Predictors of Out-of-Class Mindfulness Practice Adherence During and After a Mindfulness-Based Intervention

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W.B.B. is an MBSR and MBCT teacher and has received financial compensation for this role. WB.B. also receives payments for providing trainings and education in scientific literacy,
meditation safety, and trauma-informed mindfulness. W.B.B. is nominally affiliated with the Mindfulness Center at Brown University which generates income by offering mindfulness classes to the public. All other authors declare that they have no conflicts of interest.

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Abstract

**Objective:** Out-of-class mindfulness meditation practice is a health behavior that is considered to be a crucial ingredient in mindfulness-based interventions (MBIs), yet participant adherence to practice recommendations is often inconsistent. Further, MBIs may enhance factors that lead to greater adherence to medical regimens (MRA) in other contexts. This study examined baseline factors previously found to relate to MRA, MBI-related changes in these baseline factors, and treatment-related factors as predictors of meditation adherence in an eight-week MBI.

**Methods:** Baseline traits (personality, depressive symptoms, and executive function) were entered into regression models ($N = 96$) to predict intervention and post-intervention out-of-class meditation adherence. Trait changes and treatment-related factors were entered into models to predict post-intervention meditation adherence.

**Results:** Baseline conscientiousness ($\beta = .33, p = .002$), openness ($\beta = .23, p = .019$), and depressive symptoms ($\beta = .19, p = .042$) predicted intervention meditation adherence, while conscientiousness ($\beta = .21, p = .044$) and depressive symptoms ($\beta = .22, p = .020$) predicted post-intervention meditation adherence. Although all trait variables except for agreeableness changed significantly pre-to-post intervention, these changes did not predict post-intervention meditation adherence. Retreat attendance ($\beta = .38, p = .029$) and instructor/group related therapeutic factors collectively predicted post-intervention meditation adherence ($R^2 = .21, p = .019$).
**Conclusion:** The identified baseline trait factors could be utilized to increase adherence in these interventions as a method of increasing their effectiveness. An emphasis on the MBI retreat and social factors during the intervention may be important for participant out-of-class practice post-intervention.

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**Keywords:** mindfulness-based interventions, medical regimen adherence, personality, retreat, social factors, group therapeutic factors

**Acronyms:**
- MRA = Medical Regimen Adherence
- MBI = Mindfulness Based Intervention
- MBSR = Mindfulness Based Stress Reduction
- MBCT = Mindfulness Based Cognitive Therapy
- IDS = Inventory of Depressive Symptomology
- BFI = Big Five Inventory
- ACS = Attention Control Scale
- WAI = Working Alliance Inventory
- TFI = Therapeutic Factors Inventory
- FM = Focused Attention
- OM = Open Monitoring
INTRODUCTION

Even when qualified health providers administer an intervention with strong evidence support, a medical treatment may not lead to patient improvement if patients do not actively adhere to medical regimens (1). Medical regimen adherence (MRA), defined as the degree to which a patient correctly follows, or complies with, medical regimens and advice from their healthcare provider, is a key factor in determining the effectiveness of medical and behavioral health interventions (2). Nonadherence rates for medical interventions and treatments are well documented, with an average non-adherence rate of 25% for patients of non-psychiatrist physicians (3) and non-adherence rates of up to 70% for interventions involving lifestyle changes and modification in habits, such as changes to diet and exercise (2,4,5). While the role of client participation in psychotherapy is a more complex issue (6), psychological interventions that rely on client adherence to home-tasks, such as behavioral activation, the completion of worksheets, or mindfulness exercises, can be conceptualized in terms of MRA.

Mindfulness-Based Interventions (MBIs), such as Mindfulness Based Stress Reduction (MBSR; 7) and Mindfulness Based Cognitive Therapy (MBCT; 8) are group interventions that require a large time commitment on the part of participants, who are asked to practice daily 45-minute mindfulness meditation exercises at home for the duration of the eight-week intervention and encouraged to continue practicing indefinitely after the intervention. MBIs have been found to improve cognitive and affective skills that reduce physical and psychological suffering for both clinical and non-clinical populations (e.g. 9). Mindfulness is defined as an attentive non-judgmental focus on present moment experiences (10).
Out-of-class mindfulness meditation practice is widely considered to be a core component in MBIs, as the practice of meditation is theorized to lead to increases in mindfulness and subsequent symptom reductions (11). A meta-analysis of 28 studies found a small but significant relationship ($r = .26$) between out-of-class meditation practice adherence and intervention outcomes in MBSR and MBCT courses (12). One study found that MBCT participants who practiced mindfulness out of class at least three or more days per week during the intervention were almost half as likely to have a major depressive relapse than participants who practiced less than three days a week (13). Another study found that on days when MBSR participants meditated, they responded with greater mindfulness to daily events, which mediated the effects of meditation on outcomes (14).

However, adherence to out-of-class mindfulness practice has been found to be inconsistent during and after MBIs. Across 43 studies, MBI participants practiced at home an average of only 64% of the assigned amount (29 minutes per day, 12). Furthermore, little is known about continued practice after intervention completion and whether treatment gains are lost due to difficulty maintaining a daily practice. One review found that only five out of 98 studies measured post-intervention home practice, with participants ranging from 15 minutes per day less than once a week to 18.7 minutes per day (15). A more recent study explored an eight week post-intervention period of out-of-class meditation adherence and found that participants in this period practiced an average of 16 min per day, which was significantly less than their average practice during the intervention period (16). Given the importance of out-of-class practice adherence for outcomes and depressive relapse after the conclusion of MBIs, an
enhanced understanding of factors that lead to greater practice adherence during and following these interventions could aid in developing more effective intervention delivery.

