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Mindfulness meditation and reduced emotional interference on a cognitive task

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Abstract The effect of mindfulness meditation (MM) on attentional control in emotional contexts was examined. In Study 1, MM practitioners ($N = 28$) categorized tones presented 1 or 4 s following the onset of affective pictures. Reaction times (RTs) to tones for affective minus neutral pictures provided an index of emotional interference. Participants with more MM experience showed less interference from affective pictures and reported higher mindfulness and psychological well-being. Study 2 was a controlled, randomized experimental study in which participants ($N = 82$) received MM training, relaxation meditation (RM) training, or no intervention (waiting-list control; WLC). Behavioral, self-report, and psychophysiological measures were administered before and after a 7-week intervention period. Although both MM and RM resulted in smaller skin conductance responses to unpleasant pictures and increased well-being, reductions in emotional interference from unpleasant pictures were specific to MM. These findings indicate that MM attenuates prolonged reactivity to emotional stimuli.

Keywords Mindfulness meditation · Attentional control · Emotion · Well-being · Self-compassion

Mindfulness meditation (MM), which is derived from Eastern contemplative practices and typically involves exercises such as sitting meditation, walking meditation and body scans, is designed to cultivate continuous, clear-sighted attention to ongoing subjective experience together with an attitude of acceptance towards that experience (e.g., Bishop et al. 2004; Brown and Ryan 2003; Grossman et al. 2004; Kabat-Zinn 1990; Marlatt and Kristeller 1999). It has been argued that MM promotes behavioral flexibility (Hayes and Wilson 2003) and fosters a decenterd perspective from which subjective experiences are viewed as transient events rather than as permanent aspects of the self (Teasdale 1999; Teasdale et al. 1995).

Although the study of some other forms of meditation, such as Transcendental Meditation (Orme-Johnson 1973) and the Relaxation Response (Benson et al. 1975) has a more protracted history, the scientific examination of MM is relatively new. In the 1980s, Jon Kabat-Zinn pioneered research on Mindfulness-Based Stress Reduction (MBSR), reporting benefits for issues such as chronic pain, psoriasis, and anxiety disorders (Kabat-Zinn 1982, Kabat-Zinn et al. 1998; Miller et al. 1995). In recent years, MM has been linked to diverse salubrious effects, ranging from reduced stress in cancer patients (Carlson et al. 2001; Carlson et al. 2004) to reduced stress and improved immune function in healthy individuals (Shapiro et al. 1998; Williams et al. 2001; Davidson et al. 2003) to patterns of cortical activation that have been associated with positive affect (Davidson et al. 2003)—see Lutz et al. (2007) for a review.

Although there is much research on the benefits of MM, relatively little is known about the cognitive processes that may underlie these effects. One possibility is that MM, unlike relaxation training, teaches people to attenuate prolonged reactivity to negative stimuli. Prior research has shown that people scoring higher on a measure of mindfulness showed higher concordance between measures of implicit and explicit emotional states (Brown and Ryan

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2003). Increased awareness of affect may in turn enable individuals to moderate their response to negative stimuli. Other research in depressed patients has led to the proposition (Teasdale 1999) that metacognitive insight is a key component of change as a result of MM practice. An example of metacognitive insight is *experiencing* thoughts and feelings as events passing through the mind, rather than as facts, also called ‘decentering.’ Decentering may also enable individuals to reorient attention to current moment experience rather than continued elaborative processing of negative stimuli. This notion is consistent with anecdotal reports of MM practitioners and writings from mindfulness teachers, who suggest that psychologically distancing oneself from one’s feelings in this way allows one to return more quickly to a balanced emotional state (Kabat-Zinn 1990).

Elaborative processing of negative stimuli presumably draws on limited processing resources that might otherwise be directed towards selecting and executing an optimal response (e.g., Ellis and Ashbrook 1988). An accident witnessed while driving, for example, may capture one’s attention, and continuing to observe the scene (“rubbernecking”) may put one (and others) at risk. A mindful response—maintaining attention to the task at hand and disengaging from a negative stimulus—may permit more effective cognitive function. Reduced processing of negative stimuli may, in turn, reduce the potentially harmful long-term effects of negative emotions, including, for example, the effects of stress on immune function and physical health, and the effects of rumination on depression (e.g., Kiecolt-Glaser et al. 2002; Nolen-Hoeksema 1991).

Two studies were conducted to examine how MM affects emotional reactivity and well-being. In the first study, the relation between MM practice and reactivity to emotional stimuli and well-being was examined in a community sample of mindfulness meditators. MM practitioners with a range of duration of experience in meditation completed a number of behavioral and self-report measures. Thus, Study 1 acted as a preliminary, correlational study to test the possibility that emotional reactivity is associated with MM practice in a sample with varying durations of experience in MM. Participants with only short durations of meditation experience (as little as 1 month) were also included in the study as these are presumably people who, while they have an interest in meditation, may not yet have had enough experience to show large outcomes. However, the presence of many confounding variables, such as pre-existing personality traits and the non-specific effects of MM (e.g., relaxation, expectancy, and benefits of group membership and class participation), constrains interpretation of these findings. Thus, Study 2 was an experimental study, examining the consequences of MM training for emotional reactivity in a sample of meditation-naïve individuals who received 7 weeks of meditation classes and practice. Participants completed behavioral, physiological, and self-report measures both before and after the 7 weeks of training. Importantly, the effect of relaxation was controlled for by including a control group who practiced relaxation and body awareness. Participants were randomly assigned to MM, relaxation, or a waiting-list control group. Thus, while it was expected that both MM and relaxation classes would result in improvements in psychological well-being, it was predicted that only participants practicing MM would show an attenuation of reactivity to emotional stimuli at the end of their classes.

To assess emotional interference, the emotional interference task (EIT; Buodo et al. 2002) was employed, in which participants judge whether a tone is high- or low-pitched while viewing neutral, pleasant, or unpleasant pictures. Participants are typically slower to respond to tones when viewing unpleasant pictures compared to neutral pictures, and they are sometimes slower when viewing pleasant pictures, depending on picture content (Buodo et al. 2002). Motivational accounts (e.g., Bradley et al. 2003; Öhman et al. 2001; Pratto and John 1991) suggest that attention is automatically oriented to stimuli that have affective value because they contain information that is relevant to an individual’s needs. Thus, the slowed reaction times (RTs) are thought to reflect increased allocation of attentional resources to emotional stimuli. If MM increases attention to the current context and decreases continued processing of emotional stimuli, then participants with more MM experience should be better able to disengage their attention from emotional stimuli and should show reduced emotional interference. To examine an alternative explanation, that MM simply enhances attentional control, the effect of MM on RTs during neutral pictures was also examined.

