HHS Public Access

Author manuscript

Mindfulness (N Y). Author manuscript; available in PMC 2018 December 01.

Published in final edited form as:

Mindfulness (N Y). 2017 December ; 8(6): 1623–1633. doi:10.1007/s12671-017-0735-9.

Positive Emotion Correlates of Meditation Practice: A Comparison of Mindfulness Meditation and Loving-kindness Meditation

Barbara L. Fredrickson,
Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill

Aaron J. Boulton,
Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill

Ann M. Firestine,
Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill

Patty Van Cappellen,
Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill

Sara B. Algoe,
Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill

Mary M. Brantley,
Duke Integrative Medicine, Duke University

Sumi Loundon Kim,
Office of Religious Life, Duke University

Jeffrey Brantley, and
Duke Integrative Medicine and Department of Psychiatry and Behavioral Sciences, Duke University

Sharon Salzberg
Barre, Massachusetts

Abstract

The purpose of this study was to uncover the day-to-day emotional profiles and dose-response relations, both within-persons and between-persons, associated with initiating one of two meditation practices, either mindfulness meditation or loving-kindness meditation. Data were pooled across two studies of midlife adults ($N = 339$) who were randomized to learn either mindfulness meditation or loving-kindness meditation in a six-week workshop. The duration and frequency of meditation practice was measured daily for nine weeks, commencing with the first workshop session. Likewise, positive and negative emotions were also measured daily, using the modified Differential Emotions Scale (Fredrickson, 2013). Analysis of daily emotion reports over the targeted nine-week period showed significant gains in positive emotions and no change in

Correspondence concerning this article should be addressed to Barbara L. Fredrickson, Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill, CB# 3270, Chapel Hill, NC 27599. blf@unc.edu.

negative emotions, regardless of meditation type. Multilevel models also revealed significant dose-response relations between duration of meditation practice and positive emotions, both within-persons and between-persons. Moreover, the within-person dose-response relation was stronger for loving-kindness meditation than for mindfulness meditation. Similar dose-response relations were observed for the frequency of meditation practice. In the context of prior research on the mental and physical health benefits produced by subtle increases in day-to-day experiences of positive emotions, the present research points to evidence-based practices – both mindfulness meditation and loving-kindness meditation – that can improve emotional wellbeing.

Keywords

affect; contemplative science; mental health; positive psychology; midlife

Introduction

People's day-to-day experiences of even mild positive emotions hold value as resources in the face of life's demands. Empirical evidence has shown that positive emotions can “undo” the lingering cardiovascular aftereffects of stressful experiences and negative emotions (Fredrickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000; Kraft & Pressman, 2012) and fuel resilience to adversity (Cohn, Fredrickson, Brown, Mikels, & Conway, 2009; Galatzer-Levy et al., 2013; Ong, Bergeman, Bisconti, & Wallace, 2006; Tugade & Fredrickson, 2004). Independent of changes in negative emotions, day-to-day positive emotions have been linked to reductions in depressive symptoms (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008) and remission from major depressive disorder (Geschwind, Nicolson et al., 2011).

These findings are consistent with the *broaden-and-build theory of positive emotions* (Fredrickson, 1998, 2013). This theory holds that the human capacity to experience pleasant emotions was selectively advantageous, as these states broaden momentary awareness in ways that build personal resources (e.g., resilience, social integration, mental and physical health). Ample empirical evidence supports this theory (for a review, see Fredrickson, 2013), as do longitudinal studies showing that frequent daily experiences of positive emotions forecast longevity (Steptoe & Wardle, 2012), even after accounting for the health-diminishing effects of negative emotions (Chida & Steptoe, 2008).

Even so, people are not always successful in their pursuit of positive emotional experiences in daily life. Research shows, for instance, that individuals who excessively value happiness display poorer mental health (Ford, Shallcross, Mauss, Floerke, & Gruber, 2014) and that when people deliberately try to feel more positive in the midst of a pleasant event, their efforts can backfire (Mauss, Tamir, Anderson, & Savino, 2011). By contrast, those who prioritize positivity by deliberately seeking out activities and contexts from which positive emotions may naturally arise display better mental health (Catalino, Algoe, & Fredrickson, 2014). One way that individuals might prioritize positivity within their daily routines is by maintaining a regular meditation practice.

Meditation has been increasingly studied for its ability to improve emotional wellbeing (Dimidjian & Segal, 2015). Although mindfulness-based meditation practices were first to draw sustained scientific attention (e.g., Kabat-Zinn, 1982; Segal, Williams, & Teasdale, 2002), a growing number of researchers have also investigated the effects of loving-kindness meditation (Salzberg, 1995) and closely related practices (e.g., compassion meditation). Both mindfulness and loving-kindness practices emanate from Buddhist contemplative traditions and are often taught together in a holistic approach to wellbeing (Salzberg, 2013). Because these two meditation practices deploy distinct psychological processes, they may differentially influence emotion experiences.

Mindfulness meditation (MM) involves the concentration of attention to observe, with an open and accepting attitude, the contents of consciousness within the present moment. Mindfulness-based therapies, a recent comprehensive meta-analysis concludes, have large and clinically significant effects in the treatment of anxiety and depression, which produce lasting improvements in emotional wellbeing (Khoury et al., 2013; see also Gotink et al., 2015). Most research on MM targets the alleviation of negative affect and remains silent regarding the effects of MM on positive affect. One notable exception is an experience sampling study that randomized adults with residual symptoms of major depression (N = 130) to an 8-week mindfulness-based intervention or waitlist control. It reported pre- to post-intervention increases in day-to-day positive emotions and reward responsiveness (e.g., Geschwind, Peeters, Drukker, van Os, & Wichers, 2011). Less known, at present, are the effects of MM on day-to-day positive emotions within non-clinical samples.

Loving-kindness meditation (LKM), like MM, involves the concentration of attention. Unlike MM, however, LKM involves the intentional cultivation of authentic, warm-hearted positive emotions. The scientific study of LKM has mushroomed since 2008, which marked the first published scientific studies on LKM (Fredrickson et al., 2008; Hutcherson, Seppala, & Gross, 2008). Two recent meta-analyses conclude that LKM interventions improve health and wellbeing more generally (Galante, Galante, Bekkers, & Gallacher, 2014), and, with medium effect size, positive emotions specifically (Zeng, Chiu, Wang, Oei, & Leung, 2015). LKM has also been shown to reduce depressive symptoms (Fredrickson et al., 2008), increase compassion and altruistic behavior (Jazaieri et al., 2013; Klimecki, Leiberg, Lamm, & Singer, 2013; Leiberg, Klimecki, & Singer, 2011; Weng et al, 2013), and yield functional neural plasticity in brain circuits associated with positive affect and empathy (Klimecki et al, 2013; Weng et al, 2013). Despite the surge in scientific publications on LKM, the two meta-analyses cited above conclude that research on LKM remains in “the beginning stages” (Zeng et al., 2015, p. 13) and is “underpowered” and “generally underresourced” (Galente et al., 2014, p. 1111). As such, any meta-analytic conclusions are at best provisional.

