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Depression, Craving, and Substance Use Following a Randomized Trial of Mindfulness-Based Relapse Prevention

Katie Witkiewitz
Washington State University Vancouver

Sarah Bowen
University of Washington

Objective: A strong relation between negative affect and craving has been demonstrated in laboratory and clinical studies, with depressive symptomatology showing particularly strong links to craving and substance abuse relapse. Mindfulness-based relapse prevention (MBRP), shown to be efficacious for reduction of substance use, uses mindfulness-based practices to teach alternative responses to emotional discomfort and lessen the conditioned response of craving in the presence of depressive symptoms. The goal in the current study was to examine the relation between measures of depressive symptoms, craving, and substance use following MBRP. ***Method:*** Individuals with substance use disorders ($N = 168$; mean age 40.45 years, $SD = 10.28$; 36.3% female; 46.4% non-White) were recruited after intensive stabilization, then randomly assigned to either 8 weekly sessions of MBRP or a treatment-as-usual control group. Approximately 73% of the sample was retained at the final 4-month follow-up assessment. ***Results:*** Results confirmed a moderated-mediation effect, whereby craving mediated the relation between depressive symptoms (Beck Depression Inventory) and substance use (Timeline Follow-Back) among the treatment-as-usual group but not among MBRP participants. MBRP attenuated the relation between postintervention depressive symptoms and craving (Penn Alcohol Craving Scale) 2 months following the intervention ($f^2 = .21$). This moderation effect predicted substance use 4 months following the intervention ($f^2 = .18$). ***Conclusion:*** MBRP appears to influence cognitive and behavioral responses to depressive symptoms, partially explaining reductions in postintervention substance use among the MBRP group. Although results are preliminary, the current study provides evidence for the value of incorporating mindfulness practice into substance abuse treatment and identifies a potential mechanism of change following MBRP.

Keywords: mindfulness based relapse prevention, substance use, craving, negative affect, depression

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Addiction has generally been characterized as a chronic and relapsing condition (Connors, Maisto, & Zywiak, 1996; Leshner, 1999). Research on the relapse process has implicated numerous risk factors that appear to be the most robust and immediate predictors of posttreatment substance use, including negative affect, craving or urges, interpersonal stress, motivation, self-efficacy, and ineffective coping skills in high-risk situations (Connors et al., 1996; Witkiewitz & Marlatt, 2004). Targeting these risk factors during treatment, either pharmacologically (e.g., naltrexone to reduce alcohol craving; Richardson et al., 2008) or behaviorally (e.g., coping skills training; Monti et al., 2001), has become a priority for substance abuse researchers and clinicians.

Katie Witkiewitz, Department of Psychology, Washington State University Vancouver; Sarah Bowen, Department of Psychology, University of Washington.

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Correspondence concerning this article should be addressed to Sarah Bowen, University of Washington, Department of Psychology, Box 351629, Seattle, WA 98195-1525. E-mail: swbowen@uw.edu

Depression, Craving, and Relapse

The significant roles of negative affective states and craving in the substance use relapse process have been described for over 30 years (e.g., Ludwig & Wikler, 1974; Solomon & Corbit, 1974). Craving, the subjective experience of an urge or desire to use substances (Kozlowski & Wilkinson, 1987), has been shown to strongly predict reinstatement of substance use for all major drugs of abuse (e.g., Hartz, Frederick-Osborne, & Galloway, 2001; Hopper et al., 2006; Shiffman et al., 2002). Negative affect has been shown to be a prominent cue for craving in both laboratory and clinical studies (e.g., Cooney, Litt, Morse, Bauer, & Gaupp, 1997; Perkins & Grobe, 1992; Shiffman & Waters, 2004; Sinha & O'Malley, 1999; Stewart, 2000; Wheeler et al., 2008), and both the experience of negative affective states and the desire to avoid these aversive states have been described as primary motives for substance use (e.g., Wikler, 1948). Depressive symptomatology has been linked to reinitiation of drug use following periods of abstinence (e.g., Curran, Booth, Kirchner, & Deneke, 2007; Witkiewitz & Villarroel, 2009), and self-reported depression has been shown to predict substance use treatment outcomes (e.g., Cornelius et al., 2004; Greenfield et al., 1998; Hodgins, el-Guebaly, & Armstrong, 1995).

The relation between depression and substance use is also evident in the disproportionately higher rates of substance use relapse in individuals with affective disorders (Conner, Sorensen, & Leonard, 2005; Hasin & Grant, 2002; Kodl et al., 2008).

Individuals with depression show a particularly strong relation between depressive symptoms and both craving and relapse (Curran, Flynn, Kirchner, & Booth, 2000; Gordon et al., 2006; Levy, 2008; Zilberman, Tavares, Hodgins, & el-Guebaly, 2007).