Subjective measures of emotion processing included questionnaires assessing mindfulness, personality, self-compassion, and subjective and psychological well-being, as well as a picture ratings task in which participants rated the intensity of their feelings in response to unpleasant, pleasant, and neutral pictures. In Study 2, emotional responses were also assessed physiologically, using baseline skin conductance levels and skin conductance responses to each picture.

Both a state and a trait measure of mindfulness were included in each study. Distinguishing between state and trait aspects of mindfulness is complex. It is important to consider that mindfulness may both be a state that arises naturally and one that is selected by the individual. Thus, an individual may display varying degrees of mindfulness at different points in time. Furthermore, some individuals may have a greater tendency to engage mindfully in their activities (whether entering that state naturally or through choice). In this way, mindfulness can also be conceptualized as a trait. Individuals who are predisposed to be more mindful might show better performance on measures of attentional control and emotion regulation. The regular practice of meditation may enhance this trait, allowing individuals to enter the state of mindfulness more easily and with increasing frequency. In highly experienced meditators, this state may be entered into or chosen more often and/or with greater efficiency than in novice meditators. Inclusion of a state measure of mindfulness allowed us to establish the degree to which participants were voluntarily able to enter a state of mindfulness. In contrast, the trait measure of mindfulness provided an indicator of the extent to which participants generalized their practice of mindfulness to every-day life. In Study 2, these measures provided an important manipulation check, indicating whether participants actually acquired mindfulness skills as a result of their training.

In Study 1, it was predicted that increased MM experience would be associated with increases in self-reported mindfulness and subjective and psychological well-being (e.g., Bishop et al. personal communication; Brown and Ryan 2003; Davidson et al. 2003). It was also expected that, if mindfulness leads to more rapid recovery from an emotional response (i.e., a faster return to baseline), MM experience would be associated with decreased interference from emotional pictures on the EIT. On the picture ratings task, participants view each picture for a full 6 s, by which time it may be expected that their emotional response will have diminished. Furthermore, mindfulness scores on the questionnaire measures should predict performance on the EIT and PRT, with increasing mindfulness being associated with lower interference and lower intensity ratings. Mindfulness scores should also be positively correlated with well-being, and negatively correlated with neuroticism.

Study 1

Methods

Participants

Participants were recruited from local Buddhist meditation centers in Toronto and through word of mouth. A total of 28 meditators, with varying degrees of experience in MM, from 1 month to 29 years, participated. All participants practiced MM, having received training from either a Tibetan (Shambhala) or Vipassana perspective. Participants ranged in age from 19 to 71 (mean age 35.9 years) and included 15 women and 13 men.

Measures

Emotional Interference Task (Buodo et al. 2002). Participants viewed 20 neutral and 20 arousing (10 pleasant and 10 unpleasant) scenes from the International Affective Picture System (IAPS) (Lang et al. 2001), in random order, for 6000 ms each. There was a 1 s interstimulus interval (ISI) between picture presentations. At either 1,000 ms (1 s stimulus onset asynchrony (SOA)) or 4,000 ms (4 s SOA) after picture onset, a high- or low-pitched tone was presented. Participants pressed a button as quickly as possible to indicate whether the tone was high or low. Emotional interference was calculated separately for pleasant and unpleasant pictures by subtracting the mean RTs to tones for neutral pictures from the mean RTs for pleasant and unpleasant pictures.

Picture Ratings Task (PRT). Participants viewed 12 pictures for 6,000 ms each. Four neutral, 4 pleasant, and 4 unpleasant pictures from the IAPS were presented in a random order. The pictures were different from those used in the EIT. For each picture, participants rated the picture from 1 to 9 in terms of intensity of feelings (1 being not intense at all, 9 being extremely intense). There was a 12 s ISI between the end of the ratings and the onset of the subsequent picture.

Toronto Mindfulness Scale (TMS) (Bishop et al. 2003, unpublished manuscript). The TMS employed in the current study was a pilot version of the currently published TMS (Lau et al. 2006). It is a 10-item scale that assesses state awareness of bodily sensations, thoughts, and feelings as well as the approach of curiosity, acceptance, and openness with respect to these phenomena (e.g., "I remained open to whatever thoughts and feelings I was experiencing"). The ratings given by a respondent were based on an immediately preceding meditation session. Thus, participants were first told, "For the next 15 min, please pay attention to your breathing and anything that might arise in your experience." Subsequently, they were asked to complete the TMS in reference to their experience during that time period by rating the statements on a 5-point scale from 0 (not at all) to 4 (very much). A total score was obtained, with higher scores indicating higher mindfulness.

Mindful Attention Awareness Scale (MAAS) (Brown and Ryan 2003). The MAAS consists of 15 items regarding levels of attention and awareness in daily life (e.g., "I could be experiencing some emotion and not be conscious of it until some time later"). Respondents noted how frequently each statement applies to them on a 6-point scale from 1 (almost always) to 6 (almost never). A mean score over the 15 items was calculated, with higher scores reflecting greater mindfulness.

Scales of Psychological Well-Being (SPWB) (Ryff and Keyes 1997). The SPWB is a 46-item measure of psychological well-being (i.e., development with regards to the existential challenges of life [Keyes et al. 2002]) that assesses 6 domains: Autonomy, Environmental Mastery, Personal Growth, Positive Relations with Others, Purpose in Life, and Self-Acceptance. Responses were made on a 6-point scale (1 = strongly disagree, 6 = strongly agree). A total score on each of the 6 domains was calculated.

Positive Affect Negative Affect Scale (PANAS) (Watson et al. 1988). The PANAS consists of 20 affective descriptors (e.g., "enthusiastic", "jittery"). For each descriptor, respondents rated on a 5-point scale from 1 (very slightly or not at all) to 5 (extremely) the extent to which they have experienced the described affective state during the past few weeks. Mean scores were generated for positive and negative affect.

Satisfaction With Life Scale (SWLS) (Pavot and Diener 1993). The SWLS consists of 5 items assessing an individual's global evaluation of life satisfaction (e.g., "So far I have gotten the important things I want in life"). Participants responded on a 7-point scale (1 = strongly disagree, 7 = strongly agree). A total score on the scale was computed, with higher scores representing greater satisfaction.

Subjective Vitality Scale (SVS) (Ryan and Frederick 1997). The SVS is a measure of psychological well-being consisting of 7 items regarding aliveness and energy (e.g., "I have energy and spirit."). Participants rate each item on a scale from 1 (not at all true) to 7 (very true). A mean score across all items is computed.