In addition, mindfulness training may lead to improvements in many of the traits that lead to low MRA in general. Researchers have proposed that mindfulness training may increase patient MRA through improvements in patient-level factors such as cognitive impairment/executive function, depressive symptoms, and sleep quality (17). Thus, while factors that predict MRA in general may predict MRA in the context of MBIs, some of these MRA-related factors may also be improved through MBIs and predict MRA in the context of other interventions.

Factors predicting MRA.

Out-of-class MBI meditation adherence could be affected by a range of individual traits and treatment-factors. Regarding individual traits, personality traits from the five-factor model of personality (also known as the Big Five; e.g., 18,19) have been shown to predict MRA, such that conscientiousness and agreeableness is positively related to MRA, while neuroticism is negatively related to MRA (20,21). Neuroticism has also been linked to the perception of greater barriers to meditation (22). One study using personality to predict the frequency of engagement in MBSR activities both during and after the intervention found that openness and agreeableness were significant predictors (23). Another study found that baseline conscientiousness, openness, and neuroticism significantly predicted participant’s average level of mindfulness practice during an MBI (24). All of the Big Five personality traits have been found to be correlated with mindfulness, such that conscientiousness and neuroticism were most strongly related to
mindfulness while extraversion had the weakest connection (25–27).

Executive function, which involves cognitive factors such as attentional control, has also been shown to be related to MRA (e.g., 28,29). Executive function may aid adherence through resulting improvements in self-efficacy (28), as well as keeping appointments and medication management (29). At the same time, numerous studies suggest that mindfulness meditation leads to improvements in attentional control and executive function (30–32).

The relationship between depressive symptoms and adherence is well documented, with depressed patients substantially more likely to non-adhere to medical regimens than those who are not depressed (33,34). Furthermore, depressed individuals may be more motivated to meditate, yet their symptoms may interfere with their ability to practice (33,35). Given that MBCT has been found to reduce symptoms of depression (36,37), meditation practice adherence may improve during treatment in relation to reductions in depressive symptoms. One previous study found that depressive symptoms negatively predicted meditation practice during an MBI (24).

Studies have also found that treatment-related social and contextual factors strongly influence MRA. High quality patient-provider relationships have been shown to improve patient adherence, especially when characteristics are present such as clear and effective communication, shared decision making, nurturance of trust, and getting to know the patient as a person (1,2). Social support is also a key factor in predicting MRA (38,39), and may affect MRA in the context of group interventions such as MBIs, where group therapeutic factors have an
influence on patients beyond the therapeutic alliance with the instructor (40). While a previous study found that extra-therapeutic social support predicted greater mindfulness practice (24), the effects of treatment-related social support on mindfulness practice in MBIs has not been investigated to our knowledge. Finally, class attendance and retreat attendance in MBIs may impact the degree to which patients engage with class material, both social and experiential, and are also forms of adherence in themselves. Participants who adhere more to treatment during an intervention may also adhere more after the intervention concludes.

**Study Purpose.**

The present study investigated two research questions: 1) whether baseline participant trait characteristics previously found to be associated with MRA (agreeableness, conscientiousness, neuroticism, openness, depressive symptoms, and executive function) would predict out-of-class meditation adherence during the intervention and/or after the intervention (measured at three month follow up) and 2) whether treatment-related changes in these trait characteristics and/or treatment-related factors previously found to be associated with MRA (class and retreat attendance, working alliance with instructors, and group dynamics) would predict out of class meditation adherence after the intervention. Specifically, we hypothesized that 1) baseline trait characteristics would predict meditation adherence during the intervention and after the intervention, 2) treatment-related changes in trait characteristics would predict meditation adherence after the intervention, 3) treatment-related factors during the intervention would predict meditation adherence after the intervention, and 4) trait predictors and treatment-related predictors would be predictive of post-intervention meditation adherence independent of each other.
Methods

Participants

Participants were English-speaking adults aged 18-65 with mild to severe levels of depressive symptoms (score of 10-48 Inventory of Depressive Symptomatology; IDS-C) and high levels of negative affect (negative affect score >18 on Positive and Negative Affect Schedule). Exclusion criteria are detailed in (41), but included extremely severe depressive symptoms (IDS score >48), suicidal ideation, personality disorders, psychotic disorders, lifetime history of bipolar disorder, antisocial behavior, substance abuse or dependence, and self-harm. Additionally, participants were excluded who had a preexisting regular meditation practice, current psychotherapy, or a change in psychiatric medication within the last eight weeks. All participants provided written informed consent and did not receive financial compensation for participation in the study.

Measures

Adherence outcome measures.

Intervention Meditation Adherence. Adherence to out-of-class meditation practice assignments during the intervention was monitored through daily online survey logs that participants filled out through Survey Monkey. Participants recorded information about out-of-class meditation practice, such as the type of meditation (e.g. body scan, breath awareness), the number of minutes practiced, the use of a guided meditation recording, and whether they fell asleep during practice. Practice types were classified as either formal meditation practice, which involved a formal sit, or informal meditation practice, such as mindful activities. The present
study reports data concerning only formal meditation practices, which is summarized by the average minutes practiced per week. This was calculated as frequency multiplied by duration of all formal meditation practices, averaged across the eight weeks.