Mechanisms of the relation between depressive symptoms, craving, and relapse may be explained by a negative-reinforcement withdrawal model (Wikler, 1948). Baker, Piper, McCarthy, Majeskie, and Fiore (2004) proposed that attempts to avoid negative affect during withdrawal produce the primary motive for resumption of drug use, and evidence from recent clinical, laboratory, and ecological momentary assessment studies supports this model (e.g., Armeli, Feinn, Tennen, & Kranzler, 2006; Carter et al., 2008; Perkins et al., 2008). Research on the roles of brain systems and neurotransmitters provides further support. Persistent substance use leads to disruptions in several neurotransmitter systems, including both dopamine and serotonin in the nucleus accumbens and increased corticotropin-releasing factor in the central nucleus of the amygdala, which are central to affective changes and stress responses during withdrawal. These disruptions may increase vulnerability to relapse when experiencing craving (Koob, 1988; Weiss, Markou, Lorang, & Koob, 1992; for a review, see Weiss, 2005). Therefore, longtime substance users may be particularly susceptible to increased depressive symptoms, which heighten their motivation to seek relief through use of substances and consequently increase the intensity of their craving.

Teasdale, Segal, and Williams (2000) proposed the use of mindfulness practices to address this potential link between negative mood states and further problematic cognitive patterns that may lead to relapse. Mindfulness-based cognitive therapy for depression (MBCT; Segal, Williams, & Teasdale, 2002), a relapse prevention program for individuals with past episodes of major depression, was designed to reduce the depressive thinking that can lead to full depressive relapse. The treatment focuses on recognizing depressive thoughts, sensations, and feelings that can be risk factors for relapse to depression. Clients learn to accept these experiences as separate from themselves and as transient or subject to change, thereby interrupting the cognitive processes that may contribute to depressive relapse. MBCT has been found to be most effective for those with three or more previous depressive episodes as compared to their treatment-as-usual counterparts (Ma & Teasdale, 2004; Teasdale et al., 2000). Segal, Teasdale, and Williams (2004) hypothesized that MBCT might be of greater help to those with a greater association of depressive thinking and severely depressed mood.

Similarly, individuals with substance abuse histories may habitually react to depressive thinking or mood states with relapse-related thoughts or cravings due to past associations of depressive states with craving and substance use relapse. Through increased awareness of these cognitive and emotional patterns, and through learned alternative responses, mindfulness-based techniques may attenuate the conditioned linkage among depressive symptoms, craving, and relief seeking through substance use.

Mindfulness-Based Relapse Prevention

A recently developed behavioral intervention, mindfulness-based relapse prevention (MBRP; Bowen, Chawla, & Marlatt, in press; Witkiewitz, Marlatt, & Walker, 2005), combines Marlatt's cognitive behavioral relapse prevention program (Marlatt & Gordon, 1985) with mindfulness practice, using a structure similar to that of MBCT. MBRP was designed to directly target negative mood, craving, and their roles in the relapse process. MBRP is based largely upon the content of MBCT and offers skills in cognitive behavioral relapse prevention (e.g., identifying high-risk situations, coping skills training) and mindfulness meditation. Clients typically meditate for 30–45 min in session and are assigned approximately 45 min of daily meditation with audio-recorded instructions. The mindfulness practices are intended to increase discriminative awareness and acceptance, with a specific focus on affective and physical discomfort. They teach clients to observe physical, cognitive, emotional, or craving states without "automatically" reacting. Through formal meditation practices, other mindfulness-based exercises, and discussion, clients practice a nonjudgmental approach to negative affective states; they learn to "investigate" the emotional, physical, and cognitive components of experience, rather than to immediately attempt to escape them. It is hypothesized that clients' mindful recognition of and attention to problematic cognitive and affective states provide a "pause" that interrupts the habitual reaction. Over time, repeated exposure to previously avoided experience (e.g., depressive states), in the absence of habitual responses (e.g., substance use), may weaken the response of craving in the presence of emotional discomfort.

Recently, Bowen et al. (2009) conducted a pilot efficacy trial of an aftercare program following an intensive stabilization period, consisting of either inpatient or intensive outpatient treatment. The study evaluated substance use outcomes up to four months following postintervention assessment among participants randomly assigned to either an 8-week closed-cohort MBRP course or the program's standard rolling admission, treatment-as-usual (TAU) aftercare, which consisted of agency-delivered services based on the 12-step model (Lile, 2003) and psychoeducational content. Results suggested that those receiving intensive stabilization plus MBRP, when compared to intensive stabilization plus TAU, demonstrated significantly lower rates of substance use, greater decreases in craving, and greater increases in the Acting With Awareness subscale of the Five Factor Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) across the 4-month follow-up period. Significantly greater decreases in craving were found in the MBRP group as compared to the TAU group, and these decreases significantly mediated the relation between intervention group and substance use outcomes. The study offered preliminary support for the efficacy of the integration of mindfulness and relapse prevention strategies in the prevention of substance abuse relapse. Further evaluation of the potential mediating processes involved is needed, however.

