Thus, our expectation that MM would reduce emotional variability across all levels of valence and arousal was not supported. Some researchers have suggested that the effect of MM on emotion regulation may differ by practice and experience (Chiesa et al., 2013). It may be that more experienced practitioners exhibit a greater ability to regulate emotions with less effort than novices, although not all studies report this distinction in ability by MM experience (Taylor et al., 2011). However, it is also possible that a one-week MM training intervention does not provide adequate practice time to decrease emotional variability across all levels of arousal and valence. This is potentially important for future studies to consider because previous research has suggested that emotional variability, and particularly PE variability, is associated with health-relevant outcomes. Specifically, those with lower PE variability report better health and well-being (Gruber et al., 2013; Houben, Van Den Noortgate, & Kuppens, 2015; Human et al., 2015) over and above person-mean emotion. Thus, it is possible that longer MM interventions may influence health and well-being in part through promoting emotional stability; this intriguing possibility warrants further research. We encourage researchers to examine emotional variability and other emotion dynamics in MM interventions of longer duration, using daily diary and ecological momentary assessment designs.

Taken together, the findings from the present study may help clarify the effects of a brief MM training intervention in a sample of healthy young adults. That such MM training may increase low-arousal PE but not high-arousal PE is informative because it suggests that MM may differentially influence PE based on arousal. Although these findings will need to be replicated, and tested with longer interventions, this study provides novel evidence that one reason for discrepant results with PE may be due to differential effects on PE by arousal.

Limitations

There are several limitations to the present study. First, MM practice in this study occurred over a one-week time period. Although the average time spent meditating in the present study was comparable to other studies examining the effects of short-term MM interventions on health and well-being outcomes (Ditto, Eclache, & Goldman, 2006; Tang et al., 2007), this one-week period limited training and practice time, and did not allow for the examination of lingering effects of MM training. Previous research indicates that more time spent meditating and longer MM interventions that involve relatively extensive training are more powerful in elucidating potential effects (Baer, Carmody, & Hunsinger, 2012), as a number of the effects of MM may require substantial practice time or take longer than one week to be seen. It may be that the effects of MM on most emotions are only seen over a longer timeframe. This said, longer studies have also found null effects of MM on emotion (Barrett et al., 2012; Delgado et al., 2010; Koopmann-Holm et al., 2013), whereas a number of short-term meditation interventions have changed emotional states in other populations (Hutcherson, Seppala, & Gross, 2008; Tang et al., 2007), highlighting the complexity of the effects of MM on emotion. Nevertheless, it is a possibility that changes in high-arousal PE, high-arousal NE, and low-arousal NE require more time to cultivate than changes in low-arousal PE, which would be an interesting topic for future investigation.

In addition, generalisability of the present research is limited. Participants enrolling in the study were aware that it incorporated an MM intervention. Sampling bias is a possibility, as participants who value outcomes associated with MM interventions may have been disproportionately likely to enroll in the study. Additionally, the results of this study are specific to novice meditators because we specifically excluded potential participants who already had substantial experience in MM. Generalisability is also limited by the measures of emotion that we assessed. That is, MM may differentially influence other high- and low-arousal NE and PE states, such as anger, pride, love, etc. Future studies should include more varied emotion measures to corroborate the findings observed here.

Finally, largely due to budgetary constraints, the present study used a passive waitlist control condition rather than an active control condition. The use of an active control condition would bolster confidence that the results seen here were due to the specific effects of MM (as opposed to being in any intervention). Future work should incorporate active controls to determine whether effects such as observed here are unique to MM interventions.

CONCLUSION

Although more studies are needed before drawing definitive conclusions, the present study suggests that examination of low-arousal PE separately from high-arousal PE and as a mechanism of MM effects is warranted. This is particularly important when examining the effects of MM on health outcomes, as high-arousal PE may not always be optimal for health (Pressman & Cohen, 2005; Ritz, Steptoe, DeWilde, & Costa, 2000), and low-arousal PE may provide unique benefits for both clinical and non-clinical samples. Replications and extensions to the present study will further understanding of how MM exerts salubrious effects in promoting health and well-being.

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