Self-Compassion Scale (Neff 2003). The self-compassion scale consists of 26 items assessing 'self-kindness' (e.g., "I try to be understanding and patient towards those aspects of my personality I don't like"), 'self-judgment' (e.g., "I can be a bit cold-hearted to myself when I'm experiencing suffering"), 'common humanity' (e.g., "I try to see my failings as part of the human condition"), 'isolation' (e.g., "When I think about my inadequacies it tends to make me feel more separate and cut off from the rest of the world"), 'mindfulness' (e.g., "When I'm feeling down I try to approach my feelings with curiosity and openness"), and 'over-identification' (e.g., "When I fail at something important to me I become consumed by feelings of inadequacy"). Participants rated how often they act in the manner described in each item on a scale from 1 (almost never) to 5 (almost always). A total score on the scale was calculated by reverse-scoring the self-judgment, isolation, and over-identification items and summing the means from all 6 subscales.

Big Five Inventory (John and Srivatsava 1999). The BFI is a 44-item personality measure consisting of 5 subscales—extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience. Respondents rated on a scale from 1 (disagree strongly) to 5 (agree strongly) the degree to which they agree with statements such as, "I see myself as someone who… is helpful and unselfish with others." Mean scores on each of the 5 subscales were calculated.

Procedure

Upon entering the laboratory, participants completed an informed consent form. Participants then completed the PRT followed by the EIT. For all tasks, practice trials were completed in the presence of the experimenter to ensure correct understanding of the task requirements. Participants then completed the tasks alone. The experimenter then returned to the room to give participants the questionnaire measures, starting with the TMS, which included a 15-min period before which participants were instructed, "For the next 15 min, please pay attention to your breathing and anything that might arise in your experience."

Results

Reliability coefficients were calculated for all scales for the current sample. Current sample alphas were as follows: BFI-N: 0.87; MAAS: 0.81; TMS: 0.73; SPWB: 0.91; Self-Compassion: 0.88; PANAS-Neg: 0.90; PANAS-Pos: 0.76; SWLS: 0.66; SVS: 0.75.

Interference scores were computed on the EIT by subtracting RTs to early and late tones during neutral pictures from RTs for unpleasant and pleasant pictures separately. In order to examine the relation between duration of practice and the behavioral and questionnaire measures, partial Pearson correlations were computed, controlling for age to control for the possible confounding effects of age.

Initial analyses were also completed to examine the effects of gender on all measures. There was a significant difference between scores of men and women on the SWLS, the SVS, and the PRT intensity ratings for unpleasant pictures [$t(25) = 2.3$, $P < .05$, $t(25) = 2.3$, $P < .05$, and $t(24) = 2.1$, $P < .05$, respectively]. Thus, gender was controlled for in all analyses involving these measures.

Correlations between duration of experience and behavioral and subjective measures

The distribution of participants' self-reported duration of practice in months showed strong positive skew (one participant had 348 months experience, with all other participants showing between 1 and 120 months experience), so a log transformation was computed, resulting in a normal distribution.

On the EIT, there was no significant correlation between duration of experience and RTs during neutral pictures for either the 1 s or the 4 s SOA [$r = -.27$, $N = 28$, n.s., and $r = -.19$, $N = 28$, n.s., respectively]. However, an increased duration of experience was negatively correlated with interference scores for unpleasant pictures for the 1 s and 4 s SOA, and for pleasant pictures for the 4 s SOA only, indicating reduced emotional interference for individuals with more MM experience (Table 1). There was no significant association between duration of experience and intensity ratings for unpleasant pictures, although there was a trend towards significance for pleasant pictures. Duration of MM experience was found to be significantly and positively correlated with mindfulness for the TMS, with the association approaching significance for the MAAS. Among the questionnaire measures assessing personality and well-being, duration of experience was only significantly correlated with the SPWB, with participants with a greater duration of MM experience showing higher ratings of psychological well-being.[1]

Table 1 Study 1: correlations among duration of experience, mindfulness scales, and behavioral and questionnaire measures, controlling for age

	Duration of experience (log-months)	TMS	MAAS
Mindfulness			
MAAS	0.31†	0.13	–
TMS	0.47*	–	0.13
EIT			
Unpleas 1 s SOA	−0.39*	−0.48**	−0.07
Unpleas 4 s SOA	−0.58**	−0.35*	0.15
Pleas 1 s SOA	−0.16	−0.36*	−0.09
Pleas 4 s SOA	−0.38*	−0.18	−0.08
PRT—intensity			
Unpleasant	−0.05	0.04	0.16
Pleasant	0.32†	0.01	−0.04
Neuroticism			
BFI-N	−0.20	0.11	−0.51**
Well-being			
SPWB	0.47*	0.01	0.59**
Self-C	0.24	−0.11	0.62***
PANAS-Neg	−0.07	0.05	−0.50**
PANAS-Pos	0.23	−0.07	0.31†
SWLS	0.08	−0.16	0.51**
SVS	0.23	−0.12	0.47*

† $P < .10$; * $P < .05$; ** $P < .01$; *** $P < .001$

Note. MM = mindfulness meditation; RM = relaxation meditation; WLC = waiting-list control; TMS = Toronto Mindfulness Scale; MAAS = Mindful Attention Awareness Scale; SPWB = Scales of Psychological Well-Being; SWLS = Satisfaction With Life Scale; PANAS = Positive Affect Negative Affect Scale; SVS = Subjective Vitality Scale; Self-C = Self-Compassion Scale; BFI = Big Five Inventory

Correlations among mindfulness and behavioral, personality, and well-being measures

Pearson correlations revealed that TMS mindfulness scores were negatively correlated with emotional interference on the EIT for unpleasant pictures at the 1 s and 4 s SOA and for pleasant pictures at the 1 s SOA, indicating that more mindful participants experienced less interference from emotional stimuli (Table 1). TMS scores were not significantly correlated with any of the subjective measures of well-being or personality. In contrast, while MAAS mindfulness scores did not correlate with EIT performance, they were significantly and positively correlated with measures of well-being—psychological well-being, self-compassion, vitality and satisfaction with life—and negatively correlated with neuroticism and negative affect.

Discussion

In accordance with our predictions, MM experience was associated with reduced interference from unpleasant pictures on the EIT, for tones occurring at both the short and long SOAs (1 and 4 s), and reduced interference from pleasant pictures for tones occurring at the longer SOA only. However, there was no association between duration of MM experience and a simple measure of attentional control (RTs during neutral pictures) in the current study. These findings suggest that MM practice attenuates prolonged reactivity to emotional stimuli. By maintaining attention to the current moment, experienced MM practitioners are able to disengage their attention more rapidly from emotionally provocative (yet, in the case of the EIT, inconsequential) stimuli, freeing up attentional resources to perform the simple cognitive task of responding to the tones. MM experience also predicted psychological well-being, a measure of an individual's development with regards to the existential challenges of life, including pursuing meaningful goals, personal growth, and establishing relationships with others (Ryff and Keyes 1995).