The current study followed up on the significant mediating effect of craving that was reported by Bowen et al. (2009) and was designed to further examine one hypothesized mechanism of change following MBRP. On the basis of previous research, described above, we hypothesized that depressive symptoms and craving would be positively correlated with one another and that both would be significantly related to postintervention substance use. We further hypothesized that participation in MBRP would attenuate the relation between depressive symptoms and craving and thereby subsequently decrease substance use.

In particular, we were interested in testing the hypotheses that (a) there is a strong, positive relation among postintervention depressive symptoms, craving 2 months following the interven-

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tion, and days of substance use following the intervention; (b) the relation between depression symptoms and substance use can be partially explained by individuals' subjective reports of craving; (c) intervention assignment will attenuate relations between depressive symptoms and craving; and (d) there is an interaction among intervention assignment, depressive symptoms, and craving in the prediction of substance use. Given the focus of MBRP on helping clients to experience discomfort with decreased reactivity, we hypothesized that individuals in MBRP would be less likely to report craving in response to higher depression scores and would subsequently decrease their substance use.

Method

Sample

Participants in the original study ($N = 168$; Bowen et al., 2009) were recruited from a private, nonprofit public service agency that provided both inpatient and intensive outpatient care for alcohol and other drug use disorders. All participants were fluent in English and had completed intensive outpatient or inpatient treatment within the previous 2 weeks. Excluded from the study were those with current psychosis, dementia, imminent suicide risk, or significant risk for withdrawal; those unable to attend treatment; and those needing more intensive treatment due to high risk of relapse or continued heavy use, as determined by agency staff.

Participants ranged from 18 to 70 years of age ($M = 40.45$ years, $SD = 10.28$) and identified primarily as White (not Hispanic, 53.6%), African American (28.6%), Native American (7.7%), or Hispanic/Latino (6.0%). The majority of participants were male (63.7%). Approximately 41.3% reported being unemployed, 62.3% earned less than $4,999 per year, and 71.6% had a high school diploma. The primary drugs of abuse were alcohol (45.2%), cocaine/crack (36.2%), and methamphetamine (13.7%). Approximately 19% of those sampled reported polydrug abuse.

Measures

All measures were self-reports administered via a web-based assessment program with staff available to assist participants in using the assessment interface. Research has found no significant differences between paper-and-pencil and web administration of commonly utilized measures (Miller et al., 2002). Demographics were assessed at baseline only. All other measures were administered at baseline, postintervention (immediately following the 8-week course), and at 2 and 4 months following postintervention.

Substance use. Alcohol or other drug use was assessed with the Timeline Follow-Back (Sobell & Sobell, 1992). Participants used a calendar format to report the number of days on which they had used alcohol or other drugs over the past 60 days. The current study used calendar data from the 4-month assessment, representing the total days of use during the 60 days between the 2-month and 4-month assessments. The Timeline Follow-Back has demonstrated good reliability and validity, with no significant differences between online and in-person administration (Sobell & Sobell, 1992).

Alcohol and drug craving. The Penn Alcohol Craving Scale (PACS; Flannery, Volpicelli, & Pettinati, 1999), a five-item measure, was adapted to include craving both for alcohol and for other drugs. The PACS measures frequency, intensity, and duration of craving, as well as an overall rating of craving for the previous week. The PACS has shown excellent internal consistency and predictive validity for alcohol relapse. The internal consistency of the PACS in the current sample was .87.

Depression. Depression was assessed with the Beck Depression Inventory–II (BDI; Beck, Steer, & Brown, 1996), a measure consisting of 21 multiple-choice format items assessing specific symptoms of depression. The BDI has shown high reliability across diverse populations (e.g., Steer, Cavalieri, Leonard, & Beck, 1999; Storch, Roberti, & Roth, 2004). Internal consistency in the current sample was .92.

Intervention

MBRP was delivered by two therapists to groups of 6–10 participants. Closed cohorts met weekly for eight 2-hr sessions. Sessions included guided meditations, experiential exercises, and discussion. Participants were assigned daily exercises to practice between sessions and were given CDs for daily meditation practice. Relapse prevention practices (based on the program by Daley & Marlatt, 2006) were integrated into the mindfulness-based skills. MBRP therapists held master's degrees in psychology or social work, and all had a background in cognitive–behavioral interventions. All sessions were audio recorded. Treatment fidelity was assessed by a team of coders who were trained to identify key content- and style-related components of MBRP using the Mindfulness-Based Relapse Prevention Adherence and Competence Scale, a measure of treatment integrity for MBRP (Chawla et al., in press). Ratings by independent raters demonstrated high interrater reliability and adequate internal consistency, suggesting that therapists were adherent to the treatment protocol, therapeutic style, and discussion of core concepts (Chawla et al., in press).