To date, only a handful of studies have directly compared MM and LKM. The largest study to do so (Feldman, Greeson, & Seville, 2010) evaluated the effects of a one-time, 15-min exposure to each practice in novice undergraduate women (N = 190). MM, relative to LKM, lowered negative affective reactivity; effects on positive emotions were not reported (Feldman et al., 2010). Two other studies that compared MM and LKM used small sample sizes and were likely underpowered. One randomized first-year college students (N = 31) to 5-weeks of training in MM or LKM and reported non-significant changes in positive and

negative affect for both practices (May, Weyker, Spengel, Finkler & Hendrix, 2014). Another, which assessed brain activity via EEG, randomized previously depressed individuals ($N = 15$) to a one-time, 15-minute exposure to either MM or LKM and found that both practices showed pre-to-post increases in left prefrontal activation, a neural pattern consistent with greater positive emotionality (Barnhoffer, Chittka, Nightingale, Visser & Crane 2010). Altogether, the evidence regarding potential differences in affective responses to MM and LKM is scant and unreliable.

Most reviews of meditation research conclude by noting widespread methodological shortcomings (Galente et al., 2014; Ospina et al., 2008; Zeng et al., 2015). Among these limitations are: (a) small sample sizes, which lead to both lower statistical power and greater baseline imbalances (May, Johnson, & Weyker, 2016); (b) failure to report participants' actual practice time despite the need to elucidate dose-response relations (Edenfield & Saeed, 2012); (c) failure to examine within-person relations, which offer insight into day-to-day processes and better match theoretical questions about change over time (Curran & Bauer, 2011; Kanning, Ebner-Priemer, & Schlicht, 2013); (d) a lack of longitudinal, randomized controlled trials (RCTs) with novice, non-clinical samples, which enable stronger inference about the effects of learning a new meditation practice; and (e) inadequate measurement of positive emotions by relying either on global, retrospective reports of happiness, or on measures (e.g., PANAS; Watson, Clark, & Tellegen, 1988) that omit the low activation positive emotions (e.g., “calm,” “relaxed,” “peaceful”) often sought by meditation practitioners (Koopmann-Holm, Sze, Ochs, & Tsai, 2013).

The current work overcomes these limitations and is motivated by three research questions: (1) Do MM and LKM each increase people's day-to-day experiences of positive emotions over time? Specifically, given the explicit focus on warm-heartedness in LKM, does it produce greater gains in positive emotions than MM? (2) Is there a dose-response relation between time spent meditating and daily experiences of positive emotions? And (3) If a dose-response relation exists, does it (a) emerge within individuals, between individuals, or both; (b) rest on the frequency of meditation practice, the duration of episodes of meditation practice, or both; and (c) differ between MM and LKM? We address these questions by pooling data from two longitudinal RCTs (identified as Study 1 and Study 2 below) and following the principles of integrative data analysis (Curran & Hussong, 2009; Hussong, Curran, & Bauer, 2013). Novice midlife adults (pooled $N = 339$) were randomized to learn either MM or LKM in a six-week workshop. In each RCT, participants reported nightly on their experiences of ten positive and ten negative emotions as well as on the time they devoted to meditation practice. We analyze nine weeks of nightly reports, which included the six-week intervention plus three weeks post-workshop. We use multilevel models to test group differences in emotion trajectories as well as in within- and between-person dose-response relations.

Method

Participants

Study 1—Participants in Study 1 were recruited in Durham and Orange counties of North Carolina via paper and electronic advertisements. Eligible participants were between 35 and

64 years old (inadvertently, three enrolled participants reported ages outside this range: 65, 65, and 67), fluent in English, new to meditation, absent any chronic illnesses or disabilities, and able to access the internet from home. Those who provided informed consent ($N = 176$) were randomized to one of three experimental conditions: mindfulness meditation (MM; $n = 63$), loving-kindness meditation (LKM; $n = 62$), or waitlist control ($n = 51$). Online supplementary material (OSM) provides recruitment details and the CONSORT Diagram (Figure S1). Given our interest here in the two meditation groups (i.e., the effects of time devoted to meditation practice), the waitlist condition is not considered further. Three participants were ultimately excluded from analyses for failing to attend any workshop sessions (2 in MM; 1 in LKM), resulting in a final sample of $N = 122$. Participants received compensation after completing various portions of a larger study on health behavior change. (Data from this larger, NIH-supported study [R01NR012899] have been reported on elsewhere [Fredrickson et al., 2015, Confirmation Study; Isgett, Algoe, Boulton, Way, & Fredrickson, 2016] and will continue to support other and related investigations.)

Study 2—Participants in Study 2 were recruited from the same region and screened with the same eligibility requirements. Those who provided informed consent ($N = 231$) were randomized to one of two experimental conditions: mindfulness meditation (MM; $n = 113$) or loving-kindness meditation (LKM; $n = 118$). Fourteen participants were ultimately excluded from analyses for various reasons (7 each in MM and LKM), resulting in a final sample of $N = 217$ (for details, see CONSORT Diagram in OSM Figure S2). Participants received compensation after completing various portions of a larger study on health behavior change. (Data from this larger, NIH-supported study [R01CA170128] have been reported on elsewhere [Rice & Fredrickson, 2016, Study 2] and will continue to support other and related investigations.) Demographic characteristics for Studies 1 and 2 are similar and shown in Table 1.

Procedure

The Institutional Review Board of the University of North Carolina at Chapel Hill approved all procedures for the two studies, which were similar in research design. In Study 1, participants joined one of two waves of data collection, with daily reports collected between August 2012 and May 2013; Study 2 required five waves, with daily reports collected between May 2013 and May 2015. Participants completed daily online reports of their emotions and meditation practice (measures described below). The current investigation drew on nine weeks of these daily reports, beginning the first day of the meditation workshop (described below) and extending three weeks after the six-week workshop ended. (A few participants started the meditations workshops a bit earlier or later due to scheduling issues. All daily data were aligned to the day of each participant's first workshop session.)

