

Mindfulness

Do Contemplative Moments Matter? Effects of Informal Meditation on Emotions and Perceived Social Integration --Manuscript Draft--

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Abstract:	<p>Whereas formal meditation involves setting aside designated time for contemplative practice, meditation may also be practiced at any moment informally within the flow of daily activities. Whether informal meditation practice improves well-being is unclear. The purpose of this investigation was to test hypotheses about the day-to-day socioemotional profiles and dose-response relations, both within persons and between persons, associated with informal meditation practice. Midlife adults (N = 231), new to meditation, were randomized to learn either mindfulness meditation or loving-kindness meditation in a 6-week workshop that taught both formal and informal meditation practices. The frequency of informal meditation practice was measured daily for nine weeks, commencing with the first workshop session. Likewise, formal meditation, emotions, and perceptions of social integration were also measured daily. Multilevel models of daily reports over a 9-week period revealed significant dose-response relations between the frequency of informal meditation and positive emotions and perceived social integration—both within persons and between persons (positive emotions: within-person $b = 0.05$, 95% CI [0.03, 0.07], between-person $b = 0.35$, 95% CI [0.20, 0.51]; social integration: within-person $b = 0.11$, 95% CI [0.07, 0.14], between-person $b = 0.41$, 95% CI [0.12, 0.70]). Effects were largely comparable for the distinct informal practices of mindfulness and loving-kindness, and were statistically independent of the effects of formal meditation practice. In light of prior research that</p>	

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Response to Reviewers:	[See attached PDF for ease of reading]

Running Head: INFORMAL MEDITATION, EMOTIONS, AND SOCIAL INTEGRATION

Do Contemplative Moments Matter?

Effects of Informal Meditation on Emotions and Perceived Social Integration

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publish, or preparation of the manuscript. BLF designed the study, secured funding, and wrote the paper. CA analyzed the data and wrote sections of the paper. PVC collaborated with the design and editing of the final manuscript. MMB and SLK designed and taught the meditation workshops and collaborated on the assessment strategy. JB and SS oversaw the design of the mediation workshops and collaborated on the assessment strategy. All authors approved of the final version of the submitted manuscript. The authors wish to thank the study participants who devoted time and energy across months to be involved in this research.

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Do Contemplative Moments Matter?

Effects of Informal Meditation on Emotions and Perceived Social Integration

Abstract

Whereas formal meditation involves setting aside designated time for contemplative practice, meditation may also be practiced at any moment informally within the flow of daily activities. Whether informal meditation practice improves well-being is unclear. The purpose of this investigation was to test hypotheses about the day-to-day socioemotional profiles and dose-response relations, both within persons and between persons, associated with informal meditation practice. Midlife adults ($N = 231$), new to meditation, were randomized to learn either mindfulness meditation or loving-kindness meditation in a 6-week workshop that taught both formal and informal meditation practices. The frequency of informal meditation practice was measured daily for nine weeks, commencing with the first workshop session. Likewise, formal meditation, emotions, and perceptions of social integration were also measured daily. Multilevel models of daily reports over a 9-week period revealed significant dose-response relations between the frequency of informal meditation and positive emotions and perceived social integration—both within persons and between persons (positive emotions: within-person $b = 0.05$, 95% CI [0.03, 0.07], between-person $b = 0.35$, 95% CI [0.20, 0.51]; social integration: within-person $b = 0.11$, 95% CI [0.07, 0.14], between-person $b = 0.41$, 95% CI [0.12, 0.70]). Effects were largely comparable for the distinct informal practices of mindfulness and loving-kindness, and were statistically independent of the effects of formal meditation practice. In light of prior research that has linked both positive emotions and social integration to mental and physical health, these results suggest that future research should test whether increasing the frequency of contemplative moments improves mental and physical health.

Keywords: affect; contemplative science; mental health; positive psychology; happiness

Do Contemplative Moments Matter?

Effects of Informal Meditation on Emotions and Perceived Social Integration

Picture this: As you are waiting for the last 20 seconds to tick away on the office microwave oven that heats your lunch, you shift your attention to your breath, noticing how it feels as it passes through your nostrils. Three breaths later, your lunch is ready. Or picture yourself walking toward your workplace, noticing a passerby, and silently wishing her to find peace and ease in her day as she leaves your visual field. Do moments like these matter? Do they impact your day for more than the momentary wave of calm or kindness they create? Readers may recognize these moments as instances of informal meditation. Informal mindfulness meditation (MM) may entail a simple shift of awareness toward one's breath, whereas informal loving-kindness meditation (LKM) may entail a passing, yet heartfelt wish for another person's well-being.

Formal meditation practice involves carving out time away from the distractions of daily activities so that practitioners can sit (or walk) in deeper contemplation of their inner experience without undue interruption. The duration of a bout of formal meditation might be as long as an hour, or as short as a few minutes and these meditation sessions may or may not involve guided instruction. Informal meditation, by contrast, is practiced within the flow of daily activities, at impromptu moments and without guided instruction. Although informal meditation is presumed to be worthwhile and regularly taught alongside formal meditation (Brantley, 2014; Salzberg, 2017), scientific evidence for the benefits of informal meditation is limited and mixed.