Participants in the TAU condition continued in their standard, rolling admission outpatient aftercare, which included work in the 12-step model, process-oriented groups, and psychoeducation. Relapse prevention skills, based upon Gorski's (2007) disease model of alcohol and drug addiction, were included in some of the groups. Therapists facilitating the TAU groups were licensed chemical dependency counselors with diverse clinical training and experience.

Procedure

All study procedures were approved by the University of Washington Human Subjects Review Board. Participants were recruited close to completion of their inpatient or outpatient treatment. Recruitment started in April 2007 and ended in October 2007, and all follow-up assessments were completed by May 2008. As shown in Figure 1, 260 participants were screened for inclusion in the study and 187 met criteria for inclusion. Reasons for exclusion included acute suicidality ($n = 1$), active psychosis ($n = 10$), inability to participate due to scheduling conflicts ($n = 4$), having less than 8 weeks until completion of aftercare ($n = 9$), and not completing inpatient or intensive outpatient treatment ($n = 49$). Of those who met inclusion criteria, nine individuals declined participation, nine failed to complete the baseline assessment, and one refused randomization, reducing the overall sample to 168. This sample size was determined by the inpatient and intensive outpa-

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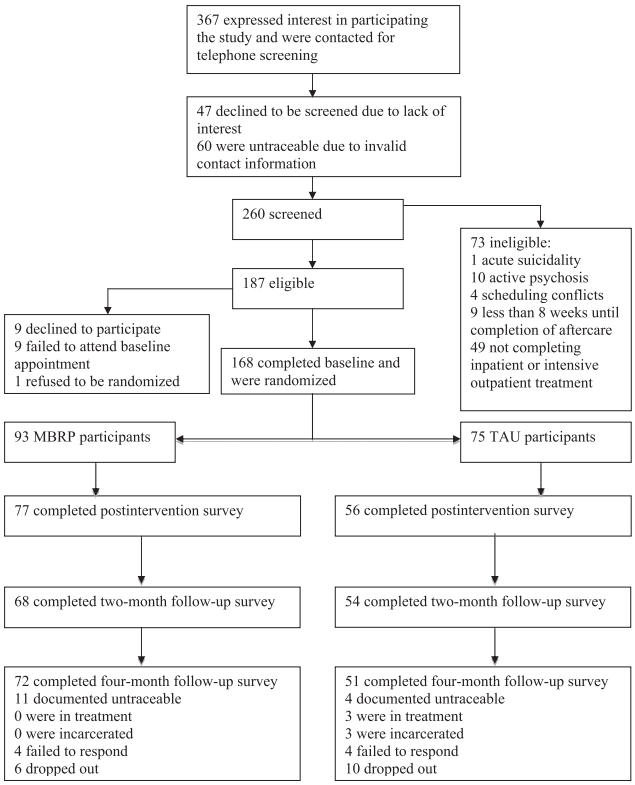

Figure 1. CONSORT participant flow diagram. MBRP = mindfulness-based relapse prevention; TAU = treatment as usual.

tient completion rates at the facility during the 2-year study period, and it provided sufficient power to detect a medium effect of intervention on substance use outcomes. Interested and eligible individuals were randomly assigned via a web-based random number sequencer (http://www.randomizer.org) to MBRP ($n = 93$) or TAU ($n = 75$) following completion of a baseline assessment. Participants were randomly oversampled for the MBRP condition due to initial concerns about potentially higher rates of attrition in the MBRP group. The random number sequence described above was generated by graduate research assistants at the baseline assessment appointment. Graduate research assistants, participants, and those administering the interventions were aware of group assignment. All participants were compensated with gift cards upon completion of each assessment. No adverse events or side effects were reported by participants in either group.

Statistical Analyses

To examine the hypotheses outlined above, we estimated a series of path models using Mplus Version 5.2 (Muthén & Muthén, 2007). In all path models, intervention assignment and depression scores at postintervention were entered as the independent variables, craving at the 2-month follow-up was included as the mediator, and days of alcohol or other drug use at the 4-month follow-up period was entered as the dependent variable. Baseline craving and baseline depression scores, number of treatment hours received (including intervention hours and other treatment services received at the agency), baseline days of use, gender, and race were included as covariates in all analyses. All models were estimated using full information maximum likelihood (FIML) via the expectation maximization algorithm, which provides estimates of the variance–covariance matrix for all available data, including those individuals who have incomplete data on some measures. FIML is considered to be superior to other methods of handling missing data (e.g., listwise deletion) when data are missing at random (Schafer, 1997). Attrition analyses indicated that only postintervention depression was significantly related to completion status, $t(102) = 2.54$, $p = .01$, and data were thus assumed to be missing at random with postintervention depression included in the model. Thus, our effective sample size for all models was 168. All analyses were intention to treat; thus, the sample sizes per group were 93 and 75 for MBRP and TAU, respectively.