Meditation Interventions

The MM and LKM workshops were created in collaboration with meditation experts (SS, JB, MMB, SLK). The format of each was designed to be identical, using a secular, health-based format and six progressive, 1-hour small group sessions with comparable resources and encouragement for individual home practice (see OSM for details on workshop development). At the first workshop session, attendees received written outlines of each of

six sessions, including each week's homework assignment, plus audio-recordings of five 20-minute guided meditations. All attendees were instructed to cultivate a daily meditation practice, realistically benchmarked at 3-5 meditation practice sessions per week. They were encouraged (but not required) to use the guided meditations. If participants missed a workshop session, they were instructed to progress with their homework assignments nevertheless.

Mindfulness Meditation (MM)—In the context of an open and nonjudgmental attitude, the workshop instructor (SLK) presented the intention of MM as to be in the present moment. The attention of the practitioner was directed toward the contents of consciousness within the present moment. Progressively, over the six weeks, the targets of consciousness expanded, with practice directed toward breathing and hearing (Week 1), the body (Week 2), emotions (Week 3), thoughts (Week 4), and choiceless awareness (Week 5), with Week 6 reserved for review and integration. Following prior research (Shapiro, Carlson, Astin, & Freedman, 2006), the hallmark meta mechanism of MM was designed to be a fundamental shift toward “reperceiving,” defined as the ability to “disidentify from the contents of consciousness (i.e., one's thoughts [and emotions]) and view [one's] moment-by-moment experience with greater clarity and objectivity” (Shapiro et al, 2006, p. 5).

Loving-Kindness Meditation (LKM)—Likewise, in the context of an open and nonjudgmental attitude, the workshop instructor (MMB) presented the intention of LKM as to self-generate warm and friendly feelings. The attention of the practitioner was directed toward various social targets as well as to physical sensations in the heart region. Progressively, over six weeks, the social targets of loving-kindness expanded, with practice directed toward a loved one (Week 1), oneself (Week 2), an acquaintance (Week 3), a difficult person (Week 4) and all beings (Week 5), with Week 6 reserved for review and integration. The hallmark meta mechanism of LKM was thus designed to be a fundamental shift toward warmth, kindness, and connection.

Measures

Emotions—Daily emotional experiences were measured each evening in both studies via the modified Differential Emotions Scale (mDES). The mDES is a 20-item measure that assesses the degree to which respondents experience different emotions, both positive and negative, within a given time frame (Fredrickson, 2013). Ten positive emotions (amusement, awe, gratitude, hope, inspiration, interest, joy, love, pride, and serenity) and ten negative emotions (anger, shame, fear, hate, disgust, embarrassment, guilt, sadness, scorn, and stress) are assessed, each with a trio of adjective (e.g., “amused, fun-loving, or silly” or “angry, irritated, or annoyed”). For each item, participants were asked to indicate the greatest degree to which they experienced the given feelings over the past 24 hours using a 5-point scale ranging from 0 (Not at all) to 4 (Extremely). Daily positive and negative emotion scale scores were calculated by computing the mean across the 10 items within each day. Respective reliabilities (omega coefficients for between-person differences and within-person changes; Bolger & Laurenceau, 2013, p. 138-140) were .87 and .96 for positive emotions and .79 and .96 for negative emotions. See the OSM for more detail on the reliability calculations.

Meditation Practice—Two items were used to assess meditation practice. In Study 1, participants were asked whether they had engaged in any meditation since the last time they had filled out the questionnaire. If the response was “yes”, participants were then asked: “How much time (in minutes) did you spend on meditation since the last time you answered this question? If there were multiple episodes, make sure to add them all together.” If the response to the first question was “no”, the duration variable was coded with a value of 0. These two items were also included in Study 2 but differed with regard to time frame. Specifically, participants were asked about their meditation practice “in the last 24 hours.” We found little evidence that these different time frames influenced participants' responses (see analyses in OSM).

Analytic Strategy

The data were analyzed with multilevel models (e.g., Hox, 2010; Snijders & Bosker, 2012) using PROC MIXED in the SAS 9.2 software. Two-level models, with daily reports (level-1) nested within individuals (level-2), were specified with the positive and negative emotion composites serving as dependent variables in separate models.

Our model building strategy was as follows. First, linear growth curve models were estimated to examine whether positive and negative emotions increased or decreased on average over the targeted nine-week period. Differences between experimental conditions (a level-2 variable) in the linear trends were also examined. Next, the indices of daily meditation practice – either total minutes of practice or frequency of practice, modeled separately – were added to the growth curve models to investigate the dose-response relations between duration [frequency] of meditation practice and daily emotion experiences. In each model, the target meditation variable was person mean-centered (Enders & Tofighi, 2007) and entered as a predictor along with each participant's mean level of the target practice variable averaged over the nine-week period, thus corresponding to within- and between-person “dose-response relations,” respectively. The linear time effect was retained in these models to detrend the data (Curran & Bauer, 2011; Wang & Maxwell, 2015); consequently, the within-person dose-response relation was estimated after controlling for observed growth or decline in emotions over time, a potential confound. Finally, to these models we added two interaction terms, crossing experimental condition (MM vs. LKM) with the meditation practice variables (i.e., person mean-centered and average meditation practice), respectively. These terms allowed us to examine whether the within- and between-person dose-response relations differed by meditation type. We tested four final models (i.e., PE/duration, PE/frequency, NE/duration, NE/frequency). Although we use the term “dose-response” to refer to the relation between meditation practice and daily emotion experience, we recognize that the effects we report are not causal estimates of the effect of practice on positive and negative emotions.

To control for between-study heterogeneity when analyzing the pooled dataset, we adopted a fixed-effects approach (Curran & Hussong, 2009; Hussong et al., 2008) such that, in all models, study membership (Study 1 vs. Study 2) was entered as a level-2 covariate and interactions between study membership and model predictors were tested at all stages of model fitting. If significant, interactions with study membership were retained in subsequent

models. All models were estimated using restricted maximum likelihood (REML) estimation. See the OSM for details on missing data handling, model specification, and model testing.