Most prior work on informal meditation has centered on mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1982), mindfulness-based cognitive therapy (MBCT; Segal, Williams, & Teasdale, 2002), or both. Three independent studies, for instance, examined the

degree to which practitioners themselves judged informal meditation to be useful. Results across these three studies were consistently positive: Whether assessed at the end of an 8-week course (Dobkin & Zhao, 2011 [MBSR, $N = 83$]), or at a 6-month (Pradhan et al., 2007 [MBSR, $N = 28$]) or 12-month follow-up (Lilja, Broberg, Norlander & Broberg, 2015 [MBCT, $N = 19$]), patients with a range of illnesses (i.e., breast cancer, rheumatoid arthritis, recurrent depression) reported that they found informal mindfulness practice to be valuable.

Five additional independent studies more directly examined the effectiveness of informal mindfulness practice in patient or elderly samples by relating compliance data extracted from practice logs (completed weekly or daily) to the positive outcomes exhibited for MBSR and MBCT (assessed either at post-training or as changes from pre- to post-training). Four of those five studies concluded that, in contrast to formal mindfulness practice, informal mindfulness practice bore little to no association to positive outcomes (Carmody & Baer, 2008 [MBSR, $N = 174$, outcome: pre- to post-training assessments of trait mindfulness and psychological well-being]; Crane et al., 2014 [MBCT, $N = 99$, outcome: post-training time to relapse to major depression]; Gallegos et al., 2013 [MBSR, $N = 100$; outcome: pre- to post-training for positive affect; post-training for immunological biomarkers]; Hawley et al., 2014 [MBSR & MBCT, $N = 34$, outcome: pre- to post-training assessments of depressive symptoms and response styles to depressed mood]). The fifth study reported that informal mindfulness practice was increasingly related to breast cancer patients' daily reports of feeling rested and refreshed upon waking (Shapiro, Bootzin, Figueredo, Lopez & Schwartz, 2003 [MBSR, $N = 63$, outcome: daily assessments of sleep quality]). So although practitioners themselves have reported that informal mindfulness meditation is a valuable practice, studies that have obtained separate estimates of practice frequency and outcomes have mostly failed to support practitioners' impressions.

One laboratory experiment, however, assigned college students ($N = 51$) to wash dishes and randomized them to receive either generic instructions on dish washing, or mindful instructions, adapted from Thich Nhat Hanh's (1975) advice on how to transform ordinary daily activities into informal mindfulness practice. Results showed that washing dishes mindfully reduced nervousness, and increased state mindfulness, inspiration, and estimates of the passage of time (Hanley, Warner, Dehili, Canto, & Garland, 2015). This experiment was important because, unlike the correlational findings of prior studies, it suggested a causal connection between informal mindfulness and beneficial state outcomes.

Past research on informal meditation is limited by several methodological shortcomings, many of which apply to research on meditation more generally (Ospina et al., 2008). Among these shortcomings are (a) small sample sizes, which translate into low statistical power (Ospina et al., 2008); (b) course measures of practice (i.e., *did* vs. *did not*), despite the need to examine dose-response relations; (c) failure to examine within-person relations, which offer insights into day-to-day processes and better match theoretical questions about change over time (Curran & Bauer, 2011; Kanning, Ebner-Priemer, & Schlicht, 2013); (d) a paucity of studies that target novice, nonclinical samples, which can illuminate the effects of learning new meditation practices; (e) an exclusive focus on informal mindfulness meditation (MM), which leaves uncharted the effects of informal loving-kindness meditation (LKM); (f) a near-exclusive focus on symptom reduction, with almost no focus on positive outcomes (for an exception see Gallegos et al., 2013); and (g) an exclusive focus on intra-individual outcomes, despite existing evidence that formal practices of both mindfulness meditation and loving-kindness meditation have been linked to improved interpersonal experiences (e.g., Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Kok et al., 2013; Adair, Fredrickson, Castro-Schilo, & Sidberry, 2017). These

methodological shortcomings cloud conclusions about the reliability, scope, and generalizability of the effects of informal meditation practice (or lack thereof) and do not support evidence-based recommendations about its value.

The present study used improved methodological rigor plus a more fine-grained measure of practice frequency (i.e., *not at all, just once, a few occasions, many occasions*) to test whether and to what degree informal meditation practice reliably improved day-to-day positive psychological outcomes previously linked to superior mental and physical health. Focal outcomes were daily experiences of positive emotions and social integration. Because LKM directly targets warm-hearted kindness toward others, we expected the effects of LKM on these outcomes to surpass those of MM. The overarching hypothesis was that dose-response relations would exist between the frequency of informal meditation practice and daily experiences of positive emotions and social integration. Specifically, for both outcomes we hypothesized that the predicted dose-response relation would (a) emerge both within individuals and between individuals, (b) be independent from the corresponding benefits of formal meditation practice, and (c) be stronger for LKM than MM. Based on prior findings (Fredrickson et al., 2008; Fredrickson et al., 2017), we did not expect effects on daily negative emotions. We tested these hypotheses using data from a longitudinal randomized trial with midlife adults ($N = 217$), all new to meditation. Participants were instructed in both formal and informal meditation practice across a 6-week workshop with home practice assignments and were randomized to learn either MM or LKM. Nightly, participants reported on their experiences of positive and negative emotions and social integration as well as on their practice of both formal and informal meditation. We analyzed nine weeks of nightly reports, which included the six-week meditation workshop plus three weeks post-workshop. In a prior publication that used this same dataset (as Study 2 in

integrative data analysis of a pooled dataset [$N = 339$]; Fredrickson et al., 2017), we reported significant dose-response relations, both within persons and between persons, between the frequency (and duration) of *formal* meditation practice and positive (but not negative) emotions, with few differences between MM and LKM. In light of those findings, the present study also tested whether the hypothesized relations between informal meditation practice and the targeted positive psychological outcomes were independent of the benefits of formal meditation practice.