Preliminary data screening indicated that the distribution of the total days of use variable was highly skewed and kurtotic. Given that days of use are count data, a negative binomial distribution was first considered for all analyses. A comparison of the negative binomial models with models that assumed a normal distribution suggested that the results from the latter models were very robust to the violation of normality, and assuming a negative binomial distribution did not greatly alter the main coefficients of interest. Methods for testing moderated mediation using count outcomes and the negative binomial distribution have not been thoroughly examined. Thus, all analyses were conducted with the normal distribution. The days of use outcome variable was square root transformed to reduce kurtosis, and after the transformation was made, we assessed multivariate normality for all variables to be included in the analysis using Mardia's (1970) test of multivariate skewness and kurtosis. Mardia's coefficient of skewness ($M_3 = 0.238$, $p = .07$) and kurtosis ($M_4 = 5.219$, $p = .07$) indicated the assumption of multivariate normality was not significantly violated.

To test the first hypothesis that there is a strong, positive relation among depressive symptoms, craving, and substance use, we examined the associations between depression scores, craving scores, and substance use outcomes for both intervention conditions using path analyses. The second hypothesis was to determine whether the relation between depressive symptoms and substance use could be explained by subjective reports of craving. To test this hypothesis, we conducted analyses of simple mediation effects of craving in the relation between depression scores and substance use, using the product of coefficients method (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). The product of coefficients method involves the multiplication of regression coefficients for the regression of the mediator on the independent variable (*a* path) and for the regression of the outcome on the mediator (*b* path) with the independent variable included in the model (*c* path), and with $a*b$ considered the mediated effect. An effect size, representing proportion of variance explained by the mediated effect, can be calculated by dividing the amount of variance in the outcome explained by the mediated effect by the total amount of variance in the outcome explained by both the mediator and the independent variable (MacKinnon, 2008). The simple mediation effects were estimated in Mplus using a maximum likelihood estimator and 1,000 bootstrap draws to obtain confidence intervals for the indirect effect. The mediation models were evaluated using multiple indices of model fit: a nonsignificant chi-square statistic, comparative fit index values greater than 0.95, and standardized root mean

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square residual values less than 0.08 (Hu & Bentler, 1998). The commonly reported root mean square error of approximation was not used because it tends to overreject true models when the sample size is small ($n \leq 250$; Hu & Bentler, 1998).

After testing the unconditional mediation effects, we examined the final two hypotheses, moderation and moderated mediation (i.e., conditional indirect effect; Preacher, Rucker, & Hayes, 2007), by incorporating the mean-centered Depression Scores × Intervention interaction into the model as independent variables using the methods described by Aiken and West (1991). First, the moderating hypothesis, that intervention assignment would attenuate the relation between depressive symptoms and craving, was tested by incorporating the Depressive Symptoms × Intervention interaction in the path model (shown in Figure 2a).[1] Second, the moderated mediation hypothesis was examined by estimating the Depressive Symptoms × Intervention interaction predicting days of use via craving (indirect effect of $a_3{*}b$). This model (shown in Figure 2b) provides a test of whether the attenuation of the relation between depressive symptoms and craving among MBRP participants predicted days of substance use postintervention. Although many variants of moderated-mediation or mediated-moderation can be tested, we used the model identified as "Model B" by Preacher et al. (2007), in which the *a* path of the indirect effect is moderated by some other variable. In this instance of moderated mediation, the relation between depressive symptoms and craving depends on the level of a moderating variable (intervention condition). In other words, the mediating (i.e., indirect) effect of craving in predicting substance use is conditional on the interaction between intervention condition and depression (Morgan-Lopez & MacKinnon, 2006; Preacher et al., 2007). As described above, models were estimated using FIML with 1,000 bootstrap draws to obtain standard errors for the indirect effect. For the moderation tests, f^2 was used as an estimate of the effect size, which is the proportion of variance explained by the interaction relative to the unexplained variance in the criterion (see Aiken & West, 1991). Unfortunately, there is much less research on effect size measures for moderated mediation (Fairchild & MacKinnon, 2009). For the current study, we calculated the effect size for the moderated mediation effect using the proportion of variance explained by the moderated mediation effect divided by the total proportion of variance explained (MacKinnon, 2008).