Results

Daily Emotions and Meditation Practice

Across the targeted nine weeks, positive emotion reports were approximately equal on average between those in the MM condition ($M = 1.76$, $SD = 0.88$) and those in the LKM condition ($M = 1.79$, $SD = 0.81$), $t(337) = 0.17$, $p = .86$. The intraclass correlation coefficient (ICC) was 0.69 suggesting that approximately two-thirds of the variance in daily positive emotions was attributable to between-person differences in average positive emotion levels. Likewise, negative emotion reports did not differ between the MM condition ($M = 0.44$, $SD = 0.47$) and the LKM condition ($M = 0.45$, $SD = 0.48$), $t(338) = 0.15$, $p = .88$. Approximately one-half of the variance (ICC = 0.50) in daily negative emotions was associated with between-person differences. Compared to those in the MM condition, participants in the LKM condition reported higher daily practice duration averages (MM: $M = 13.63$, $SD = 12.53$, min = 0, max = 150; LKM: $M = 15.32$, $SD = 13.23$, min = 0, max = 200), $t(333) = 2.06$, $p = .04$. After the six-week workshops ended, participants rated their "overall satisfaction with the class" on a 1 (Poor) to 5 (Excellent) scale. Class ratings were high in both conditions (MM: Mdn = 4.5; LKM: Mdn = 4.0) with participants in the MM condition reporting somewhat more satisfaction compared to those in the LKM condition, Wilcoxon rank-sum $W = 11241$, $p = .026$.

Figure 1 displays condition-specific linear trends in the emotion and meditation practice variables. As shown in Figure 1a, positive emotions increased over the duration of the study in both experimental conditions at approximately the same rate. Negative emotions decreased slightly over time, again at approximately the same rate in each experimental condition. In the remaining plots, non-linear trends in practice duration (Figure 1b) and frequency (Figure 1c) were observed, represented by smoothed trend lines (i.e., LOESS curve; Cleveland, Grosse, & Shyu, 1992). For both duration and frequency of meditation, and in both experimental conditions, participants increased their practice time during (approximately) the first five weeks of learning meditation, followed by a decline and leveling off for the remainder of the study.

Changes in Daily Emotions

To formally assess whether participants' daily experiences of positive and negative emotions increased or decreased over the targeted nine weeks, we estimated linear growth curve models by including time (scaled in weeks and centered at individuals' first workshop session) as a level-1 predictor of the daily emotion reports. For positive emotions, the effect of time was significantly different from zero, suggesting that on average participants' daily experiences of positive emotions increased linearly over the duration of the study, $b = 0.017$, $SE = 0.002$, $p < .001$. In contrast, participants' levels of daily negative emotions did not change significantly over time, $b = -0.003$, $SE = 0.002$, $p = 0.15$. For both positive and negative emotions, initial levels (i.e., intercepts) and rates of change (i.e., slope coefficients)

varied significantly across participants, suggesting individual differences in the emotion trajectories.

Experimental condition did not significantly predict initial positive emotion levels (b = 0.014, SE = 0.077, p = 0.857), positive emotion growth rates (b = -0.0001, SE = 0.006, p = 0.992), initial negative emotion levels (b = -0.0004, SE = 0.037, p = 0.990), or negative emotion growth rates (b = 0.004, SE = 0.004, p = 0.345). Thus, regardless of whether participants practiced MM or LKM (and in the context of significant variation among individuals) they showed significant improvements in positive emotions over time with no significant changes in their negative emotions. For positive emotions, using model-implied means on the first (1.600) and last (1.753) days of the targeted nine-week period, as well as the standard deviation of the daily emotion reports during the two-week baseline period (.855) as a divisor, the within-sample standardized increase in positive emotions after nine weeks of meditation practice is approximately .179.

Dose-Response Relations

To assess the impact of time spent meditating on positive emotions, the person-mean centered and mean practice *duration* variables were added to the growth curve model. Fixed effects estimates from this model are shown in the upper left section of Table 2. Coefficients for both practice variables were positive and significantly different from zero. This reflects a within-person dose-response relation such that participants who spent more minutes meditating on a given day, compared to their own typical level of daily practice, reported greater levels of positive emotions on that day; in addition, a between-person effect emerged, such that relative to others in the sample, participants who maintained longer average lengths of practice throughout the study had higher average levels of daily positive emotions. To determine whether these dose-response relations differed across meditation type, two interaction terms were added to the model by crossing experimental condition with both duration of practice variables separately. The results revealed that, compared to the MM condition, the within-person dose-response relation was larger in the LKM condition (b = 0.003, SE = 0.001, p = .001) whereas the between-person dose-response relation did not differ between conditions (b = 0.012, SE = 0.011, p = 0.280).

Regarding negative emotions, both coefficients for the *duration* of practice variables were negative but neither was significantly different from zero (Table 2, lower left). Nevertheless, we subsequently tested whether condition differences were evident. The results suggested that, compared to the MM condition, the within-person dose-response relation was further from zero in the negative direction in the LKM condition (b = -0.002, SE = 0.001, p = .005), whereas the between-person dose-response relation did not differ between conditions (b = -0.004, SE = 0.006, p = 0.542). This pattern suggests that participants who spent more minutes engaged in LKM (vs. MM) on a given day, compared to their own typical level of daily practice, reported lower levels of negative emotions on that day.

We repeated each of the above tests for dose-response relations replacing variables that represented the *duration* of meditation practice with those reflecting the *frequency* of practice. The overall pattern of results remained largely the same (see Table 2, right columns), albeit with two minor differences: (a) the between-person relation for positive

emotions was not significantly different from zero (see Table 2); (b) for negative emotions, the within-person dose-response relation did not differ between conditions, $b = -0.029$, $SE = 0.016$, $p = .06$. Analyses of simple slopes for the significant interactions described above are provided in the OSM.

Discussion

People need evidence-based tools to improve their emotional wellbeing. The research presented here provides relevant evidence. We sought to learn whether novices who initiate a regular meditation practice experience changes over time in their day-to-day positive and negative emotions, and whether mindfulness meditation (MM) and loving-kindness meditation (LKM) differ in their emotional impact. We also sought to learn whether and how the duration and frequency of meditation practice mattered by testing for dose-response relations (a) within and between individuals, and (b) for MM and LKM practices comparatively.

We pooled data from two fairly large longitudinal RCTs, which produced a sample of 339 midlife women and men who were new to meditation. Each had been randomized to learn either MM or LKM in a six-week workshop. Results revealed that MM and LKM were similarly associated with increases in participants' day-to-day experiences of positive emotions over time. This was contrary to our expectation that LKM, given its explicit focus on warm-heartedness, would increase positive emotion trajectories at a steeper rate. Even so, the statistically significant, albeit subtle gains in positive emotions were similar in direction and magnitude to the effects observed in two prior studies that randomized participants to either LKM or a waitlist control group and used similar measures of daily emotions (Fredrickson et al., 2008; Kok et al., 2013). Even subtle gains in positive emotions, these and other RCTs suggest, may improve mental and physical health.