Method

Participants

Participants were midlife adults between the ages of 35 and 64. Sample size was set based on a power analysis for a theory-based longitudinal structural equation model that encompassed 18 months of data designed to test Specific Aims in the grant that supported this project (see Author Note). Fit statistics were based on a prior longitudinal study of meditation (Fredrickson et al., 2008), an alpha level of .05, and an RMSEA value set to .07 as an indication of approximate close fit in the null model and an alternative RMSEA set to .16 for a model in which the key hypothesized paths were omitted (MacCallum, Browne & Sugawara, 1996). From this, it was determined that 188 participants were needed to achieve 80% power to test the full longitudinal model. Noting a 31% reduction in N due to non-compliance and attrition in our past longitudinal studies on meditation, the target sample size was set to $N = 240$. Procedures for recruitment and screening have been described elsewhere (Fredrickson et al., 2017). Practical considerations (e.g., staffing and workshop offerings) dictated stopping with a slightly smaller sample ($N = 231$). After providing informed consent, participants were randomized to one of two meditation workshops: mindfulness meditation (MM; $n = 113$) or loving-kindness meditation (LKM; $n = 118$). Ultimately, 14 participants were excluded (primarily for not attending any

workshop sessions or failing to provide daily reports), resulting in a final sample of $N = 217$ (for MM, $n = 106$; for LKM, $n = 111$; for more detail, see CONSORT diagram in Figure). In the final sample, the mean age was 48.6 years ($SD = 9.0$). The majority of participants were female (59.9%) and Caucasian (76.5%), and 18.0% were Black. (For more details on demographic characteristics by condition, see Table 1 [Study 2] in Fredrickson et al., 2017; data from this larger, NIH-supported study [R01CA170128] have been reported on elsewhere [Fredrickson et al., 2017; Major, Le Nguyen, Lundberg & Fredrickson, 2018; Rice & Fredrickson, 2017] and will continue to support other and related investigations.)

Procedure

Procedures for the study were approved by the Institution Review Board of the University of North Carolina at Chapel Hill. Data collection occurred over five waves between May 2013 and May 2015, in which participants completed 11 weeks of daily diary reporting. During this phase, participants were sent an email each day that included a hyperlink to a short electronic survey. The overarching instruction for the daily survey asked participants to “please think back to what you did and how you felt in the past 24 hours. If it’s been less than 24 hours since you last logged in, please do not report the activities and feelings that you already reported yesterday.” The measures described below appeared in the daily survey alongside others that were beyond the scope of the present investigation. In group-based study orientation sessions before data collection began, participants were reminded that just as people vary from one another so do days and that the integrity of the study rested on the accuracy and honesty with which they described each day as it was. This study included data from the last nine weeks of data collection, as the first two weeks were used to get participants accustomed to completing the daily reports. Participants were randomized to one of two meditation workshops, MM or LKM,

each of which held six weekly, small-group evening sessions beginning in the third week of the study. (A few participants started their meditation workshop slightly earlier or later than the three-week mark; however, all participants' data were aligned at the date of the first workshop session they attended.)

The MM and LKM workshops were designed to have identical formats, each with six progressive, 1-hour small group sessions with comparable resources and encouragement for both formal and informal home practice. For the MM workshop (taught by SLK), the foci of present moment awareness were 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. For the LKM workshop (taught by MMB), the foci of warm and friendly feelings were 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. Specific instructions for home practice of informal meditation are presented in Table 1. (More details on MM and LKM and how these workshops were developed can be found in Fredrickson et al., 2017.)

Measures

Emotions. Emotions were assessed in the daily survey using the modified Differential Emotions Scale (mDES). The mDES includes 20 items to assesses the degree to which respondents experience different emotions, both pleasant and unpleasant, within a given time frame (Fredrickson, 2013). Ten positive emotions (i.e., amusement, awe, gratitude, hope, inspiration, interest, joy, love, pride, and serenity) and ten negative emotions (i.e., anger, contempt, disgust, embarrassment, fear, guilt, hate, sadness, shame, and stress) were assessed, each with a trio of adjectives (e.g., “awe, wonder, amazement” and “contemptuous, scornful,

disdainful”). For each item, participants are asked to indicate the greatest degree to which they experienced the given feelings over the past 24 hours using a 5-point scale in which 0 = *Not at all*; 1 = *A little bit*; 2 = *Moderately*; 3 = *Quite a bit*; and 4 = *Extremely*. Composite scores for positive emotions and negative emotions were obtained by calculating the mean of the ten items within each day. Respective reliabilities (omega coefficients) for between-person differences and within-person changes were 0.87 and 0.96 for positive emotions and 0.79 and 0.96 for negative emotions. (For more details on reliability calculations, see Fredrickson et al., 2017).