Post-Intervention Meditation Adherence. Follow-up evaluations took place three months after interventions ended. At this time, participants recorded the frequency, duration, and types of meditation that they had practiced out-of-class since the end of the intervention. The mean formal meditation minutes practiced per week was calculated for each participant and used as a measure of post-intervention meditation adherence.

Trait measures.

Personality was measured using The Big Five Inventory (BFI), a 44-item questionnaire that assesses five dimensions of personality (18,42). Participants rate statements about themselves on a scale of one (strongly disagree) to five (strongly agree). The agreeableness subscale (9 items; pre, post, 3 month $\alpha = 0.79, 0.76, 0.76$) measures traits such as forgiving, not demanding, warm, flexible, modest, and sympathetic. The conscientiousness subscale (9 items; pre, post, 3 month $\alpha = 0.84, 0.82, 0.86$) measures traits such as efficient, organized, careful, thorough, self-disciplined, and not impulsive. The neuroticism subscale (8 items; pre, post, 3 month $\alpha = 0.71, 0.84, 0.84$) measures traits such as tense, irritable, depressed, shy, moody, and not self-confident. The openness subscale (10 items; pre, post, 3 month $\alpha = 0.79, 0.77, 0.82$) measures traits such as curious, imaginative, artistic, wide interests, excitable, and unconventional. The extraversion scale was not included in analysis due to a lack of association with MRA in previous studies (20–23).
Depressive symptoms were measured using The Inventory of Depressive Symptomatology (IDS), a 30 item clinician-administered depression questionnaire that directly corresponds to the DSM-IV criteria for major depression (pre, post, 3 month $\kappa = 0.89, 0.93, 0.94$; ,43,44). Responses on the IDS range from 0-3 and are summed to create a total score. Total scores of 0-13 are within the normal range, 14-25 are considered mild depression, 26-38 are considered moderate depression, 39-48 are considered severe depression, and 49-84 are considered very severe depression.

Executive function was measured using The Attention Control Scale (ACS; pre, post, 3-month $\alpha = 0.84, 0.88$, and 0.88; ,45,46), a 20-item measure of the self-reported ability to sustain attention or to concentrate and direct attention at will. These two abilities are associated with improvements in self-control and emotion regulation. Items are assessed on a four-point Likert scale ranging from “almost never” to “always.”

**Treatment-related measures.**

Participant attendance was recorded for each of the eight classes and summed to create a measure of class attendance. Participation at the day-long retreat was also recorded as a separate dichotomous variable, since the extended practice in silence that participants underwent during the retreat was considered to be different from other class attendance.

Working Alliance between client and instructor was measured with The Working Alliance Inventory (WAI; 47). The scale has 3 subscales: tasks ($\alpha = .87$), which measures client
perception of therapeutic activities being relevant and efficacious, goals ($\alpha = .78$), which measures client perception of agreement on goals of treatment, and bond ($\alpha = .91$), which measures client perception of the development of a bond between instructor and client. This study, following the example of (48), used the 20-item version of the scale. Each item ranged from not at all true (1) to very true (7).

The presence of group therapeutic factors within a given group was measured by clients using The Therapeutic Factors Inventory-19 (TFI-19; 49,50). It measures four group therapeutic factors: instillation of hope, secure emotional expression, awareness of relational impact, and social learning. The instillation of hope subscale ($\alpha = .90$) assesses the degree to which the group gave participants positive expectations and hope. The secure emotional expression subscale ($\alpha = .82$) assesses participant’s feelings of safety and comfort in the group, as well as self-disclosure and emotional expression. The awareness of relational impact subscale ($\alpha = .83$) assesses the degree to which the group led to insight into connections between interpersonal interactions and personal thoughts, feelings and behaviors. The social learning subscale ($\alpha = .58$) assesses whether the group led to the acquisition of communication skills and other behavioral processes. Items are rated on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

**Procedure**

This study is a secondary analysis of data from a larger dismantling study of MBCT, which is further detailed in (41). It was approved and supervised by the Brown University Institutional Review Board, an independent Data Safety Monitoring Board and the National
Center for Complementary and Integrative Health’s Office of Clinical and Regulatory Affairs. All assessments and treatments took place between November 2012 and March 2016 at Brown University in Providence, RI. Participants were recruited by community flyers for a general mindfulness-based intervention program for people with anxiety, stress, or depression, and then screened for study eligibility over the phone and in person (see 41). Nine groups of participants underwent an eight-week mindfulness intervention, with three of those groups completing a standard MBCT protocol, three groups completing a dismantled MBCT intervention focusing only on Focused Attention (FM) meditation, and three groups completing a dismantled MBCT intervention focusing only on Open Monitoring (OM) meditation. Participants were unaware of which treatment they had been assigned to during treatment, and were debriefed regarding the treatment types during the follow-up interview.