Results

Preliminary Analyses

Descriptive statistics and bivariate correlation coefficients for all measured variables in the analyses are shown in Table 1. A series of chi-square tests and *t* tests was conducted to determine whether there were any significant differences between the intervention groups at baseline. Results indicated a significant difference on racial distribution between the groups, $\chi^2(1, N = 168) = 5.51$, $p = .02$, such that the MBRP group consisted of a higher proportion of White participants (63%, $n = 59$) than the TAU group (45%, $n = 34$). This difference was a nonsystematic effect of randomization, and there were no differences in attrition between White and non-White participants in the MBRP group, $\chi^2(1, N = 93) = 0.631$, $p = .43$. There were no other baseline intervention differences on key demographic or main outcome variables ($ps > .14$).

MBRP participants attended an average of 65% of intervention sessions, or 10.36 ($SD = 4.83$) hr of treatment, across the 8 weeks. The majority (86%) reported practicing meditation at postintervention (for an average of 2.60 [$SD = 1.45$] hr per week), and 54% reported continued practicing through 4 months postintervention (for an average of 2.18 [$SD = 1.80$] hr per week). TAU participants reported an average of 9.75 ($SD = 8.17$) hr of treatment, which was significantly less ($p = .006$) than the total number of treatment hours received by the MBRP group ($M = 12.79$, $SD = 4.91$). Of the participants, two thirds ($N = 103$; MBRP $n = 62$, TAU $n = 41$) completed the postintervention assessment, 57% ($N = 95$; MBRP $n = 53$, TAU $n = 42$) completed the 2-month follow-up, and 73% ($N = 122$; MBRP $n = 70$, TAU $n = 52$) completed the 4-month follow-up. No significant differences in rates of attrition between groups were found at postintervention, $\chi^2(1, N = 168) = 1.663$, $p = .20$; 2 months, $\chi^2(1, N = 168) = 1.514$, $p = .22$; or 4 months, $\chi^2(1, N = 168) = 0.012$, $p = .91$.

As shown in Table 1, mean depression scores in both conditions and at both baseline and postintervention were in the mild range. Scores were lower for the MBRP group than the TAU group at baseline and postintervention; however, these differences were not significant ($p > .33$). Likewise, the MBRP group had lower craving scores (at baseline and postintervention) and had fewer days of use 4 months postintervention, but these differences did not reach statistical significance ($p < .05$) in independent samples *t* tests. It is important to note the low average days of use over the 60-day period (9.33 days for TAU, 5.62 days for MBRP) and the large standard deviations for both groups. Across both groups, less than 30% of participants (29.1% in TAU, 28.6% in MBRP) had any days of use. Of those who used, 28.6% and 33.3% of TAU and MBRP participants, respectively, used substances on only one day during the 60-day follow-up period.

For purposes of the current study, it was useful to examine the different patterns of correlations across groups. Correlations below the diagonal indicated that participants in TAU evinced strong associations between postintervention BDI, 2-month craving, and days of use 4 months postintervention. Correlations above the diagonal indicated that among MBRP participants, postintervention BDI was not significantly correlated with 2-month craving or days of use 4 months postintervention.

Path Models

The first goal in the current study was to examine the association between postintervention depression symptoms, craving 2 months following the intervention, and substance use 4 months following the intervention. These time points were chosen to establish temporal precedence between measures of depressive symptoms and both the mediator (craving) and the outcome (substance use). To examine these associations, we started by assessing

[1] It is important to note that we are testing the interaction between intervention and depression; thus, in the analyses neither intervention nor depression is specifically designated as the moderator. Given that probing moderation effects is often easier with categorical variables we indicate intervention as the moderator, but it is the interaction between depression and intervention that defines the moderating effect.