Formal and informal meditation practice. Formal meditation was assessed in the daily survey by asking participants an initial yes/no question: “Did you engage in any meditation in the last 24 hours? Note: You may include your meditation class.” If participants indicated “yes,” then they were also asked “How much time (in minutes) did you spend on meditation in the last 24 hours? If there were multiple sessions, make sure to add them all together.” Afterwards, they were asked, “Did you engage in any informal practice of meditation skills in the last 24 hours?” They responded on a 1-4 scale in which 1 = *No, not at all*; 2 = *Yes, just once*; 3 = *Yes, on a few occasions*; and 4 = *Yes, on many occasions*. We opted for this ordinal scale because informal meditation is, by definition, practiced impromptu, without structure, intermixed within the flow of daily activities, and potentially quite frequently. Absent the structure of formal meditation (e.g., dedicated time, guided audio), we reasoned that the response bias of duration neglect (Fredrickson & Kahneman, 1993) may make a time-based ratio scale ill-suited to capture people’s experiences of informal practice.

Perceived social integration. Lastly, social integration was assessed in the daily survey with one question. Participants were asked, “In the past 24 hours, how much did you feel socially

integrated or ‘on the same page’ with others?” They responded using a Likert-type scale ranging from 1 = *Not at all*, to 7 = *Completely*.

Data Analysis

We conducted analyses using R 3.3.1 and the nlme package. Three separate, two-level models, nesting daily reports (Level 1) within persons (Level 2) were used to test a priori hypotheses. The dependent variables for each model were positive emotions (Model 1), negative emotions (Model 2), and social integration (Model 3). Model building occurred in two stages.

In Stage 1, linear growth curve models were fit to assess whether an overall increase or decrease in the dependent variables emerged over the course of the study. Experimental condition (MM or LKM) was included as a Level-2 covariate to test whether any observed linear trends differed by condition. This linear trend was included at all stages of the model to detrend the data (Curran & Bauer, 2011, Wang & Maxwell, 2015), an approach that removes the potential confound of growth or decline over time from the estimates of within-person dose-response relations. (Results from Stage 1 for positive and negative emotions [Models 1 and 2, respectively] were also reported in Fredrickson et al., 2017; those results are reported again here as important precursors to Stage 2 analyses.) In Stage 2, informal meditation was added as a predictor to each model to estimate dose-response relations between the frequency of informal meditation practice and daily experiences of emotions and social integration. In all final models, both random intercepts and random slopes for informal meditation were estimated. Informal meditation was included both as a person mean-centered variable (Level 1) and as an individual mean over time variable (Level 2), to test for within-person differences and between-person differences, respectively. As a Level 1 predictor, informal meditation was person mean-centered at all stages of the model-building process (Enders & Tofghi, 2007). We again tested for main

effects of experimental condition as well as (in expanded models) interaction effects, crossing both person mean-centered and mean informal meditation practice with experimental condition, to test whether within-person effects, between-person effects, or both differed by condition. Finally, we conducted two sets of sensitivity analyses. First, we added time spent engaging in formal meditation to the model to test the effects of informal meditation beyond the effects of formal meditation. Condition main effects and interaction effects were again assessed at this point, as well as the between-person interaction between informal and formal meditation. Next, we conducted a sensitivity analysis to assess whether the effects of informal meditation remained after including the covariates of age, sex, ethnicity, and body mass index. All models were estimated using restricted maximum likelihood (REML) estimation. We chose REML because it accounts for degrees of freedom when estimating fixed effects, resulting in less biased estimates (Raudenbush & Bryk, 2002).

Results

Descriptive Statistics

Because the data for negative emotions exhibited a floor effect, we log-transformed them to create a distribution closer to normality. Averaging daily reports across the nine week period, positive emotions did not differ significantly between those in the MM condition ($M = 1.89$, $SD = 0.73$) and those in the LKM condition ($M = 1.74$, $SD = 0.68$); $t[212] = 1.62$, $p = 0.11$). The intraclass correlation (ICC) was 0.68, indicating that about two-thirds of the variance in daily positive emotions was attributable to between-person differences in average positive emotion levels. Similarly, no significant differences between MM and LKM emerged for negative emotions (MM: $M = 0.34$, $SD = 0.21$; LKM: $M = 0.34$, $SD = 0.21$; $t[214] = -0.20$, $p = 0.84$), perceived social integration (MM: $M = 4.53$, $SD = 1.24$; LKM: $M = 4.53$, $SD = 1.23$; $t[215] = -$

0.02, $p = 0.99$), or frequency of informal meditation practice (MM: $M = 2.06$, $SD = 0.61$; LKM: $M = 2.15$, $SD = 0.64$; $t[215] = -0.26$, $p = 0.29$). The variances attributable to between-person differences were about 50% for negative emotions ($ICC = 0.51$), about 70% for perceived social integration ($ICC = 0.71$), and 45% for frequency of informal meditation ($ICC = 0.45$).

To investigate whether our primary predictor, informal meditation exhibited a linear trend over the course of the study, we fit a linear growth curve model, with time included as a Level 1 predictor and informal meditation as the outcome. On average, informal meditation significantly increased within individuals over the course of the study ($b = 0.04$, $SE = 0.01$, $p < .001$), with an average response of 1.97 over the first week of the workshop and an average response of 2.25 in the week after the workshop ended.