[1] When correlations were computed on the untransformed data, the correlation between duration of experience and emotional interference on the EIT approached significance for unpleasant pictures for the 1 s [$r = -.28$, $P < .10$] and 4 s SOA [$r = -.28$, $P < .10$] and for pleasant pictures for the 4 s SOA [$r = -.30$, $P < .10$]. The correlation between duration of experience and mindfulness was significant for the MAAS [$r = .45$, $P < .05$] and approached significance for the TMS [$r = .34$, $P < .10$]. There was also a significant correlation with neuroticism [$r = -.36$, $P < .05$] and correlations approaching significance with SPWB and Self-Compassion [$r = .32$, $P < .10$ and $r = .31$, $P < .10$].

Keyes et al. (2002) distinguish between psychological well-being, and another related, but distinct, aspect of well-being: subjective well-being. Subjective well-being, here assessed by the PANAS and SWLS, refers to self-reported evaluations of affect and quality of life, and was not related to duration of MM experience.

An examination of the associations among the measures of mindfulness (TMS and MAAS) and other behavioral and subjective measures revealed an interesting pattern: while the TMS predicted reduced interference from emotional stimuli on the EIT, the MAAS showed correlations with neuroticism, self-compassion, vitality, and measures of psychological and subjective well-being. One possible explanation for these differing correlations between the MAAS and the TMS is that the MAAS focuses mostly on measuring the presence of awareness of present moment experience (Brown and Ryan 2003), while the TMS includes aspects of awareness *and* acceptance. Baer et al. (2006), in an analysis of the facets of mindfulness, found that the facet of non-judgment (acceptance) was more highly correlated with questionnaire measures of difficulties in emotion regulation than the facet of awareness.

Unfortunately, the small sample size precluded a mediational analysis of the role of mindfulness and emotional interference in mediating the relation between MM experience and well-being.

The findings of Study 1 are promising in suggesting an association between mindfulness and MM practice, on the one hand, and emotional reactivity and well-being, on the other. However, the presence of many confounding variables, such as pre-existing personality traits, limits the interpretation of these findings. Furthermore, MM may contain a number of components, including mindfulness and relaxation, which may each contribute to these beneficial effects. Study 2 was designed to address these issues.

Study 2

Study 2 involved a controlled, experimental design, to test the hypothesis that MM enhances disengagement of attention from unpleasant pictures. The battery of behavioral and self-report measures used in Study 1 was also used in Study 2, but converging, psychophysiological measures of emotional reactivity were added—skin conductance responses (SCRs) to emotional pictures and baseline skin conductance level (SCL). The complete battery was administered before (Time 1; T1) and after (Time 2; T2) a 7-week intervention period. Intervention consisted of either MM, body awareness and relaxation meditation (RM), or a waiting-list control group (WLC).

The results of Study 1 were consistent with the suggestion that MM decreases continued processing of emotional stimuli. Thus, our primary prediction in Study 2 was that the MM group, but not the control groups, should show a reduction in emotional interference from T1 to T2, with no effect of MM on a simple measure of attentional control in neutral contexts. An additional prediction was that the MM group would show increases in subjective and psychological well-being. Whereas it was expected that the RM group may also show increased subjective and psychological well-being, increased scores on questionnaire measures of mindfulness (the TMS and the MAAS) were expected to be specific to MM. Increases in mindfulness scores provided a manipulation check that MM participants were indeed learning mindfulness, but it was also expected that increases in mindfulness scores would be associated with improvements on the behavioral, subjective, and psychophysiological measures. Finally, it was expected that MM would be associated with decreased intensity ratings and SCRs for unpleasant pictures, but that both MM and RM might produce decreases in baseline SCL, indicating lower resting physiological arousal.

Method

Participants

Eighty-two paid participants from a large, urban university were randomly assigned to one of 3 groups: MM, RM, or WLC. Participants ranged in age from 19 to 44 years, with a mean age of 23. After attrition (MM, $n = 7$: RM, $n = 4$; WLC, $n = 3$), group sizes were 21, 23, and 24 for the MM, RM, and WLC groups, respectively, with 52 women and 16 men in total. There were no significant differences in rates of attrition among the 3 groups [$\chi^2(2, N = 82) = 2.0$, n.s.].

Measures

The measures were the same as in Study 1, with the addition of the collection of SCLs and SCRs during the PRT. Two electrodes were attached to the first two fingers of the participant's non-dominant hand. Signals were sampled at 20 Hz with a BIOPAC MP150 system. SCLs were collected prior to the task, and SCRs to each picture were calculated by subtracting the mean SCR (in μSiemens) for the 3 s prior to picture onset from the maximum reached during the 6 s of picture presentation.

Procedure

All participants completed the battery of measures at T1 and T2. Participants in the MM and RM groups received a

7-week course in MM or RM, respectively, as part of the experiment. WLC participants received the MM course after completion of the experiment (i.e., after T2). Courses were designed and taught by S. J. K., a yogi with an honorary M.A. in meditation from The Vishwa Unnyayan Samsad (West Bengal India, 1987) and a teacher's certificate from the International Meditation Institute in the Himalayas, where she has conducted research and taught since 1981.

The courses consisted of weekly 1.5-h classes and daily meditation practice (participants completed a daily log describing the nature and duration of their practice). The stated focus of the MM classes was to "become present to the condition of the mind, through enhanced self-awareness and adoption of a non-judgmental stance, recognizing that thoughts and emotions are not the self." The course included: developing attention, focus, and stillness through mindfulness of breathing or use of a mantra, watching thoughts and emotions with acceptance and non-judgment, attending to time between breaths/mantra, being versus doing, achieving mastery versus control of thought, making choices versus responding automatically, being in the present (noticing that thoughts are past/future based), and discussion. The focus of the RM classes was to "become present to the condition of the body, through enhanced bodily awareness, bringing the body to a place of stillness and relaxation." The course included: visualization, breathing, progressive muscle relaxation, spin breathing, attending to parts of the body that hold tension, refining attention in the body through tension/release, conducting body scans, maintaining body awareness in daily life, and discussion. Participants also completed a daily practice log, recording the duration of their daily meditation practice.

Results

Reliability coefficients were calculated for all scales for the current sample at T1. Current sample alphas were as follows: BFI-N: 0.85; MAAS: 0.84; TMS: 0.76; SPWB: 0.94; Self-Compassion: 0.92; PANAS-Neg: 0.84; PANAS-Pos: 0.83; SWLS: 0.88; SVS: 0.72.