Results also revealed that, regardless of meditation type, the duration and frequency of practice time was related to daily emotional experiences: Significant dose-response relations emerged both within and between individuals (although the between-person effect for the frequency of practice was not significant at $p = .07$). That is, on average, when a participant reported meditating more on a given day, compared to their own average level of practice, they also reported experiencing more positive emotions that day. In addition, comparing across individuals, those who reported meditating more on average also reported higher than average positive emotions. Moreover, a significant difference emerged between MM and LKM for the within-person dose-response relations such that, relative to those practicing MM, for those randomized to practice LKM, the duration and frequency of meditation practice were more tightly coupled to same-day reports of positive emotions.

The results for negative emotions were more limited. Day-to-day negative emotions did not change over time for either MM or LKM. This null finding for LKM coincides with one of the prior RCTs mentioned above (Fredrickson et al., 2008, $N = 139$), but not the other (Kok et al., 2013, $N = 65$). Results also revealed that, regardless of meditation type, the duration and frequency of meditation practice did not appear to influence day-to-day negative emotions. The sole exception was that the within-person effect for duration of practice

differed between conditions, suggesting that, relative to MM, days with longer LKM practice (compared to individual-specific averages) were associated with *lower* negative emotion scores. We interpret effects for negative emotions with caution, however, because (as in past published studies), the negative emotion scores demonstrated a floor effect and, as a result, model residuals were not normally distributed. Although multilevel models are generally robust to model assumption violations such as residual non-normality (Maas & Hox, 2004), and robust procedures were implemented to try and remedy this issue (see OSM), it is unclear whether and to what extent floor effects impacted the results.

Strengths and Limitations

One strength of the work presented here is the focus on positive emotions, which contrasts with the focus on negative emotions in the mainstream scientific literature on MM. A second strength is the densely-repeated use of the mDES, which captures the low activation positive emotions that are especially relevant for studies of contemplative practices (Koopmann-Holm et al., 2013; Van Cappellen, Way, Isgett & Fredrickson, 2016). This work thus advances understanding of meditation by identifying positive emotions as important short-term indicators that, according to theory and past evidence, produce longer-term improvements in mental and physical health. A third clear strength of this investigation is the large sample size ($N = 339$) gained through dataset pooling. By combining datasets from two RCTs with similar designs and measures, we had the rare opportunity to study a relatively large number of participants who were randomized to one of two contemplative interventions.

Despite these many strengths, this research also has limitations. Participants were all midlife adults interested in (or open to) learning a meditation practice. Even though many individuals who begin a meditation practice may be drawn from a similar population, generalization to other age groups, or to those uninterested in meditation may be inappropriate. Likewise, MM and LKM were each taught by just one workshop instructor (who differed slightly from the other in course evaluations), so the effects of each teacher's unique pedagogical approach cannot be evaluated here. Also, the nature and cause(s) of the differing dose-response relations between MM and LKM remain unknown at this time. Finally, in this study MM and LKM were taught in group-based, face-to-face workshop sessions that progressed over six weeks. Generalization to other instruction modalities (e.g., online, telephone, self-paced) may be inappropriate.

Perhaps most significantly, although study participants were randomly assigned to experimental condition (MM or LKM), they were not randomly assigned to differing amounts of practice time. As such, although causal claims about the effects of MM vs. LKM are appropriate, such claims are *not* appropriate regarding the effects of practice time because the amount of time devoted to meditation practice was participants' own choice. These choices may have been driven by many factors, including the emotions that participants experienced that day or in previous days. In addition, the nightly reports examined here inquired about all the emotions experienced in a day, not just the emotions experienced during, or resulting from meditation practice. As such, the dose-response relations between meditation duration [frequency] and positive [negative] emotions reported

here are correlational relations, and the direction of causality (if any) between practice time and emotions remains unknown.

Future Research

Additional questions about how MM and LKM affect practitioners' emotional wellbeing point to further avenues for research. Ecological momentary assessment (EMA) of affect, for instance, may be better suited for capturing subtle or short-lived emotions that may be forgotten by the end of the day. In addition, event-contingent EMA could illuminate affect immediately before and after meditation. Investigation of moderators and boundary effects will also be useful to uncover individual differences – whether biological or psychological – that may increase or reduce the gains in positive emotions linked to meditation. For instance, recent work (that used the same sample as Study 1) reported that genetic differences related to oxytocin signaling (i.e., *OXTR* rs1042778) moderated positive emotion growth for LKM, but not MM (Isgett et al., 2016). Relatedly, another recent study found that oxytocin, administered intra-nasally in a randomized, double-blind design, elevated positive emotions (assessed implicitly and explicitly) after a one-time, 20-minute guided meditation of either MM or LKM (Van Cappellen et al., 2016). Further research is also needed to test for generalization to other populations, including clinical samples, younger and older age groups, other cultures and geographical regions, and individuals who have progressed beyond the novice stage of their meditation practice. Finally, greater understanding is needed regarding the mechanisms through which meditation may influence day-to-day positive emotions, which theory suggests may differ between MM and LKM. The mindfulness-to-meaning theory (Garland, Farb, Goldin, & Fredrickson, 2015), for instance, suggests that MM improves emotional wellbeing through the intra-individual psychological processes of decentering and positive reappraisal. By contrast, a recent extension of the broaden-and-build theory of positive emotions unpacks the complex momentary experience of love (Fredrickson, 2016) and suggests that LKM improves emotional wellbeing through the social psychological processes of other-focus and positivity resonance between and among individuals.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research was supported by two research grants awarded by the U.S. National Institutes of Health (NIH) to Barbara L. Fredrickson. These were, for Study 1, a National Institute for Nursing Research Grant (R01NR012899), an award supported by the NIH Common Fund, which is managed by the NIH Office of the Director/Office of Strategic Coordination; and, for Study 2, a National Cancer Institute Research Grant (R01CA170128). Additional support for the authors' time came from an NIH National Center for Complementary and Integrative Health Research Grant (R01AT007884) and an NIH National Institute on Aging Research Grant (R01AG048811), each also awarded to Fredrickson. These funding agencies played no role in study design, data collection, data analysis, decision to publish, or preparation of the manuscript. The authors wish to thank Susan S. Girdler for sharing laboratory space and Cara Arizmendi for her role as study coordinator. Special thanks are offered to the study participants who devoted time and energy across months to be involved in this research.