Positive Emotions (Model 1)

Stage 1. First, we fit a linear growth curve model, with time included as a Level 1 predictor, and positive emotions as the outcome. Results suggest that, on average, positive emotions increased within individuals over the course of the study, ($b = 0.017$, $SE = 0.004$, $p < .001$). As further evidence of improved model fit (i.e., better explained variance in positive emotions), the model that included time as a random effect alongside both between-person and within-person differences resulted in the lowest AIC of all candidate models ($AIC = 14263.35$). Other candidate models produced greater than the threshold of $\Delta AIC > 10$ (Burnham & Anderson, 2003; i.e. the model with only a random intercept [$AIC = 14704.47$] and the model with no random effects [$AIC = 25134.80$]). Better model fit when random effects were included suggests that individuals differed both in their levels of positive emotions at the start of the meditation workshops and in their trajectories of positive emotions over the ensuing nine weeks. As reported in Fredrickson et al., 2017, no significant effects for experimental condition emerged

either in the initial levels of positive emotions or in the rate of growth of positive emotions, suggesting that participants in both MM and LKM workshops experienced overall increases in positive emotions over the course of the study.

Stage 2. To test both within-person and between-person effects of informal meditation on positive emotions, person-mean centered informal meditation and individual means of informal meditation were added as predictors to the model. Both random slopes and random intercepts were estimated. Fixed effects from Stage 2 of the model are presented in Table 2. As hypothesized, the relationship between the frequency of informal meditation and daily experiences of positive emotions was significant at both the within-person and between-person levels. The within-person result indicated that on days in which participants engaged in informal meditation practice more frequently than their own daily average, they reported higher positive emotions for that day. The between-person result indicates that, on average, those participants who engaged in informal meditation practice more frequently than others reported higher intensity positive emotions. Additionally, participants in the MM condition experienced higher positive emotions on average. Although this last finding contradicts the null result for condition in Stage 1 of the model building process, it is not unusual for changes in a model to yield significant results when a given variable borders the significance threshold. To test our hypothesis about larger dose-response relations for LKM vs. MM, we extended the model to include experimental condition interaction effects with both person mean-centered and individual mean informal meditation variables. Contrary to our prediction, neither interaction effect was significant (condition X within-person effect: $b = 0.12$, $SE = 0.16$, $p = 0.44$; condition X between-person effect: $b = -0.003$, $SE = 0.02$, $p = 0.86$) and the extended model resulted in a

larger AIC value ($\Delta AIC = 11.15$). Accordingly, these predictors were excluded from the final model reported in Table 2.

Sensitivity Analyses

Inclusion of formal meditation practice. We repeated the above tests adding duration of time spent engaged in formal meditation practice as a predictor to assess whether the effects of informal meditation practice on positive emotions existed above and beyond the effects of formal meditation practice. As expected based on Fredrickson et al., 2017, a significant within-person effect emerged for formal meditation practice ($b = 0.001$, $SE = 0.00$, $p < .01$). Independently, however, the within-person effect of informal meditation remained statistically significant ($b = 0.05$, $SE = 0.01$, $p < 0.01$). In contrast to Fredrickson et al., 2017, we found no between-person effect of formal meditation ($b = 0.001$, $SE = 0.01$, $p = 0.90$) on positive emotions in this smaller sample ($N = 217$ vs. $N = 339$). Independently, however, the between-person effect of informal meditation remained statistically significant ($b = 0.34$, $SE = 0.09$, $p < 0.01$). Finally, we tested the addition of a between-person interaction effect that crossed formal and informal meditation practices. While this interaction effect was not significant ($b = 0.01$, $SE = 0.01$, $p = 0.30$), adding it to the model resulted in the between-person effect of informal meditation becoming non-significant ($b = 0.18$, $SE = 0.18$, $p = 0.33$).

Inclusion of covariates. The effect of informal meditation practice on positive emotions also remained significant at the within-person level ($b = 0.05$, $SE = 0.01$, $p < .01$) and the between-person level ($b = 0.35$, $SE = 0.08$, $p < .01$) after including the fixed-effect covariates of age, sex, ethnicity, and body mass index. Only ethnicity demonstrated a significant effect for the frequency of daily informal meditation ($b = -0.41$, $SE = 0.12$, $p < 0.01$), with White participants

reporting lower positive emotions than non-White participants when controlling for all other variables in the model.

Negative Emotions (Model 2)

Stage 1. For outcome variable of negative emotions, we repeated the same model building process with a linear growth curve model to test whether a significant positive or negative linear trend existed. Consistent with Fredrickson et al. (2017), results revealed no change in level of negative emotions over the 9-week reporting period ($b = -0.00$, $SE = 0.00$, $p = 0.62$). As for Stage 1 in Model 1, the AIC for the model that included time as a random effect was the lowest of all candidate models ($AIC = -2620.41$), suggesting better explanation of the variance in negative emotions (i.e., the model with only a random intercept [$AIC = -2432.38$] and the model with no random effects [$AIC = 3892.44$], each exceeded the threshold of $\Delta AIC > 10$, suggesting worse model fit). Again consistent with Fredrickson et al. (2017), no significant effect emerged for experimental condition on the growth rate of negative emotions ($b = 0.00$, $SE = 0.03$, $p = 0.90$), suggesting that participants in both MM and LKM experienced similar (flat) trajectories of negative emotions during the study.