There was no significant difference in the number of males and females in each group [MM: 19 females, 2 males; RM: 15 females, 8 males; WLC: 18 females, 6 males; $\chi^2(2) = 3.9$, n.s.]. Overall, women showed significantly higher scores on the BFI Neuroticism subscale at T1 than men [$t(66) = 2.0$, $P < .05$], so further analyses with the BFI were conducted controlling for gender.

At T1, there were no significant group differences on any measures. To examine emotional interference effects on the EIT, mean RTs to tones for neutral pictures were compared with mean RTs to tones for unpleasant and pleasant pictures, for tones occurring 1 and 4 s after picture onset. Analyses of performance on the EIT at T1 showed that unpleasant pictures produced interference at both SOAs [1 s SOA: $t(65) = 4.78$, $P < .001$; 4 s SOA: $t(65) = 3.0$, $P < .005$] (Table 2) and that the pleasant pictures only produced interference for the 1 s SOA [$t(65) = 3.1$, $P < .005$]. Drop-outs (who failed to complete the study) and completers (who completed the classes and both testing sessions) were compared for all measures at T1. No significant differences were found on the EIT, questionnaire measures, skin conductances, or picture ratings at T1. Analysis of interference effects at T2 revealed that all 3 groups showed significant interference from unpleasant pictures for the 1 s SOA, but only the RM and WLC groups showed interference for the 4 s SOA [1 s SOA: MM: $t(20) = 3.7$, $P < .01$; RM: $t(22) = 2.1$, $P < .05$; WLC: $t(23) = 2.8$, $P < .01$; 4 s SOA: MM: $t(20) = -0.1$, n.s.; RM: $t(22) = 2.0$, $P < .05$; WLC: $t(23) = 2.3$, $P < .05$].

ANCOVA analyses, with RTs during neutral pictures on the EIT at T1 as the covariate, group as the independent variable and RTs during neutral pictures on the EIT at T2 as the dependent variable, revealed no effect of group on RTs during neutral pictures, for either the 1 or 4 s SOA [$F(2,62) = 0.6$, n.s. and $F(2,62) = 0.1$, n.s., respectively].

ANCOVA analyses were conducted for the 1 s SOA and 4 s SOA, for unpleasant and pleasant pictures separately, with performance on the EIT at T1 as the covariate, group as the independent variable and performance on the EIT at T2 as the dependent variable. For both unpleasant and pleasant pictures for the 1 s SOA, and for pleasant pictures for the 4 s SOA, there was no significant effect of group on interference effects at T2 [$F(2, 62) = 1.5$, n.s., $F(2, 62) = 0.9$, n.s., and $F(2, 62) = 0.7$, n.s., respectively]. For the 4 s SOA for unpleasant pictures, the effect of group on interference effects at T2 showed a trend towards significance [$F(2, 62) = 2.3$, $P = .1$]. The power for this effect was low, 0.45.

Given our a priori predictions of reductions in interference from emotionally salient stimuli for the MM group only, planned comparisons of the change in interference effects from T1 to T2 were computed for each group

Table 2 Study 2: mean RTs in ms to tones occurring 1 s and 4 s after picture onset on the emotional interference task at T1, for different picture types (standard deviations in parentheses)

SOA	Picture type		
	Unpleasant	Neutral	Pleasant
1 s	662[a] (181)	593[b] (137)	634[a] (193)
4 s	646[a] (229)	602[b] (184)	595[b] (201)

Note. Within each row, differing alphabetical superscripts indicate significant differences, $P < .05$

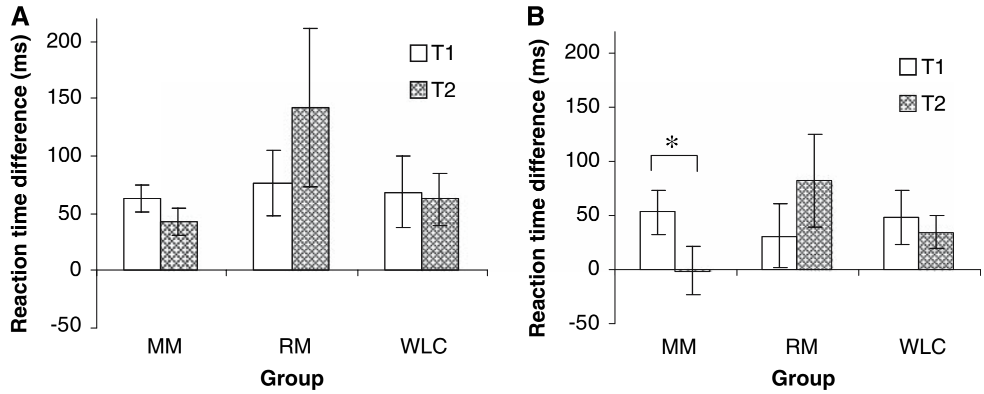

Fig. 1 Interference effects on the emotional interference task (EIT) for unpleasant pictures for the 1 s (**a**) and 4 s (**b**) stimulus onset asynchrony (SOA). Scores represent differences between unpleasant and neutral RTs. Error bars indicate standard errors. MM = mindfulness meditation, RM = relaxation and body awareness meditation, WLC = waiting-list control. Asterisk indicates significantly different values, $P < .05$

independently. Comparisons of T1 and T2 revealed that only the MM group showed a reduction from T1 to T2 in emotional interference from unpleasant pictures, and this was only significant for the 4 s SOA [1 s SOA: MM: $t(20) = 1.6$, $P = .07$; RM: $t(21) = -1.0$, n.s.; WLC: $t(22) = 0.2$, n.s.; 4 s SOA: MM: $t(20) = 1.9$, $P < .05$; RM: $t(21) = -1.2$, n.s.; WLC: $t(22) = 0.5$, n.s.] (Fig. 1). There was no significant reduction from T1 to T2 in interference from pleasant pictures for any of the groups at either SOA.

Examining the durations and frequency of practice in the MM and RM groups, there was no significant difference in either duration (total number of minutes per practice—MM mean = 655, $SD = 388$, RM mean = 532, $SD = 335$) or frequency of practice (total number of times practiced during the course of the study—MM mean = 20.8, $SD = 9.2$, RM mean = 43, $SD = 87$) [$t(42) = 1.1$, n.s. and $t(42) = 1.1$, n.s., respectively]. Furthermore, the mean amount of time practiced per day was not significantly correlated with interference scores for unpleasant pictures at the 4 s SOA for either the MM or RM groups [$r = -.11$, $N = 22$, n.s. and $r = .01$, $N = 21$, n.s., respectively].