All three interventions were matched for duration, format, and content. Meditation homework was assigned as 45 minutes per day of formal meditation practice six days a week. In addition, informal mindfulness practice was assigned each week, and participants at times were asked to complete worksheets outside of class. Each class contained an average of 12 participants with a range of 10-13 participants per class. Classes met for three hours once a week for eight weeks with a full day silent retreat offered during week six or seven. Participants were given surveys and other assessments before the onset of the intervention (baseline BFI, IDS, and ACS), at the end of the eight-week intervention (post-intervention BFI, IDS, and ACS, as well as WAI and TFI), and at three-month follow-up (post-intervention meditation adherence).
Data Analysis

All statistical analyses were performed using R 4.0. Participants who did not complete the intervention were excluded from analyses. Missing data was imputed at the scale item level using the Multivariate Imputation by Chained Equations (MICE; 51) R package. Passive imputation was used to relate mean and sum score values to imputed scale items. The percentage of missing values for variables used in this study was between 0-2% and 77 out of 96 cases had no missing data. All statistical analyses used Rubin’s rules to pool the results from ten multiply imputed datasets. Univariate and multivariate model assumptions were tested for each statistical model. No univariate or multivariate extreme outliers were identified. Meditation adherence at post-course was found to violate model assumptions for univariate and multivariate normality. Examination of the data found that meditation adherence at post-course was highly positively skewed and fit an over-dispersed poisson distribution. As a result, quasi-poisson generalized linear models with a log-link function were used to predict meditation adherence at post-course. Standardized estimates were reported for these models in order to more easily compare the strength of predictors to other models. McFadden’s pseudo $R^2$ was used for these models as a measure of explained variance and improvement in model fit.

Analysis began by estimating correlations for predictor variables that would be entered together in multiple regression and for meditation adherence outcome measures. Repeated measures ANOVA tests were used to determine the main effect of time (baseline to post-course) and time-treatment interactions on participant personality, depressive symptoms, and executive function. Unconditional multilevel models with group as a random effect for the two meditation adherence outcomes were constructed to determine intra-class correlation coefficients. When
random effects for group were non-significant and close to zero, multiple regression models were used. Dummy variables for treatment types were calculated and added into models as fixed predictors and interaction terms with all other fixed predictors in additional model steps. One-way ANOVAs were also used to test for differences in meditation adherence outcomes by treatment and group.

For hypothesis one, all hypothesized baseline trait variables were entered into a model to predict each out-of-class meditation adherence outcome (intervention and post-intervention). For hypothesis two, trait variables that changed significantly pre-to-post (as based on main effects of time from repeated ANOVA models) were entered as a second step into the model with baseline variables as predictors of post-intervention meditation adherence. The model with baseline and post-course trait measures was compared with the model with only baseline measures, enabling a test of whether trait changes predicted post-intervention meditation adherence. For hypothesis three, a model with all hypothesized treatment related factors was constructed to predict post-intervention meditation adherence. For hypothesis four, the variance explained by trait and treatment predictors on post-intervention meditation adherence was compared by constructing stepwise models with trait and treatment variables in separate steps. Exploratory regression models were also constructed after each hypothesized model to examine the characteristics of refined models that included only predictors with significant correlations with outcomes or with a trend-level effect ($p < .10$) in hypothesized models.
Results

Participant Demographics

A total of 104 individuals were enrolled in the study. Eight participants dropped out over the course of the eight-week intervention leaving 96 participants to be included in analysis. The sample was primarily female (\(N = 70, 72.9\%\)), middle aged (\(M\) age = 40.39, \(SD = 12.89\)), and college educated (\(M\) years of education = 17.13, \(SD = 2.69\)). One third (33.3\%) of the population was taking psychiatric medication. Participants attended between four and eight of the eight classes (\(M = 7.22, SD = 0.89\)) and 87 participants (90.63\%) attended the retreat. Regarding meditation adherence, participants reported that, on average, they practiced a range of 37.50-395.00 minutes per week during the intervention (\(M = 202.66, SD = 73.70\)) and a range of 0-440.88 minutes per week after the intervention (\(Median = 60.25, M = 100.54, SD = 100.92\)). See (41) for further information regarding participant demographics.

Preliminary Analyses

Preliminary analyses tested whether meditation adherence outcomes were dependent on the nine groups or three treatment types included in the study. One-way ANOVAs found that intervention meditation adherence did not significantly differ across groups, \(F(8, 87) = 0.88, p = .531, \eta^2 = .07\), or treatment types, \(F(2, 93) = 1.41, p = .244, \eta^2 = .03\). Likewise, post-intervention meditation adherence also did not significantly differ across groups, \(F(8, 87) = 0.74, p = .659, \eta^2 = .06\), or treatment types, \(F(2, 93) = 0.03, p = .971, \eta^2 < .01\). An unconditional multilevel model with group as a random effect and intervention meditation adherence as the dependent variable found an ICC for group of less than 0.0001. When compared to a model predicting intervention meditation adherence without a random effect for group, a likelihood ratio test found no
significant difference, $\chi^2(1) < .01, p > .99$. Likewise, an unconditional multilevel model with group as a random effect and post-intervention meditation adherence as the dependent variable found an ICC for group of less than .0001. When compared to a model without a random effect for group, a likelihood ratio test found no significant difference, $\chi^2(1) < .01, p > .99$. Thus, subsequent models were constructed as simple multiple linear regression models.

**Hypothesis 1: Baseline Predictors of Meditation Adherence**

First, bivariate correlations were run between all baseline predictor variables and measures of meditation adherence. Baseline consciousness ($r = .35, p < .001$), openness ($r = .25, p = .014$), depressive symptoms ($r = .20, p = .048$), and executive function ($r = .23, p = .027$) were significantly correlated with meditation adherence during the intervention. Only baseline depressive symptoms ($r = .24, p = .019$) were significantly correlated with post-intervention meditation adherence. See Table S1, Supplemental Digital Content, http://links.lww.com/PSYMED/A691, for all correlations among trait predictors and measures of meditation adherence.