Stage 2. Inspection of Table 2 reveals that, unlike Model 1's results for positive emotions, in Model 2 virtually no effects of informal meditation practice on negative emotions were evident. Specifically, tests of both within-person and between-person effects of informal meditation on negative emotions were null. This pattern indicates that participants reported similar levels of negative emotions regardless of their frequency of informal meditation. Before including interaction effects with experimental condition, there was no significant main effect of condition on negative emotions ($b = 0.01$, $SE = 0.03$, $p = 0.64$). However, extending the model to include experimental condition interaction effects with both person mean-centered and individual

mean informal meditation variables led to a change in the significance of the main effect of experimental condition ($b = 0.32$, $SE = 0.11$, $p < 0.01$). We note here that the presence of a significant interaction effect renders this main effect uninterpretable. Although the interaction of condition with the within-person effect was null ($b = -0.00$, $SE = 0.01$, $p = 0.65$), that with the between-person effect was significant ($b = -0.15$, $SE = 0.05$, $p < 0.01$), indicating a pattern in which participants in the LKM condition who engaged in more frequent informal meditation reported, on average, fewer negative emotions, whereas those in the MM condition who engaged in more frequent informal meditation reported, on average, more negative emotions. Results in Table 2 reflect the model that includes the condition interaction effects.

Sensitivity Analyses

Inclusion of formal meditation practice. Although Fredrickson et al. (2017) reported a null effect for the within-person effect of duration of formal meditation on negative emotions, we were unable to test a comparable within-person effect in this smaller sample due to convergence issues. Mirroring Fredrickson et al. (2017), the between-person effect of duration of formal meditation on negative emotions was null ($b = 0.002$, $SE = 0.07$, $p = 0.78$). The effects of informal meditation practice on negative emotions remained null, at both the within-person level ($b = 0.00$, $SE = 0.00$, $p = 0.75$) and the between-person level ($b = 0.06$, $SE = 0.05$, $p = 0.27$). In addition, the between-person interaction effect crossing formal and informal meditation was not significant ($b = -0.00$, $SE = 0.00$, $p = 0.32$) and its inclusion did not alter other null results.

Inclusion of covariates. With the inclusion of the covariates age, sex, ethnicity, and body mass index, the effects of informal meditation on negative emotions remained null at both the within-person level ($b = 0.001$, $SE = 0.00$, $p = 0.79$) and the between-person level ($b = -0.01$, $SE = 0.03$, $p = 0.77$). Only age had a significant effect on negative emotions, with older

participants reporting lower levels of negative emotions ($b = -0.004$, $SE = 0.001$, $p < .05$), a pattern consistent with prior studies of age-related differences in affect (Charles, Reynolds & Gatz, 2001).

Perceived Social Integration (Model 3)

Stage 1. We again began the model building process with a linear growth curve model to test whether a significant linear trend existed for the outcome variable of social integration. We found that reports of social integration increased within individuals over the course of the study ($b = 0.03$, $SE = 0.01$, $p < .01$). As for Stage 1 in Models 1 and 2, the *AIC* for the model that included time as a random effect was the lowest of all candidate models ($AIC = 24338.24$), suggesting better explanation of the variance in social integration (i.e., the model with only a random intercept [$AIC = 24889.57$] and the model with no random effects [$AIC = 36065.07$] each exceeded the threshold of $\Delta AIC > 10$, suggesting worse model fit). Better model fit when random effects were included suggests that individuals differ both in their levels of social integration at the start of the meditation workshops and in their trajectories of social integration over the ensuing nine weeks. No significant effect emerged for experimental condition on the growth rate of social integration ($b = 0.01$, $SE = 0.17$, $p = 0.94$), suggesting that participants in both MM and LKM experienced overall increases in social integration over the course of the study.

Stage 2. Fixed effects from Stage 2 of the model are presented in Table 2. These results are similar to those for positive emotions. Within-person increases in informal meditation practice were associated with within-person increases in reports of social integration, and those who reported higher average frequency of informal meditation practice reported higher average levels of social integration. Unlike for positive emotions, there was no significant effect of experimental condition on reports of social integration. That is, participants in the MM workshop

and those in the LKM workshop reported similar levels of social integration over time. We next extended the model to include interactions with experimental condition to test the prediction about larger dose-response relations for LKM vs MM. As for positive emotions, neither interaction effect was significant (condition X within-person effect: $b = 0.02$, $SE = 0.03$, $p = 0.54$; condition X between-person effect: $b = 0.41$, $SE = 0.29$, $p = 0.16$) and inclusion of them resulted in a larger AIC value ($\Delta AIC = 7.42$). As such, experimental condition interaction effects were excluded from the final model reported in Table 2.