ANCOVA analyses were conducted to examine the effect of group on questionnaire scores at T2, controlling for scores at T1. The results are shown in Table 3. Given our predictions of increased well-being as a result of MM and RM, but changes in mindfulness only as a result of MM, *t*-tests were conducted for each group separately, comparing scores at T1 with scores at T2 (Table 3). MM and RM resulted in changes in subjective and psychological well-being, but only MM resulted in increases in mindfulness and psychological well-being.

The effect of group on ratings of intensity on the PRT at T2 was examined by ANCOVA, controlling for ratings at T1. There was a significant effect of group on ratings at T2 for unpleasant pictures and the effect approached significance for pleasant pictures [$F(2,64) = 3.7$, $P < .05$, $F(2,64) = 2.4$, $P < .1$, respectively]. When changes from T1 to T2 were examined for each group separately (Fig. 2), self-reported intensity ratings for unpleasant pictures decreased significantly from T1 to T2 for the MM group only [MM: $t(20) = 3.5$, $P = .001$; RM: $t(22) = 1.1$, n.s.; WLC: $t(23) = 0.9$, n.s.]. For pleasant pictures, both the MM and RM group showed significantly reduced intensity ratings at T2 [MM: $t(20) = 2.6$, $P < .01$; RM: $t(22) = 2.3$, $P < .05$; WLC: $t(23) = -0.05$, n.s.].

Table 3 Study 2: self-report scales: main effect for ANCOVA (scores at time 2 controlling for scores at T1) and *t*-tests assessing changes from time 1 to time 2 for each group

Questionnaire	ANCOVA	*t*-Tests		
	F(2,64)	MM	RM	WLC
Mindfulness				
TMS	3.0*	4.2***	1.5	0.1
MAAS	2.5*	2.7***	1.3	0.9
Neuroticism				
BFI-N	3.3**	−2.2**	−2.4**	0.4
Well-being				
SPWB	2.9*	2.3**	0.2	1.3
Self-C	3.5**	2.9***	2.0**	0.7
PANAS-negative	1.4	−0.9	−2.2**	−0.3
PANAS-positive	1.2	0.7	0.1	−1.6
SWLS	4.1**	1.8**	1.9**	1.4
SVS	1.1	2.2**	1.9**	0.2

* $P < .10$; ** $P < .05$; *** $P < .01$

Note. Positive *t*-values reflect an increase in score from T1 to T2

MM = mindfulness meditation; RM = relaxation and body awareness meditation; WLC = waiting-list control; TMS = Toronto Mindfulness Scale; MAAS = Mindful Attention Awareness Scale; SPWB = Scales of Psychological Well-Being; SWLS = Satisfaction With Life Scale; PANAS = Positive Affect Negative Affect Scale; SVS = Subjective Vitality Scale; Self-C = Self-Compassion Scale; BFI = Big Five Inventory

ANCOVA analysis revealed no significant effect of group on baseline SCL at T2, using baseline SCL at T1 as a covariate [$F(2,59) = 0.7$, n.s.]. Examining each group separately, only the MM group showed a reduction from T1 to T2 in baseline SCL [MM: $t(19) = 2.1$, $P < .05$; RM: $t(18) = -0.3$, n.s.; WLC: $t(23) = 0.7$, n.s.] (Table 4).

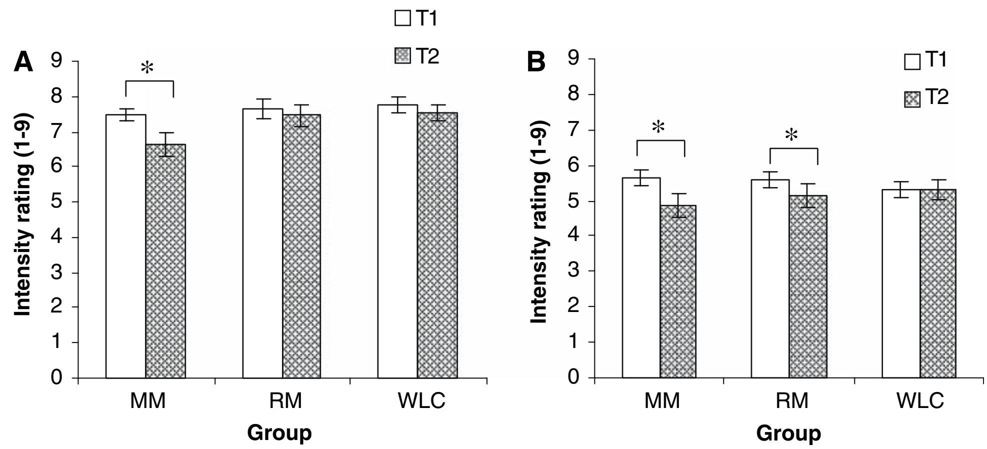

Fig. 2 Self-reported feelings of intensity for unpleasant (**a**) and pleasant (**b**) pictures. Error bars indicate standard errors. MM = mindfulness meditation, RM = relaxation and body awareness meditation, WLC = waiting-list control. Asterisk indicates significantly different values, $P < .05$

Table 4 Study 2: baseline skin conductance levels (SCLs) for each group at time 1 (T1) and time 2 (T2) (standard deviations in parentheses)

	SCL (μS)	
	T1	T2
MM	9.0[a] (5.5)	7.8[b] (5.9)
RM	7.4 (3.2)	7.6 (4.1)
WLC	7.2 (2.7)	6.7 (2.1)

Note. MM = mindfulness meditation; RM = relaxation and body awareness meditation; WLC = waiting-list control. Within each row, differing alphabetical superscripts indicate significant differences, $P < 0.05$

There was also no significant effect of group on SCRs to unpleasant and pleasant pictures at T2, controlling for SCRs at T1 [$F(2,59) = 0.7$, n.s., $F(2,59) = 1.2$, n.s., respectively]. Within-group comparisons from T1 to T2 showed that for unpleasant pictures, the MM and RM groups but not the WLC group showed reductions from T1 to T2 in maximum SCR attained [MM: $t(19) = 2.8$, $P = .01$.; RM: $t(18) = 2.9$, $P < .05$.; WLC: $t(23) = 1.2$, n.s.] (Fig. 3). For pleasant pictures, only the MM group showed significantly reduced SCRs at T2 [MM: $t(19) = 2.3$, $P = .05$.; RM: $t(18) = 0.6$, n.s.; WLC: $t(23) = -0.3$, n.s.]. There were no changes in intensity ratings or SCRs to neutral pictures for any of the groups.