References

Barnhofer T, Chittka T, Nightingale H, Visser C, Crane C. State effects of two forms of meditation on prefrontal EEG asymmetry in previously depressed individuals. Mindfulness. 2010; 1:21–27. DOI: 10.1007/s12671-010-0004-7 [PubMed: 21125024]

Bolger, N., Laurenceau, JP. Intensive Longitudinal Methods: An Introduction to Diary and Experience Sampling Research. New York: Guilford Press; 2013.

Catalino LI, Algoe SB, Fredrickson BL. Prioritizing positivity: An effective approach to pursuing happiness? Emotion. 2014; 14:1155–1161. DOI: 10.1037/a0038029 [PubMed: 25401290]

Chida Y, Steptoe A. Positive psychological well-being and mortality: A quantitative review of prospective observational studies. Psychosomatic Medicine. 2008; 70:741–756. DOI: 10.1097/PSY.0b013e31818105ba [PubMed: 18725425]

Cleveland, WS., Grosse, E., Shyu, WM. Local regression models. In: Chambers, JM., Hastie, TJ., editors. Statistical Models in S. New York, NY: Chapman & Hall; 1992. p. 309-376.

Cohn MA, Fredrickson BL, Brown SL, Mikels JA, Conway AM. Happiness unpacked: Positive emotions increase life satisfaction by building resilience. Emotion. 2009; 9:361–368. DOI: 10.1037/a0015952 [PubMed: 19485613]

Curran PJ, Bauer DJ. The disaggregation of within-person and between-person effects in longitudinal models of change. Annual Review of Psychology. 2011; 62:583–619. DOI: 10.1146/annurev.psych.093008.100356

Curran PJ, Hussong AM. Integrative data analysis: The simultaneous analysis of multiple data sets. Psychological Methods. 2009; 14:81–100. DOI: 10.1037/a0015914 [PubMed: 19485623]

Dimidjian S, Segal ZV. Prospects for a clinical science of mindfulness-based intervention. American Psychologist. 2015; 70:593–620. DOI: 10.1037/a0039589 [PubMed: 26436311]

Edenfield TM, Saeed SA. An update on mindfulness meditation as a self-help treatment for anxiety and depression. Psychology Research and Behavior Management. 2012; 5:131–141. DOI: 10.2147/PRBM.S34937 [PubMed: 23175619]

Enders CK, Tofighi D. Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. Psychological Methods. 2007; 12:121–138. DOI: 10.1037/1082-989X.12.2.121 [PubMed: 17563168]

Feldman G, Greeson J, Senville J. Differential effects of mindful breathing, progressive muscle relaxation, and loving-kindness meditation on decentering and negative reactions to repetitive thoughts. Behaviour Research and Therapy. 2010; 48:1002–1011. doi:http://dx.doi.org/10.1016/j.brat.2010.06.006. [PubMed: 20633873]

Ford BQ, Shallcross AJ, Mauss IB, Floerke VA, Gruber J. Desperately seeking happiness: Valuing happiness is associated with symptoms and diagnosis of depression. Journal of Social and Clinical Psychology. 2014; 33:890–905. doi:http://dx.doi.org/101521jscp20143310890. [PubMed: 25678736]

Fredrickson BL. What good are positive emotions? Review of General Psychology. 1998; 2:300–319. DOI: 10.1037/1089-2680.2.3.300 [PubMed: 21850154]

Fredrickson BL. Positive emotions broaden and build. Advances in Experimental Social Psychology. 2013; 47:1–53. DOI: 10.1016/B978-0-12-407236-7.00001-2

Fredrickson, BL. Love: Positivity resonance as a fresh, evidence-based perspective on an age-old topic. In: Barrett, LF.Lewis, M., Haviland-Jones, JM., editors. Handbook of Emotions. 4th. New York: Guilford Press; 2016. p. 847-858.

Fredrickson BL, Cohn MA, Coffey KA, Pek J, Finkel SM. Open hearts build lives: Positive emotions, induced through loving-kindness meditation, build consequential personal resources. Journal of Personality and Social Psychology. 2008; 95:1045–1062. DOI: 10.1037/a0013262 [PubMed: 18954193]

Fredrickson BL, Grewen KM, Algoe SB, Firestine AM, Arevalo JMG, Ma J, Cole SW. Psychological well-being and the human conserved transcriptional response to adversity. PLoS One. 2015; 10:e0121839.doi: 10.1371/journal.pone.0121839 [PubMed: 25811656]

Fredrickson BL, Levenson RW. Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. Cognition and Emotion. 1998; 12:191–220. DOI: 10.1080/026999398379718 [PubMed: 21852890]

Fredrickson BL, Mancuso RA, Branigan C, Tugade MM. The undoing effect of positive emotions. Motivation and Emotion. 2000; 24:237–258. DOI: 10.1023/A:1010796329158 [PubMed: 21731120]

Galante J, Galante I, Bekkers MJ, Gallacher J. Effect of kindness-based meditation on health and well-being: A systematic review and meta-analysis. Journal of Consulting and Clinical Psychology. 2014; 82:1101–1114. DOI: 10.1037/a0037249 [PubMed: 24979314]

Galatzer-Levy IR, Brown AD, Henn-Haase C, Metzler TJ, Neylan TC, Marmar CR. Positive and negative emotion prospectively predict trajectories of resilience and distress among high-exposure police officers. Emotion. 2013; 13:545–553. DOI: 10.1037/a0031314 [PubMed: 23339621]

Garland EL, Farb NA, Goldin P, Fredrickson BL. Mindfulness broadens awareness and builds eudaimonic meaning: A process model of mindful positive emotion regulation. Psychological Inquiry. 2015; 26:293–314. DOI: 10.1080/1047840X.2015.1064294 [PubMed: 27087765]

Geschwind N, Nicolson NA, Peeters F, van Os J, Barge-Schaapveld D, Wichers M. Early improvement in positive rather than negative emotion predicts remission from depression after pharmacotherapy. European Neuropsychopharmacology. 2011; 21:241–247. doi: http://dx.doi.org/10.1016/j.euroneuro.2010.11.004. [PubMed: 21146375]

Geschwind N, Peeters F, Drukker M, van Os J, Wichers M. Mindfulness training increases momentary positive emotions and reward experience in adults vulnerable to depression: A randomized controlled trial. Journal of Consulting and Clinical Psychology. 2011; 79:618–628. [PubMed: 21767001]

Gotink RA, Chu P, Busschbach JJV, Benson H, Fricchione GL, Hunink MGM. Standardised mindfulness-based interventions in healthcare: An overview of systematic reviews and meta-analyses of RCTs. PLoS One. 2015; 10:e0124344.doi: 10.1371/journal.pone.0124344 [PubMed: 25881019]

Hox, J. Multilevel Analysis: Techniques and Applications. Mahway, NJ: Lawrence Erlbaum Associates; 2010.