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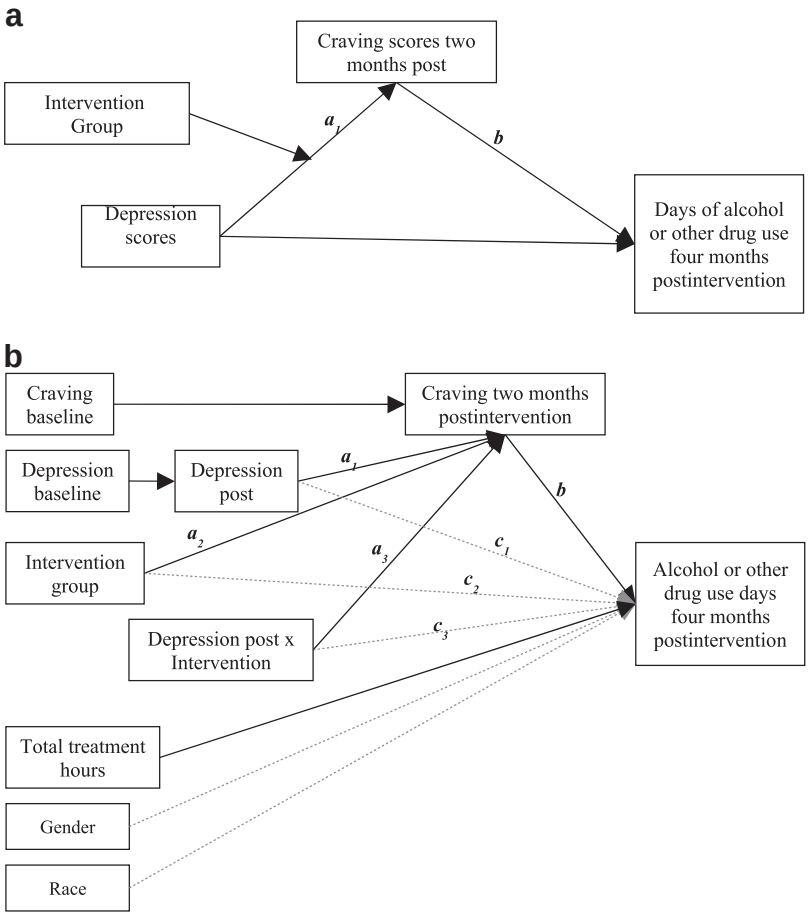

Figure 2. a: Hypothesized moderation effect. b: Moderated-mediation model with nonsignificant paths indicated by gray dashed lines and significant paths indicated by black solid lines. Paths are labeled with *a*, *b*, and *c*, corresponding to path coefficients in Tables 2 and 3.

the direct effect of intervention on postintervention depression scores, craving scores 2 months following intervention, and days of substance use 4 months following the intervention, while controlling for treatment hours, gender, race, and baseline levels of substance use, craving, and depression scores. The direct effect of intervention in predicting days of use at the 4-month follow-up was not significant ($\beta = .24$, $p = .06$);[2] however, several hypothesized relations among intervention assignment, depressive symptoms, craving, and days of use were supported. Significant effects were observed for the regression of days of use on craving at 2-month follow-up ($\beta = .65$, $p < .01$), BDI scores postintervention ($\beta = -.28$, $p = .02$), and total treatment hours ($\beta = -.32$, $p = .02$). Craving at 2-month follow-up was significantly predicted from intervention assignment ($\beta = -.20$, $p = .03$) and postintervention depression scores ($\beta = .32$, $p < .01$). Postintervention levels of depression were significantly related to baseline levels ($\beta = .72$, $p < .01$) but were not significantly related to intervention assignment ($\beta = -.06$ $p > .05$) or baseline craving ($\beta = .02$, $p = .76$). Thus, craving and postintervention depression predicted total days of use, and both intervention assignment and postintervention levels of depression were significantly related to craving. Gender and race were not significantly related to days of use, postintervention depression scores, or craving ($p > .05$). Also, total treatment hours were not significantly related to postintervention depression scores or craving ($p > .05$).

Mediation Models

In order to examine the potential mechanisms underlying the relations among intervention, depressive symptoms, craving, and

[2] The nonsignificant direct effect of intervention on 4-month days of use in the current study was inconsistent with the significant main effect of the MBRP intervention on substance use found in the main outcomes study (Bowen et al., 2009) for two reasons. First, the current study evaluated days of use only at the 4-month follow-up, whereas the main outcomes study evaluated the effect of MBRP across the entire 4-month follow-up. The differences between days of use for the MBRP and TAU groups were larger at the 2-month follow-up (TAU average days of use = 5.32 [*SD* = 14.67] and MBRP average days of use = 1.59 [*SD* = 5.94]) than the 4-month follow-up (TAU average days of use = 9.33 [*SD* = 20.80] and MBRP average days of use = 5.62 [*SD* = 14.33]). Second, the main outcomes study used generalized estimating equations to estimate the time by treatment effect, whereas the current study evaluated the direct effect of intervention at a single point in time.

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Table 1
Descriptive Statistics and Bivariate Correlations for Primary Study Variables

Variable	1	2	3	4	5	6	MBRP *M* (*SD*)
1. BDI baseline	—	.69**	.19	.11	−.06	−.21	13.07 (9.56)
2. BDI postintervention	.82**	—	.16	.12	−.11	−.19	12.16 (12.37)
3. PACS baseline	.28*	.29	—	.40**	−.046	−.07	1.55 (1.13)
4. PACS 2 months	.43**	.54**	.18	—	.08	.46*	0.98 (0.98)
5. Treatment hours received	−.003	−.02	.19	−.20	—	−.05	12.79 (4.91)
6. AODD 4 months postintervention	.08	.53*	.14	.73**	−.52**	—	5.62 (14.33)
TAU *M* (*SD*)	14.80 (12.94)	14.21 (13.84)	1.73 (1.42)	1.42 (1.49)	9.75 (8.16)	9.33 (20.80)	—

Note. Means are based on untransformed variables. *SD* = standard deviation; MBRP = mindfulness-based relapse prevention (shown above the diagonal); BDI = Beck Depression Inventory; PACS = Penn Alcohol Craving Scale; AODD = alcohol or other drug use days; TAU = treatment as usual (shown below the diagonal).
* $p < .05$. ** $p < 0.01$.