Next, a multiple linear regression using the six baseline variables to predict intervention meditation adherence was constructed (see Table 1). The overall model was significant, $F(6,87) = 4.60, R^2 = .24, p < .001$, indicating that baseline personality, depressive symptoms, and executive function collectively predicted 24% of the variance in participant’s intervention meditation adherence. Within this model, conscientiousness ($b = 3.91, SE = 1.18$) and openness ($b = 2.78, SE = 1.13$) were significant unique predictors. The addition of treatment type dummy variables into the model was not significant, $F(2, 85) = .38, p = .682$, nor were the addition of
treatment type interactions with all other predictors, $F(12, 73) = 1.62, p = .104$. An exploratory refined model was constructed using only baseline predictors that were significantly correlated with intervention meditation adherence at baseline (conscientiousness, openness, depressive symptoms, executive function). This model was also significant, $F(4,89) = 6.46, R^2 = .23, p < .001$, and did not result in a significant reduction in variance explained when compared to the first model, $\Delta R^2 = 0.01, F(2,87) = 0.62, p = .539$. Within this model, conscientiousness ($\beta = .33, p = .002$) openness ($\beta = .23, p = .019$) and depressive symptoms ($\beta = .19, p = .042$) were significant predictors of intervention meditation adherence, while executive function was non-significant ($\beta = .06, p = .581$).

A quasi-poisson generalized linear model using the six baseline predictor variables to predict post-intervention meditation adherence was also significant, $F(6,87) = 2.34, R^2 = .14, p = .038$, indicating that baseline personality, depressive symptoms, and executive function collectively predicted 14% of the variance in post-intervention meditation adherence. Within this model, none of the predictors were uniquely significant (see Table 1). The addition of treatment type dummy variables into the model was not significant, $F(2, 85) = .38, p = .832$, nor were the addition of treatment type interactions with all other predictors, $F(12, 73) = .80, p = .652$. A refined model was constructed containing only predictors with trend level significance ($p$ values less than .10) from the first model. Conscientiousness, openness, and depressive symptomology fit this criterion and were included in the model. This model was also significant, $F(3, 90) = 4.56, R^2 = .13, p = .005$, and did not result in a significant reduction in variance explained when compared to the first model, $\Delta R^2 = 0.01, F(3, 86) = 0.26, p = .855$. Within this model, conscientiousness ($\beta = .21, p = .044$) and depressive symptoms ($\beta = .22, p = .020$) were
significant, while openness was non-significant ($\beta = .20, p = .069$).

**Hypothesis 2: Treatment related changes as predictors of post-intervention meditation adherence**

In order to determine which trait variables changed from pre to post intervention and whether these changes were moderated by treatment type, repeated measures ANOVA tests were used to investigate the effects of time (pre to post-intervention) and time-treatment interactions for each trait variable. See Table 2 for pre-intervention and post-intervention $M$ and $SD$, results of the main effects of time on each outcome, and Cohen’s $d$ effect sizes. Findings indicate that conscientiousness, openness, and executive function significantly increased from pre to post intervention, while neuroticism and depressive symptoms significantly decreased from pre to post intervention. Only agreeableness did not significantly change from pre to post-intervention. Cohen’s $d$ effect sizes revealed that conscientiousness and openness had small effect sizes, neuroticism and executive function had medium effect sizes, and depressive symptoms had a large effect size. All treatment-time interactions were non-significant (agreeableness: $F(2, 145913) = 0.64, p = .529$, conscientiousness: $F(2, 7635) = 0.75, p = .471$, neuroticism: $F(2, 1564620) = 0.78, p = .458$, openness: $F(2, 143762) = 0.59, p = .557$, depressive symptoms: $F(2, 93) = 0.18, p = .832$, executive function: $F(2, 47461) = 1.57, p = .208$, indicating that treatment type did not moderate pre-post changes.

Bivariate correlations were calculated between all post-intervention variables and measures of meditation adherence (see Table S1). Post-intervention conscientiousness ($r = .25, p = .014$) and openness ($r = .28, p = .005$) were significantly correlated with intervention
meditation adherence, while none of the post-intervention variables were significantly correlated with post-intervention meditation adherence.

Next, the post-intervention variables that significantly changed from baseline were entered into a second step of the quasi-poisson generalized linear model that used baseline variables to predict post-intervention meditation adherence (see Table 3). Note that when the effects of baseline variables are controlled for, post-intervention variables represent residualized change scores. Results indicated that the addition of post-intervention variables into the model did not significantly contribute to the variance of post-intervention meditation adherence, $\Delta R^2 = .02$, $F(5, 82) = 0.37, p = .869$, contributing only 2% of variance above and beyond what was accounted for by baseline variables. Furthermore, the overall model was non-significant with post-intervention variables added, $R^2 = .16$, $F(11, 82) = 1.40, p = .188$, and none of the post-intervention variables significantly predicted unique variance.