Sensitivity Analyses

Inclusion of formal meditation practice. With social integration as the outcome, we were unable to test the within-person effect of formal meditation due to convergence issues. However, we found no significant between-person effect of duration of time spent engaged in formal meditation on social integration ($b = 0.006$, $SE = 0.01$, $p = 0.62$), and the effect of informal meditation on social integration remains at both the within-person level ($b = 0.10$, $SE = 0.01$, $p < 0.01$) and the between-person level ($b = 0.38$, $SE = 0.16$, $p < 0.05$). Again, we tested the addition of a between-person interaction effect that crossed formal and informal meditation. While this interaction effect was not significant ($b = 0.02$, $SE = 0.02$, $p = 0.36$), as for positive emotions, adding it resulted in the between-person effect of informal meditation becoming non-significant ($b = 0.11$, $SE = 0.33$, $p = 0.74$).

Inclusion of covariates. With the inclusion of the covariates age, sex, ethnicity, and body mass index, the effects of informal meditation practice remained significant at both the within-person level ($b = 0.11$, $SE = 0.02$, $p < 0.05$) and the between-person level ($b = 0.40$, $SE = 0.15$, $p < 0.01$). None of the covariates demonstrated a significant effect on daily reports of social integration.

Discussion

Informal meditation practice is a ubiquitous part of meditation training and instructors and practitioners alike believe it to be beneficial. Even so, most systematic studies that have examined records of informal meditation practice and related them to psychological and physical health outcomes have failed to find those presumed benefits. Deploying greater precision in both assessments and analyses, the present study tested the overarching hypothesis that those who first learn to meditate would exhibit a dose-response relation between the frequency of their informal meditation practice and their day-to-day experiences of positive emotions and social integration. Results supported this overarching hypothesis. Specifically, results revealed that—for both positive (but not negative) emotions and social integration—dose-response relations were evident both within individuals and between individuals. This pattern of results indicates that on days in which novice meditators practiced informal meditation more frequently—relative to days in which they practiced less—they experienced greater positive emotions and social integration. In addition, novice meditators who—relative to their fellow practitioners—practiced informal meditation more frequently, experienced greater positive emotions and social integration. Supporting another of our specific predictions, results suggested that these positive socioemotional experiences linked to informal meditation practice were independent of the benefits of formal meditation practice, which was measured separately. We failed to find support, however, for our final specific hypothesis: Despite the greater focus on social warmth in loving-kindness meditation, we did not find evidence that the observed dose-response relations were stronger for LKM than MM.

Limitations and Future Research

One strength of the work presented here is that, to our knowledge, it is the first empirical study of informal meditation to include both mindfulness and loving-kindness practices. A second strength is that it includes densely repeated assessments of perceived social integration and emotions, the latter assessed with the mDES (Fredrickson, 2013), a self-report scale that captures low activation positive emotions that may be especially pertinent to studies of contemplative practices (Koopmann-Holm et al., 2013). In doing so, this work advances understanding of informal meditation practices by identifying positive emotions and social integration as vital short-term indicators that, according to theory and past evidence, are linked to both mental health (Garland, Fredrickson, Kring, Johnson, Meyer & Penn, 2010; Kawachi & Berkman, 2001) and physical health (Cohen, 2004; Pressman & Cohen, 2005). A third strength of this study is the relatively large sample size ($N = 217$) and >50 consecutive daily reports which supported the use of multilevel models that simultaneously test for both within-person and between-person effects.

Alongside these strengths, this study also has limitations. Participants were all midlife adults open to learning meditation practices. Even though many beginning meditators may be drawn from a similar population, generalization to other age groups or to those uninterested in meditation is not warranted. Likewise, MM and LKM were each taught by just one workshop instructor, so the effects of each teacher's unique pedagogical style cannot be evaluated here. Finally, in this study, formal and informal meditations were taught together in group-based, face-to-face workshop sessions. Generalizations to other instruction modalities (e.g., online, telephone, self-paced, or with informal meditation taught without parallel instruction in formal mediation) is not warranted. Future research is needed to test for generalization to other

populations, including clinical samples, younger and older age groups, other cultures and geographic regions, and to individuals with greater expertise in contemplative practices.

Perhaps the most significant limitation is that the design of the present study does not support causal claims. Although participants were randomized to meditation condition (MM vs. LKM), these two practices were not found to differ and no randomized control condition (active or waitlist) was included. So despite the evidence that informal meditation increased in step with workshop participation and showed dose-response relations with daily positive experiences, we cannot conclude that informal meditation practice causes these positive experiences. Likewise, study participants were not randomized to differing frequencies of informal practice.

Accordingly, causal claims about the frequency of informal meditation practice are also inappropriate because the time devoted to informal meditation practice was participants' own choice. These personal choices may have been shaped by many factors, including positive emotions and social integration experienced that day or in previous days. In addition, the nightly reports used in this study inquired about participants' subjective experiences for the entire day, not just those experienced during, or resulting from informal meditation practice. As such, dose-response relations between the frequency of informal meditation practice and the socioemotional experiences examined herein are correlational relations. The direction of causality (if any) remains to be tested in future research. Even so, a previous, tightly-controlled laboratory experiment by Hanley et al. (2015) revealed that the causal arrow can run from informal meditation toward improved subjective experiences.