Hussong AM, Cai L, Curran PJ, Flora DB, Chassin LA, Zucker RA. Disaggregating the distal, proximal, and time-varying effects of parent alcoholism on children's internalizing symptoms. Journal of Abnormal Child Psychology. 2008; 36:335–346. DOI: 10.1007/s10802-007-9181-9 [PubMed: 17891557]

Hussong AM, Curran PJ, Bauer DJ. Integrative data analysis in clinical psychology research. Annual Review of Clinical Psychology. 2013; 9:61–89. DOI: 10.1146/annurev-clinpsy-050212-185522

Hutcherson CA, Seppala EM, Gross JJ. Loving-kindness meditation increases social connectedness. Emotion. 2008; 8:720–724. DOI: 10.1037/a0013237 [PubMed: 18837623]

Isgett SF, Algoe SB, Boulton AJ, Way B, Fredrickson BL. Common variant in *OXTR* predicts growth in positive emotions from loving-kindness training. Psychoneuroendocrinology. 2016; 73:244–251. [PubMed: 27543885]

Jazaieri H, Jinpa GT, McGonigal K, Rosenberg EL, Finkelstein J, Simon-Thomas E, et al. Goldin PR. Enhancing compassion: A randomized controlled trial of a compassion cultivation training program. Journal of Happiness Studies. 2013; 14:1113–1126. DOI: 10.1007/s10902-012-9373-z

Kabat-Zinn J. An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation. General Hospital Psychiatry. 1982; 4:33–47. DOI: 10.1016/0163-8343(82)90026-3 [PubMed: 7042457]

Kanning MK, Ebner-Priemer UW, Schlicht WM. How to investigate within-subject associations between physical activity and momentary affective states in everyday life: A position statement based on a literature overview. Frontiers in Psychology. 2013; 4:187.doi: 10.3389/fpsyg.2013.00187 [PubMed: 23641221]

Khoury B, Lecomte T, Fortin G, Masse M, Therien P, Bouchard V, et al. Hofmann SG. Mindfulness-based therapy: A comprehensive meta-analysis. Clinical Psychology Review. 2013; 33:763–771. DOI: 10.1016/j.cpr.2013.05.005 [PubMed: 23796855]

Klimecki OM, Leiberg S, Lamm C, Singer T. Functional neural plasticity and associated changes in positive affect after compassion training. Cerebral Cortex. 2013; 23:1552–1561. DOI: 10.1093/cercor/bhs142 [PubMed: 22661409]

Kok BE, Coffey KA, Cohn MA, Catalino LI, Vacharkulksemsuk T, Algoe SB, et al. Fredrickson BL. How positive emotions build physical health: Perceived positive social connections account for the upward spiral between positive emotions and vagal tone. Psychological Science. 2013; 24:1123–1132. DOI: 10.1177/0956797612470827 [PubMed: 23649562]

Koopmann-Holm B, Sze J, Ochs C, Tsai JL. Buddhist-inspired meditation increases the value of calm. Emotion. 2013; 13:497–505. DOI: 10.1037/a0031070 [PubMed: 23356567]

Kraft TL, Pressman SD. Grin and bear it: The influence of manipulated facial expression on the stress response. Psychological Science. 2012; 23:1372–1378. DOI: 10.1177/0956797612445312 [PubMed: 23012270]

Leiberg S, Klimecki O, Singer T. Short-term compassion training increases prosocial behavior in a newly developed prosocial game. PLoS One. 2011; 6:e17798.doi: 10.1371/journal.pone.0017798 [PubMed: 21408020]

Maas CJM, Hox JJ. The influence of violations of assumptions on multilevel parameter estimates and their standard errors. Computational Statistics and Data Analysis. 2004; 46:427–440. http://dx.doi.org/10.1016/j.csda.2003.08.006.

Mauss IB, Tamir M, Anderson CL, Savino NS. Can seeking happiness make people unhappy? Paradoxical effects of valuing happiness. Emotion. 2011; 11:807–815. [PubMed: 21517168]

May, CJ., Johnson, K., Weyker, JR. Experimental approaches to loving-kindness meditation and mindfulness that bridge the gap between clinicians and researchers. In: Shonin, E.Van Gordon, W., Griffiths, MD., editors. Mindfulness and Buddhist-derived Approaches in Mental Health and Addiction. Switzerland: Springer International Publishing; 2016. p. 85-93.

May CJ, Weyker JR, Spengel SK, Finkler LJ, Hendrix SE. Tracking longitudinal changes in affect and mindfulness caused by concentration and loving-kindness meditation with hierarchical linear modeling. Mindfulness. 2014; 5:249–258. DOI: 10.1007/s12671-012-0172-8

Ong AD, Bergeman CS, Bisconti TL, Wallace KA. Psychological resilience, positive emotions, and successful adaptation to stress in later life. Journal of Personality and Social Psychology. 2006; 91:730–749. DOI: 10.1037/0022-3514.91.4.730 [PubMed: 17014296]

Ospina MB, Bond K, Karkhaneh M, Buscemi N, Dryden DM, Barnes V, et al. Shannahoff-Khalsa D. Clinical trials of meditation practices in health care: Characteristics and quality. Journal of Alternative and Complementary Medicine. 2008; 14:1199–1213. DOI: 10.1089/acm.2008.0307 [PubMed: 19123875]

Rice EL, Fredrickson BL. Of passions and positive spontaneous thoughts. Cognitive Therapy and Research. 2016; 40:1–12. DOI: 10.1007/s10608-016-9755-3

Salzberg, S. Lovingkindness: The Revolutionary Art of Happiness. Boston, MA: Shambhala Publications; 1995.

Salzberg, S. Real Happiness. New York, NY: Workman Publishing; 2013.

Segal, ZV., Williams, JMG., Teasdale, JD. Mindfulness-based Cognitive Therapy for Depression. New York, NY: Guilford Press; 2002.

Shapiro SL, Carlson LE, Astin JA, Freedman B. Mechanisms of mindfulness. Journal of Clinical Psychology. 2006; 62:373–386. DOI: 10.1002/jclp.20237 [PubMed: 16385481]

Snijders, TAB., Bosker, RJ. Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling. 2nd. London: Sage Publishers; 2012.