Correlations among mindfulness and behavioral, personality, well-being, and psychophysiological measures

To examine correlations among the changes in behavioral, questionnaire, and psychophysiological measures, change scores from T1 to T2 were calculated by subtracting each participant's scores at T1 from their scores at T2. Pearson correlations revealed that changes in TMS and MAAS scores were positively correlated (Table 5). Furthermore, changes in both TMS and MAAS scores predicted improvements on a number of measures of personality and well-being, including psychological well-being, self-compassion, satisfaction with life, and positive affect. In addition, increases in MAAS scores correlated with reductions in neuroticism and intensity ratings for pleasant pictures, while increases in TMS scores predicted reductions in baseline SCL and SCRs to pleasant pictures.

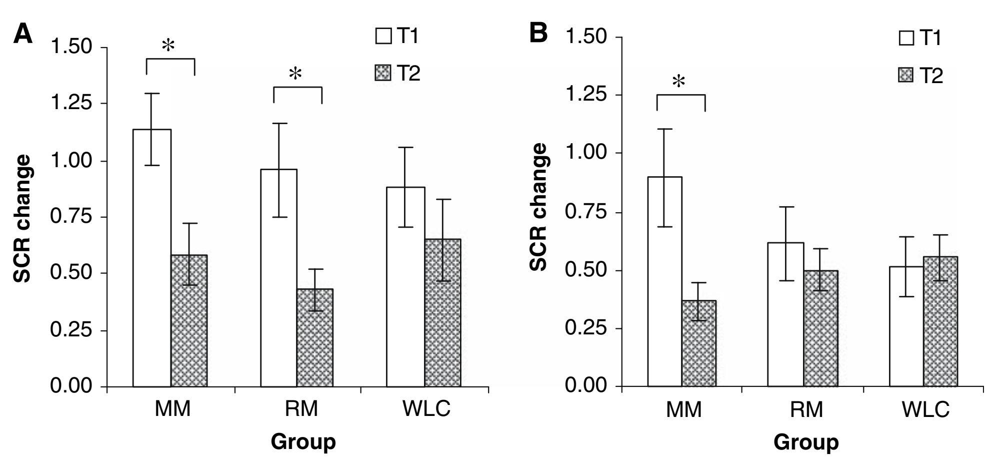

Fig. 3 Maximum Skin Conductance Response (SCR) change (in μS) during picture viewing from pre-picture baseline for unpleasant (**a**) and pleasant (**b**) pictures. Error bars indicate standard errors. MM = mindfulness meditation, RM = relaxation and body awareness meditation, WLC = waiting-list control. Asterisk indicates significantly different values, $P < .05$

Table 5 Study 2: correlations among time 1 to time 2 change scores on mindfulness scales, and behavioral, questionnaire, and psychophysiological measures

	TMS	MAAS
Mindfulness		
MAAS	0.20*	–
TMS	–	0.20*
EIT		
Unpleasant 1 s SOA	0.12	0.19†
Unpleasant 4 s SOA	0.1	−0.01
Pleasant 1 s SOA	0.07	0.02
Pleasant 4 s SOA	0.16	0
PRT—intensity		
Unpleasant	0.13	−0.05
Pleasant	−0.02	−0.21*
Neuroticism		
BFI-N	−0.14	−0.26*
Well-being		
SPWB	0.31**	0.42**
Self-C	0.27*	0.30**
PANAS-negative	−0.01	−0.18†
PANAS-positive	0.18†	0.29**
SWLS	0.22*	0.36**
SVS	0.06	0.09
Skin conductance		
Baseline SCL	−0.19†	0.05
SCR—unpleasant	−0.04	0.01
SCR—pleasant	−0.22*	−0.05

† $P < .10$; * $P < .05$; ** $P < .01$

Note. MM = mindfulness meditation; RM = relaxation and body awareness meditation; WLC = waiting-list control; TMS = Toronto Mindfulness Scale; MAAS = Mindful Attention Awareness Scale; SPWB = Scales of Psychological Well-Being; SWLS = Satisfaction With Life Scale; PANAS = Positive Affect Negative Affect Scale; SVS = Subjective Vitality Scale; SCS = Self-Compassion Scale; BFI = Big Five Inventory; SCL = Skin Conductance Level; SCR = Skin Conductance Response

Finally, an unexpected finding was a trend towards a significant correlation between change in MAAS scores and emotional interference for unpleasant pictures at the short (1 s) SOA, indicating that increases in MAAS scores were associated with increased interference.

Discussion

Only MM led to reduced interference from unpleasant stimuli on the EIT, and this reduction only occurred for tones occurring at a longer SOA (4 s). Thus, participants in all 3 groups initially oriented their attention to the unpleasant stimuli, and this processing interfered with cognitive performance for at least 1 s, but MM participants then disengaged their attention from these stimuli more rapidly than participants in the other two groups. There was no effect of MM on RTs during neutral pictures on the EIT, a simple measure of attentional control in neutral contexts. Only MM led to a reduction in self-reported intensity ratings after viewing unpleasant pictures, providing further support for the notion that an important consequence of MM practice is to interrupt the prolonged processing of negative stimuli. It is possible that by enhancing controlled attention to the current context ("the present moment"), MM minimizes redundant processing of negative stimuli. This facilitates effective cognitive function and may reduce the potentially harmful effects of negative emotions.

Only the MM group showed increased scores on questionnaire measures of mindfulness, suggesting that this group did indeed learn mindfulness skills. Both MM and RM produced improvements on a variety of self-report measures, including vitality and self-compassion, and these changes are reflected in smaller SCRs to unpleasant pictures. These findings, which are broadly consistent with previous research showing beneficial changes in stress and positive affect as a result of a Mindfulness-Based Stress Reduction (MBSR) program (e.g., Brown and Ryan 2003; Davidson et al. 2003), suggest that part of the effect of MM may indeed be attributable to relaxation or expectancy. However, the current experiment also revealed effects specific to MM, including decreases in baseline resting SCL and decreases in emotional interference on the EIT. While questionnaire measures may be particularly susceptible to demand characteristics, it is unlikely that improvements on the behavioral (emotional interference) and psychophysiological (baseline SCL) could be attributed to expectancy—or to relaxation, given that these did not change for the RM group.

One possibility is that RM also led to increases in mindfulness, which may have resulted in some of the changes in well-being in this group. However, a lack of increase in mindfulness scores on either the TMS or the MAAS suggests that participants in the RM group did not learn mindfulness skills.

Increases in mindfulness at the end of the classes were associated with improvements in well-being, including increased psychological well-being, self-compassion, positive affect, and satisfaction with life, as well as reductions in neuroticism and negative affect. Due to small group sizes, these associations were not examined separately by group, nor was it possible to test the mediating effects of mindfulness and emotional interference on well-being.