Additional questions about the benefits of informal meditation practice point to additional promising directions for future research. For instance, event-contingent ecological momentary assessment (EMA) of affect and social integration could illuminate the immediate experiential

effects of informal meditation. Peer- or observer-reports would also be valuable to corroborate the effects reported here based on self-reports. Investigation of moderators and boundary conditions will also be useful. Might the practice of informal meditation, for example, provide socioemotional benefits even if taught in a self-paced manner without accompanying instruction in formal meditation? Might individual differences shape the degree to which informal meditation carries socioemotional benefits? Our team's recent work revealed that genetic differences related to oxytocin signaling (i.e., *OXTR* rs1042778) moderated trajectories of change in positive emotions for LKM, but not MM (Isgett et al., 2016). Such biological or other individual differences may also alter responses to informal meditation (c.f., Van Cappellen, Rice, Catalino & Fredrickson, 2017). Future research is also needed to illuminate the biopsychosocial mechanisms through which informal meditation practice alters people's experiences of emotions and social integration, and whether those mechanisms differ for MM and LKM. If future findings replicate and extend those of the present study, the belief among meditation instructors and practitioners that contemplative moments matter may one day rise to the standard of evidence-based.

Compliance with Ethical Standards

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Table 1

Week-By Week Summary of Instructions for Informal Meditation Practice

Week	Mindfulness Meditation	Loving-Kindness Meditation
1	Mindfulness of the breath during the day	Loving-kindness meditation for loved one during the day
	<i>Anywhere we happen to be breathing, we can be meditating (e.g., standing in line). A few times a day, wherever you are, take a moment to tune in to the physical feeling of your breath, grabbing a quick, centering moment--as short as following three breaths.</i>	<i>A few times a day wherever you are as your loved one comes to mind take a moment to turn your attention to their goodness and wish them well. You could say one of the phrases that you learned in class (may you live with ease, be safe, happy, healthy) or create your own.</i>
2	Mindfulness of the body in a routine activity	Loving-kindness for yourself throughout the day
	<i>Bring mindfulness to one routine activity (e.g., brushing your teeth, washing the dishes). Try slowing the activity down, bringing your awareness to every part of the process and especially to its direct physical and tactile experience.</i>	<i>During every day activities (e.g., driving, waiting for an appointment), try to pay attention to your self-talk; is it kind and accepting or critical and mean? Send well wishes to yourself, for your own happiness and peace (e.g., may I be free of anger or worry).</i>
3	Mindfulness of emotions in daily life	Loving-kindness for acquaintance

During the day, tune into your emotional landscape and notice the variety and intensity of your feelings. Try to notice how the feeling came about, how it changes your body sensations, and what your attitudes and beliefs about it are. When it goes away, notice what its absence feels like.	Take an opportunity to spread your kindness to someone nearby for whom you don't have much feeling (e.g., someone you often see at work or at the grocery store but don't know well). You can repeat phrases like "May you be happy; may you be peaceful, may you be free from suffering."
Mindful eating	Loving-kindness for irritating person
Devote one meal to eating slowly and mindfully (you can try to close your eyes), paying attention to the tastes, textures, temperature, and other qualities of your food, and to the experience of your body eating. Let go of judgments and thoughts that may come up.	Send loving-kindness to a person you judge or have negative thoughts toward. This does not need to be the most difficult person in your life. Imagine seeing them as human beings like ourselves, sharing a universal human condition. This person can teach us patience, compassion, and letting go of resentment.
Mindfulness in conversation	Loving-kindness for all beings
Pay attention to how you are in conversation and experiment with being in more of a listening mode. Bring awareness to your inner commentary (e.g., why you are saying what you are going to say), your underlying feelings, and your body sensations (e.g., how is your body reacting to what is said).	Explore bringing loving-kindness to all beings. This may include the known and unknown, people in your town, state, country, even across the world. You can practice repeating phrases like "May all beings be happy; may all beings be healthy; may all beings be peaceful, may all beings be safe" and experience a deep sense of connection with them.

6	Review and discussion of resources for continued practice	Review and discussion of resources for continued practice
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Table 2
Estimates for dose-response models

	Fixed Effects					
	Positive Emotions		Negative Emotions		Social Integration	
	<i>b</i>	<i>95% CI</i>	<i>b</i>	<i>95% CI</i>	<i>b</i>	<i>95% CI</i>
Intercept	1.11**	[0.76, 1.45]	0.19**	[0.04, 0.34]	3.54**	[2.89, 4.19]
Informal_PC	0.05**	[0.03, 0.07]	0.00	[-0.01, 0.02]	0.11**	[0.07, 0.14]
Informal_M	0.35**	[0.20, 0.51]	0.07	[-0.00, 0.02]	0.41**	[0.12, 0.70]
Time	0.01*	[0.00, 0.02]	0.00	[-0.00, 0.00]	0.02**	[0.01, 0.04]
Cond	-0.21*	[-0.40, -0.01]	0.33**	[0.11, 0.54]	-0.03	[-0.39, 0.33]
-2LL	11602.94		-2443.90		19882.02	

Note. Cond = experimental condition (MM = 0, LKM = 1). -2LL = -2 x ln(model likelihood), a.k.a. model deviance. Informal_PC indicates person mean-centered informal meditation, or within-person effects. Informal_M indicates individual means of informal meditation, or between-person effects. Negative emotions was log transformed.

** $p < .01$. * $p < .05$.

Figure. *Consort Diagram*