Steptoe A, Wardle J. Enjoying life and living longer. Archives of Internal Medicine. 2012; 172:273–275. DOI: 10.1001/archinternmed.2011.1028 [PubMed: 22332162]

Tugade MM, Fredrickson BL. Resilient individuals use positive emotions to bounce back from negative emotional experiences. Journal of Personality and Social Psychology. 2004; 86:320–333. DOI: 10.1037/0022-3514.86.2.320 [PubMed: 14769087]

Van Cappellen P, Way B, Isgett SF, Fredrickson BL. Effects of oxytocin administration on spirituality and emotional responses to meditation. Social Cognitive and Affective Neuroscience. 2016; 11:1579–1587. DOI: 10.1093/scan/nsw078 [PubMed: 27317929]

Wang L, Maxwell SE. On disaggregating between-person and within-person effects with longitudinal data using multilevel models. Psychological Methods. 2015; 20:63–83. DOI: 10.1037/met0000030 [PubMed: 25822206]

Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology. 1988; 54:1063–1070. DOI: 10.1037/0022-3514.54.6.1063 [PubMed: 3397865]

Weng HY, Fox AS, Shackman AJ, Stodola DE, Caldwell JZ, Olson MC, et al. Davidson RJ. Compassion training alters altruism and neural responses to suffering. Psychological Science. 2013; 24:1171–1180. DOI: 10.1177/0956797612469537 [PubMed: 23696200]

Zeng X, Chiu CPK, Wang R, Oei TPS, Leung FYK. The effect of loving-kindness meditation on positive emotions: A meta-analytic review. Frontiers in Psychology. 2015; 6:1693.doi: 10.3389/fpsyg.2015.01693 [PubMed: 26579061]

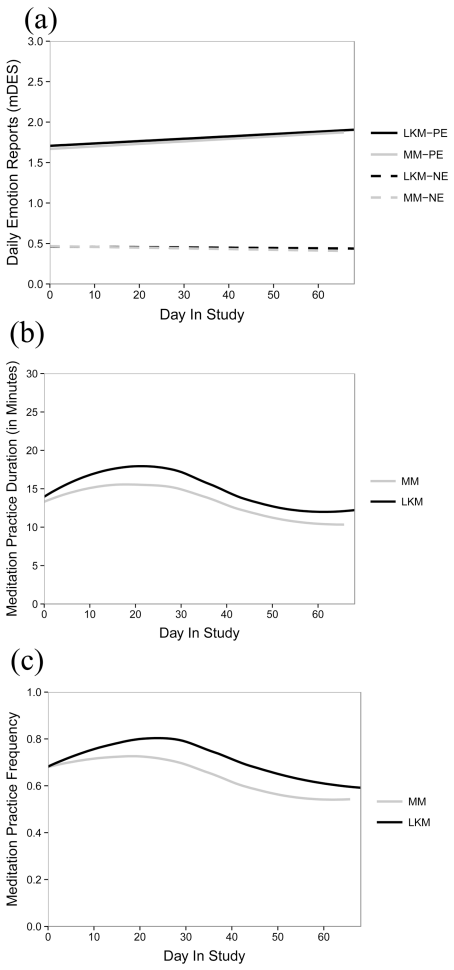

Figure 1. Trends in emotion and meditation practice, by condition

Time was coded in days and centered at the initial daily report following the first workshop attended. (a) Linear trends for positive and negative emotion composites. (b) Loess trend lines of the average number of minutes spent practicing meditation each day. (c) Loess trend lines of the proportion of participants meditating each day to represent practice frequency. Loess lines in plots (b) and (c) had a windowing parameter of .75.

Table 1

Demographic Characteristics by Study and Condition

	Study 1 (*N* = 122)				Study 2 (*N* = 217)			
	MM (*n* = 61)		LKM (*n* = 61)		MM (*n* = 106)		LKM (*n* = 111)	
	M	SD	M	SD	M	SD	M	SD
Age (years)	48.75	9.56	48.56	8.48	49.68	9.01	47.56	8.90
	N	%	N	%	N	%	N	%
Sex (female)	46	75.4	42	68.9	67	63.2	63	56.8
Race								
Am. Indian / Alaskan Native	1	1.6	0	0.0	1	0.9	0	0.0
Asian	5	8.2	3	4.9	6	5.7	5	4.5
Native Hawaiian/Pacific Islander	1	1.6	0	0.0	0	0.0	0	0.0
Black	4	6.6	11	18.0	19	17.9	20	18.0
White	50	82.0	47	77.0	80	75.5	86	77.5
Hispanic Ethnicity	4	6.6	2	3.3	3	2.8	2	1.8

Table 2
Fixed Effect Estimates for Dose-Response Models

	Positive Emotions			
	Duration		**Frequency**	
	b	**95% C.I.**	**b**	**95% C.I.**
Intercept	1.260 **	[1.038, 1.483]	1.244 **	[0.962, 1.526]
Practice_PC	0.002 **	[0.001, 0.003]	0.051 **	[0.027, 0.075]
Practice_M	0.014 **	[0.003, 0.025]	0.312	[-0.026, 0.651]
Time	0.019 **	[0.012, 0.025]	0.017 **	[0.011, 0.023]
Cond	0.251 *	[0.001, 0.500]	0.266 *	[0.014, 0.517]
Study	0.359 **	[0.139, 0.579]	0.373 **	[0.152, 0.593]
Cond × Study [a]	-0.406 *	[-0.717, -0.096]	-0.412 **	[-0.725, -0.100]
-2LL	20881.2		21435.1	
	Negative Emotions			
	Duration		Frequency	
	b	95% C.I.	b	95% C.I.
Intercept	0.495 **	[0.396, 0.594]	0.545 **	[0.422, 0.667]
Practice_PC	-0.000	[-0.001, 0.000]	-0.010	[-0.026, 0.005]
Practice_M	-0.004	[-0.010, 0.002]	-0.157	[-0.313, -0.001]
Time	-0.003	[-0.007, 0.001]	-0.003	[-0.007, 0.001]
Cond	0.012	[-0.061, 0.086]	0.009	[-0.062, 0.081]
Study	0.047	[-0.023, 0.117]	0.037	[-0.033, 0.107]
-2LL	10438.7		10582.0	

Note. Practice_PC = person mean-centered meditation practice, in number of minutes spent meditating. Practice_M = mean meditation practice levels. Cond = experimental condition (MM = 0, LKM = 1). -2LL = -2 × ln(model likelihood), a.k.a. model deviance.

** $p < .01$.

* $p < .05$.

[a] The Cond × Study interaction was retained in the dose-response models for positive emotions in light of a significant Cond × Study interaction in the linear growth curve model for positive emotions (see the OSM for details).