In order to test whether this model was inhibited by the presence of too many predictor variables, a refined model was constructed using only the variables that at baseline were uniquely related to either intervention or post-intervention meditation adherence. The model at step one predicted post-intervention meditation adherence with contentiousness, openness, and depressive symptoms at baseline, as reported in hypothesis one above. In step two, contentiousness, openness, and depressive symptoms at post-intervention were added to the model. The addition of the post-intervention measures in step two did not add a significant amount of variance to the model, $\Delta R^2 = .01$, $F(3, 86) = 0.14, p = .935$, and no post-intervention variables had significant coefficients.
Hypothesis 3: Treatment factors as predictors of post-intervention meditation adherence

Bivariate correlations were calculated between all treatment-related predictor variables and measures of meditation adherence (see Table S2, Supplemental Digital Content, http://links.lww.com/PSYMED/A691). The WAI and TFI subscales were all significantly correlated with each other ($r$ ranging from .34 to .78, $p<.05$). Class attendance ($r = .22, p = .034$), retreat attendance ($r = .21, p = .036$), and TFI awareness of relational impact ($r = .24, p = .018$) were significantly correlated with intervention meditation adherence. Retreat attendance ($r = .23, p = .027$), TFI instillation of hope ($r = .22, p = .031$), and TFI awareness of relational impact ($r = .22, p = .028$) were significantly correlated with post-intervention meditation adherence.

A multiple regression model with all nine treatment-related variables predicting post-intervention meditation adherence was significant, $R^2 = .21$, $F(9, 84) = 2.37, p = .019$, indicating that the treatment-related variables were able to explain 21% of post-intervention meditation adherence variance. The only variable within the model that uniquely predicted post-intervention mediation adherence was retreat attendance (see Table 4). The addition of treatment type dummy variables into the model was not significant, $F(2, 82) = .03, p = .968$, nor were the addition of treatment type interactions with all other predictors, $F(18, 64) = .71, p = .784$. A refined model was constructed including only treatment-related variables significantly correlated with post-intervention meditation adherence or with trend level unique effects in the model ($p < .10$). These variables included retreat attendance, WAI leaders bond, TFI installation of hope, and TFI awareness of relational impact. This model was also significant, $F(4, 89) = 2.63, R^2 = .13, p = .040$, and did not result in a significant reduction in variance explained when compared
to the first model, $\Delta R^2 = 0.08$, $F(5, 84) = 1.79$, $p = .125$. Within this model, only retreat attendance was significant ($\beta = .36$, $p = .042$), while WAI leaders bond ($\beta = .02$, $p = .879$), TFI installation of hope ($\beta = .12$, $p = .395$), and TFI awareness of relational impact ($\beta = .14$, $p = .304$) were non-significant. A further exploratory model removed WAI leaders bond to determine whether collinearity among predictors inhibited results. However, results were nearly identical to the previous model, with only retreat attendance significant within the model.

**Hypothesis 4: Comparison of trait and treatment-related factors**

A final analysis compared the variance in post-intervention meditation adherence explained by baseline and treatment-related predictors. A stepwise model with the six baseline variables entered in the first step and the treatment-related variables entered in the second step found that the addition of the treatment-related variables while controlling for baseline variables did not significantly increase variance explained in post-intervention meditation adherence, $\Delta R^2 = .13$, $F(9, 78) = 1.50$, $p = .164$, explaining 13% of additional variance. A regression model with treatment-related variables entered in step one and baseline trait variables entered in step two found that the addition of baseline variables while controlling for treatment related variables did not significantly increase the variance explained in post-intervention meditation adherence, $\Delta R^2 = .07$, $F(6, 78) = 1.18$, $p = .325$, explaining 7% of additional variance. The overall model with both baseline and treatment-related variables was significant, $R^2 = .27$, $F(15, 78) = 2.03$, $p = .023$, explaining 27% of the variance in post-intervention meditation adherence. None of the variables in the overall model were significant unique predictors.
Discussion

With the rise in the use of mindfulness-based interventions (MBIs), it is important to consider factors that can lead to greater adherence in these interventions, as well as whether MBIs can improve factors that may lead to greater MRA in other medical interventions. This paper had two research questions: 1) which baseline factors can predict MBI out-of-class meditation adherence both during and after the intervention, and 2) which treatment related factors, such as traits that changed during the intervention and social/contextual treatment factors, were related to meditation adherence after the intervention.

Our findings support the role of baseline personality, executive function, and depressive symptoms in MBI adherence to out-of-class meditation practice for both intervention and post-intervention adherence. Among these factors, the strongest predictors were conscientiousness, openness, and depressive symptoms, while executive function was correlated with intervention meditation adherence but not post-intervention meditation adherence, and was not a unique predictor when entered into models with the other variables. Agreeableness and neuroticism had no relation to MBI meditation adherence.

The more conscientious a participant was at baseline, the more they adhered to out-of-class meditation practice during and post intervention. This may help to explain findings that MBSR resulted in greater improvements for study stress for participants with higher levels of baseline conscientiousness (52). Conscientiousness is characterized by self-discipline, self-regulation, and achievement-striving (18,19,25), and has been associated with problem-focused rather than emotion-focused coping responses (53). It would make sense that these qualities
would be associated with positive health behaviors and MBI meditation adherence inasmuch as out-of-class meditation practice requires a commitment to practicing even on days when one would rather do something else.

Baseline openness was positively associated with out-of-class intervention meditation adherence but not post-intervention meditation adherence. This finding is similar to the findings of (23), who found that agreeableness and openness predicted the frequency of out-of-class engagement in mindful activities both during and after MBSR and to the findings of (24) who found openness to be predictive of out-of-class meditation practice adherence. The personality characteristic of openness may especially facilitate engagement with mindfulness practices, since these practices involve curiosity regarding one’s subjective experience and promote less conventional ways of viewing oneself and one’s experience.