There was no significant difference between drop-outs (those who did not complete the study) and completers (those who completed the classes and both testing sessions) on any of the behavioral, subjective, or physiological measures. However, this does not preclude the possibility that participants who dropped out of the study differed in some systematic way from those who completed, thus limiting the generalizability of the findings.

General discussion

Studies 1 and 2 provide converging evidence for the effects of MM practice on emotional reactivity. First, using a correlational approach, individuals with a greater duration of MM experience showed facilitation of disengagement of attention from emotionally provocative stimuli, as measured by the EIT. Second, using an experimental design, participants who completed a 7-week course in MM showed reduced emotional interference on the EIT after training, which was not matched in the group receiving RM training or in the waiting-list control group. In both studies, MM was also associated with enhanced psychological well-being.

These findings add to previous experimental research on the benefits of MM, including evidence of an augmentation of left versus right anterior brain activation, as well as self-reported reductions in negative affect and anxiety after participation in an MBSR program (Davidson et al. 2003). The current studies build on this finding by demonstrating measurable behavioral changes in emotional interference, which in turn could contribute to changes in well-being. In the real world, reduced emotional interference may have a number of beneficial outcomes, including, for example, reducing the tendency to ruminate on negative events (one of the factors involved in maintaining depression), increasing emotion regulation and the ability to problem-solve in situations provoking anger, increasing attentional control in those who frequently encounter traumatic situations (e.g., paramedics on the scene of an accident), and increasing ability to manage stress in general.

The effect of MM on interference from emotional stimuli was only observed for unpleasant pictures in Study 2, but for both pleasant and unpleasant pictures in Study 1. This is consistent with the possibility that MM practitioners may, at least initially in their practice, target the management of unpleasant subjective experiences. However, in Study 2, the lack of an initial T1 interference effect from pleasant pictures for tones presented at 4 s effectively precluded observing potential reductions in interference from T1 to T2. Other studies have also suggested that attentional resources allocated to pleasant and unpleasant stimuli are not equivalent, perhaps because rapid detection and processing is less canalized for pleasant stimuli (Buodo et al. 2002; Ito et al. 1998; Pratto and John 1991). Future research will be required to assess whether the demonstrated effects of MM on emotional interference are in fact specific to negative stimuli and whether they extend to positive stimuli with increasing experience in MM.

Similarly, the reduction in emotional interference was observed only for pictures occurring at the 4 s SOA in Study 2, whereas Study 1 was suggestive of an effect at both the early (1 s) and late (4 s) SOAs. Perhaps the longer durations of meditation experience in Study 1 (with a median of 23 months) enabled those more experienced participants to reduce emotional interference even earlier in the information processing stream.

Increases in self-reported mindfulness were associated with enhanced self-reports of well-being and self-compassion in both studies, consistent with the suggestion that mindfulness is an important outcome of MM practice that may contribute to improvements in well-being (although mindfulness as a mediating variable was not examined here due to insufficient sample sizes). However, increases in self-reported mindfulness were inconsistently related to reductions in emotional interference. TMS scores only predicted emotional interference in Study 1, and in Study 2, there was only a non-significant trend towards a positive association between increases in MAAS scores from T1 to T2 and decreases in emotional interference. Thus, our findings suggest that while MM practice can both enhance self-reported mindfulness and reduce emotional interference after only 7 weeks of training, these changes are not correlated until the practitioners have a greater duration of meditation experience (as in Study 1). Indeed, this finding concurs with a conceptualization of mindfulness as both state-like and trait-like (cf. Brown and Ryan 2003). In highly experienced meditators, the state of mindfulness may be entered into or chosen more often and/or with greater efficiency than in novice meditators. Thus, more experienced MM practitioners may be expected to perform better on measures of emotion regulation and report greater mindfulness on a more consistent basis than those who are less experienced. With more MM practice, then, a higher correlation between emotional interference and self-reported mindfulness may be observed—as in Study 1, where the median duration of experience was 23 months. In contrast, practitioners in Study 2, who received only 7 weeks of training, would be expected to show a lower correlation between trait (as indicated by emotional interference scores) and state (as measured by the TMS) mindfulness.

Importantly, the experimental approach taken in Study 2 parses out any contribution of a selection bias to the relation between MM practice and emotional interference and well-being. That is, individuals high on certain personality traits such as openness to experience may be more likely to join a meditation group and openness to experience may also be related to lower levels of emotional reactivity or superior emotion regulation abilities. Such influences were controlled for by randomly assigning participants to the three training conditions so that changes in mindfulness scores or emotional reactivity could be more readily attributed to the training itself. It is important to note, however, that participants in the study were self-selected, responding to advertisements for a study on meditation. Individuals drawn to participate in meditation classes could have certain traits that also make them most likely to benefit from it.

Another important feature of Study 2 is that by including a relaxation training group, the results lend support to the notion that MM training, and not the relaxation and body awareness techniques that are presented in conjunction with MM in many training programs, is a key component in enhancing well-being, perhaps particularly through changes in the ability to attenuate prolonged emotional reactivity to unpleasant stimuli. This is not to say that relaxation does not have benefits of its own: as was noted in the current study, the RM group experienced significant changes on measures of self-compassion and subjective well-being.

Despite controlling for the effects of relaxation, however, there are other possible mechanisms that were not addressed in these studies. An important distinction is between what is practiced and what is taught. Although the practice of the meditation techniques themselves is thought to be a driving force for change, a substantial amount of time in each class (approximately 20–30 min) was devoted to discussion of the philosophy behind the meditation practice, such as what constitutes the 'self.' One specific example is the notion that one's thoughts and emotions are transient and are not the self. This idea is one that can be taught as well as being observed directly through one's own experience and meditation practice. Thus, conceptual changes could contribute to changes in emotional flexibility, and this was not assessed in the current study. Other mechanisms leading to change, discussed in more depth by Baer (2003) and Roemer and Orsillo (2003), include exposure to unpleasant thoughts and feelings, ability to drawn upon coping skills, and acceptance of unpleasant symptoms. None of these were specifically addressed in the current studies, so while the current studies have shown that emotional flexibility is enhanced as a result of MM, the contribution of these other factors, whether in an additive or interactive fashion, must still be considered.

In summary, the current studies provide both correlational and experimental evidence that MM reduces the interfering effects of emotional (especially unpleasant) pictures on performance of a simple cognitive task—an index of the extent to which participants disengage attention from negative stimuli and focus on the task at hand. This change cannot be attributed to increases in relaxation or expectancy because although RM produced a variety of beneficial changes in Study 2, it did not affect emotional interference. The effects of MM on processing of negative stimuli may mediate observed relations between MM and various health outcomes.

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