Depressive symptoms at baseline were significantly positively correlated with both intervention and post-intervention meditation adherence, although they were not uniquely significant when entered into hypothesized models with all other trait variables. However, exploratory models including only depressive symptoms, openness, and conscientiousness did find significant unique effects of depressive symptoms when predicting intervention and post-intervention out-of-class meditation adherence. While depression has a well-established relationship with adherence in other studies, these studies have found an inverse relationship, such that depressed individuals adhere less to medical interventions (33,34). Furthermore, a previous study linking depressive symptoms to out-of-class meditation adherence found a significant negative relationship (24). In contrast, our study found a positive relationship, which
may relate to the fact that the study was specifically targeted to treat depressive symptoms. Thus, individuals with more depressive symptoms may have had more motivation to adhere to meditation practice as a method to improve their depressive symptoms.

Baseline executive function was correlated with intervention meditation adherence but not with post-intervention meditation adherence, and was not a significant predictor in the regression models predicting meditation adherence at either time point. Executive function was highly correlated with conscientiousness, indicating that the two predictors shared variance within the model, and the data indicate that contentiousness was a stronger predictor of meditation adherence than executive function. The measure of executive function used in this study measured ability to focus and shift one’s attention (46), which at baseline may have led some participants to experience meditation practice as less difficult. Alternately, these skills could have facilitated the regulation of emotion and behavior that enables a daily out-of-class practice to occur.

The present study also found support for the role of MBIs in leading to changes in factors that have been found to predict MRA in other contexts. While the effects of MBIs on depressive symptoms and executive function are well established, the significant changes in the personality traits of conscientiousness, neuroticism, and openness from pre to post intervention is a more novel finding. Ribeiro et al. (16) also reported a reduction in neuroticism and an increase in conscientiousness from baseline to follow-up of an MBI. Additionally, a cross-sectional study measuring differences between meditators and controls found that the meditators on average had higher openness and lower contentiousness, while self-reported mindfulness meditation
experience (in months) was correlated with lower neuroticism and greater extraversion and openness (54). Our findings indicate that although personality was once considered to be fixed, MBIs may have the potential to change personality or at least the way people fill out personality scales. Changes in personality after therapy have been reported since the 1950s (55), and a recent study found increases in neuroticism and extraversion after cognitive therapy for depression (56), so it is no surprise that MBCT can also have an impact to personality traits.

The present study did not find that the changes to these MRA-related trait factors had an impact on post-intervention meditation adherence. This is an unexpected finding given that these factors changed in relation to the intervention and at baseline were predictive of meditation adherence. Particularly puzzling is the bivariate correlational finding that none of the post-intervention trait variables were significantly related to post-intervention meditation adherence, while the same trait variables at baseline were correlated with post-intervention meditation adherence. Our results may show that by post-intervention, these trait characteristics had already exerted an effect on habits of meditation practice that were not likely to change after the course. Despite the lack of significant findings for treatment-related trait changes on post-intervention meditation practice adherence, these trait changes may still exert an influence on other forms of MRA that participants are involved with after the MBI. Future studies could investigate other forms of MRA before and after an MBI.

The present study found support for the role of treatment-related factors in predicting post-intervention meditation adherence. Among the treatment-related factors, only retreat attendance was a unique predictor of intervention meditation adherence, which is a novel finding
to this study. While numerous studies have investigated the effects of long-term intensive meditation retreats (e.g. 57,58), there has been little research on the effects of the day-long retreats that are part of MBIs. Given that improvements in personality traits, depressive symptoms, and executive function did not impact post-intervention meditation adherence, the retreat was unlikely to have impacted post-intervention meditation adherence through effects on participant traits. Instead, the retreat may have given participants a deeper and more intensive experience of meditation practice, which may have resulted in greater motivation to continue meditating after the intervention and greater feelings of comfort and ease with the practice. This also aligns with the correlational findings that intervention and post-intervention meditation adherence were significantly related, as more intensive practice during the intervention may be one of the best predictors of post-intervention out of class meditation adherence.

The group therapeutic factors of instillation of hope and awareness of relational impact were significantly correlated with post-intervention meditation adherence but were not uniquely significant in the model with other predictors. In general, the social factor variables (alliance with the instructor and group therapeutic factors) were highly intercorrelated, which may have resulted in predictors contributing to the overall variance explained in the model but not being unique predictors. Previous research strongly supports the relationship between social support, patient provider relationships, and MRA (2,38). Our results suggest that the fostering of relationships, social support, and self-efficacy skills learned from the group atmosphere in which everyone underwent the same treatment helped participants better adhere to their practice. Previous research indicates that a group therapy setting may be more efficacious for behavior change than an individual setting (59). Additionally, the group aspect of MBIs presents an
excellent opportunity to foster social support and improve health behaviors and self-regulation. Future studies looking at factors associated with mindfulness meditation adherence should include additional measures of social support across time in the intervention as well as outside of the intervention setting.

**Limitations and Future Research**

This paper is limited by its reliance on self-report questionnaires. Self-report questionnaires may introduce response bias, which should be taken into account with these results. Additionally, self-report scales at post-assessment, along with the clinician administered depression scale at all time points, could have been influenced by social desirability and expectations of change. Future research should focus on utilizing as many objective measures as possible in order to limit these potential biases.

While intervention meditation adherence was measured weekly, post-intervention meditation adherence was based on participants’ abilities to recall their meditation practice over the previous three months. This format introduces recall bias into the study. A continuous online diary throughout the follow-up period would have helped to avoid any memory biases. Additionally, it is important to consider how long the benefits gained from MBIs persist through a participant’s life. For this reason, future research should include a longer follow-up time.

Future research is needed to replicate our findings in other (shortened or adapted) MBIs, in other populations, and with other forms of MRA. While the sample was designed to be characteristic of Americans who choose to be involved in meditation, the present findings do not
generalize to underrepresented groups. Finally, our results are specific to out-of-class meditation adherence and do not generalize to all forms of MRA. Future research should investigate whether mindfulness training leads to increased MRA in other contexts, such as for chronic medical illness.

**Implications and Future Directions**

Mindfulness meditation has been used as a treatment in the medical community for a few decades now; however, very few studies have examined possible predictors of treatment adherence (22-24). To improve MRA, and more specifically, mindfulness meditation adherence, it is necessary to understand what causes people to engage with mindfulness meditation and what keeps people practicing mindfulness meditation. The current study found that baseline conscientiousness, openness, and depressive symptoms predicted greater adherence to out-of-class meditation practice during and after an MBI, while changes in these factors did not have an effect on post-intervention meditation adherence. Treatment related factors such as retreat attendance and instructor and group related social factors also predicted greater post-intervention meditation practice.

Renewed emphasis and research on these less-studied dimensions of mindfulness-based interventions may be an avenue to maximize treatment effects. For example, a specific focus on participants with lower conscientiousness and lower openness to help them to structure and implement the workload of out-of-class practice into their daily lives and develop curiosity about their experience could be one possible approach. Early individual sessions with the MBCT therapist could help individuals with low conscientiousness to structure their routine by helping
them to develop time tables, or providing apps that help them remember to do their practice in their daily lives. Individual meetings with individuals low in openness could involve validation of their needs and fears about the practices and help to enhance their curiosity towards the training. Pointing out the benefits of the practice for depressive symptoms that individuals exhibit in screening interviews could also help to increase participant adherence through increasing their motivation.

Additionally, our findings indicate that instructor and group-related social factors are essential to the effective implementation of MBIs and should be emphasized throughout mindfulness teacher trainings. Finally, the impact of the retreat should not be neglected in shortened adaptations of MBIs, as our research underscores the importance of the retreat for continued engagement with the practice. The importance of the retreat and social factors for post-intervention meditation adherence especially has implications for interventions that do not typically have interpersonal dimensions, such as apps and internet delivered mindfulness programs. These interventions may require more creative ways to inspire participant adherence, such as online support groups and daily reminders.
References


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58. Jacobs TL, Shaver PR, Epel ES, Zanesco AP, Aichele SR, Bridwell DA, Rosenberg EL,

Table 1. Baseline trait variable models predicting intervention and post-intervention meditation adherence.

| Models/Predictor Variables | Intention Adherence $R^2$ | | Post-intervention Adherence $R^2$ | |
|----------------------------|---------------------------|---------------------------|---------------------------|
| Total Model                | 24                        | .001                      | 14                        | 038                      |
| Agreeableness (BFI)        | 04                        | 691                       | 08                        | 452                      |
| Conscientiousness (BFI)    | 35                        | 001                       | 22                        | 055                      |
| Neuroticism (BFI)          | 12                        | 273                       | 07                        | 553                      |
| Openness (BFI)             | 24                        | 016                       | 21                        | 063                      |
| Depression (IDS)           | 16                        | 103                       | 19                        | 066                      |
| Executive Function (ACS)   | 08                        | 479                       | .01                       | 904                      |

Note: $N = 96$. The model with intervention meditation adherence as a dependent variable was run as a multiple linear regression. The model with post-intervention meditation adherence as a dependent variable was run as a quasi-poisson generalized linear model. $R^2$ for this model refers to McFadden’s pseudo $R^2$. 
Table 2. Descriptive statistics and main effects of time (baseline to post-course) for all trait variables

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<th>$SD_1$</th>
<th>$M_2$</th>
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<th>$f$</th>
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<td>4.89</td>
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Note: $N = 96$. Results are main effects of time (pre to post intervention) from repeated measures ANOVA tests.
Table 3. Trait variable residual changes as predictors of post-intervention adherence

<table>
<thead>
<tr>
<th>Models/Predictor Variables</th>
<th>Post-intervention meditation adherence</th>
<th>( R^2 )</th>
<th>( p )</th>
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</thead>
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<td>Executive Function (ACS)</td>
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<td>.231</td>
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</table>

Note: \( N = 96 \). Post-intervention trait variables were entered into the quasi-poisson generalized linear model as a second step after baseline variables, which are reported in Table 1. \( \Delta R^2 \) measures the amount of additional variance explained in the model when the post-intervention variables were added. McFadden’s pseudo \( R^2 \) was used as a measure of variance explained.
Table 4. Treatment Variable model predicting post-intervention out-of-class meditation adherence

<table>
<thead>
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<th>Models/Predictor Variables</th>
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<td>Secure Emotional Expression (TFI-19)</td>
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<tr>
<td>Social Learning (TFI-19)</td>
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</tr>
<tr>
<td>Awareness of Relational Impact (TFI-19)</td>
<td>20</td>
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</table>

Note: $ N = 96 $. Results are from a quasi-poisson generalized linear model. McFadden’s pseudo $ R^2 $ was used as a measure of variance explained.