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days of use, we investigated whether craving at 2 months postintervention mediated the relation between postintervention depressive symptoms and days of use at 4 months postintervention.[3] Baseline levels of craving, depressive symptoms and days of use, gender, race, and treatment hours were included as covariates. This model provided an excellent fit to the observed data, $\chi^2(8) = 12.21$, $p = .14$, comparative fit index = 0.97, standardized root mean square residual = 0.04. As shown in Table 2, results indicated that craving scores significantly mediated the relation between postintervention depressive symptoms in the prediction of days of use over the 4 months following the intervention (indirect effect = 0.23, 95% CI [0.08, −0.40], $p = .01$, proportion mediated = 0.07). The mediation model explained 40% of the variance in postintervention days of use, assessed at 4 months.

Moderation Models

Moderated regression analyses were conducted to examine whether there was an interaction between depressive symptoms and intervention in the prediction of craving following the intervention. There was a significant moderation effect for the relation among intervention assignment, depression scores at postintervention, and craving scores at 2 months ($\beta = -.32$, $p = .001$, $f^2 = 0.21$). As shown in Figure 3, probing the moderation effect indicated that individuals who were randomly assigned to MBRP did not evince the strong, positive association between depression scores and craving scores that was present for the TAU participants.

Moderated Mediation Models

The final hypothesis, that the attenuation of the relation between depression and craving among MBRP participants explained postintervention substance use, was examined with moderated mediation analyses. The goal in this analysis was to test the significance of the product of the a_3 path and the b path in Figure 2b. As shown in Table 3, the indirect effect of craving in the analysis of postintervention days of use regressed on the Depression × Intervention interaction was significant, providing evidence for moderated mediation (indirect effect = −0.06, 95% CI [−0.13, −0.01], proportion mediated = 0.07, $f^2 = 0.18$). The moderated mediation model explained 50% of the variance in days of use at 4 months postintervention.

This finding can be further broken down by examining the indirect effect of craving in the association between levels of depression and days of use for each intervention group separately. The indirect effect approached significance for the TAU group (indirect effect = 0.05, 95% CI [−0.02, −0.09], $p = .05$, proportion mediated = 0.18) but not for the MBRP group (indirect effect = 0.005, 95% CI [−0.02, −0.03], $p = .65$, proportion mediated = 0.002). Therefore, craving partially mediated the relation between depressive symptoms and substance use for TAU but not for MBRP participants.

Given the complexity of moderated mediation effects, it is often helpful to examine these effects with a variety of plotting techniques (e.g., simple slopes, creating cutoff scores). As shown in Figures 4a and 4b, individuals with the highest level of depressive symptoms (BDI scores greater than 20) in MBRP had significantly lower craving scores and significantly fewer days of use than did TAU participants with higher depressive symptoms. Figure 4a suggests craving increased proportionally to increasing levels of depressive symptoms for TAU participants but not for MBRP participants. Figure 4b shows participants in TAU had the most substance use days at the highest level of depressive symptoms, whereas participants in MBRP had few substance use days at the highest levels of depressive symptoms and more substance use days at low levels of depressive symptoms.

Discussion

Results from the current study supported all four study hypotheses. First, positive relations were supported between postintervention depressive symptoms, craving at the 2-month follow-up, and days of alcohol or other drug use over the

[3] Ideally, in testing mediation it is important to control for posttreatment changes in the dependent variable that might have occurred prior to the posttreatment changes in the hypothesized mediator. In the current study we could not control for days of use at 2 months because of unequal variances between groups at the 2-month follow-up, Levene's test, $F(1, 122) = 15.15$, $p < .005$, as well as significant differences in the correlations between 2-month and 4-month days of use between intervention groups (TAU $r = .84$, $p < .005$; MBRP $r = .08$, $p = .61$). Thus, including the days of use at 2 months would have violated the homoscedasticity and serial independence assumptions of regression, respectively.

Table 2
Results From Mediation Analyses

Path	Direct and indirect effects	β	*B* [95% CI]
	Days of use on gender (female = 1)	.13	4.75 [−4.39, 12.93]
	Days of use on race (White = 1)	−.16	−5.21 [−15.99, 1.42]
	Days of use on treatment hours	−.30	−0.74 [−1.69, −0.04]
	Days of use on baseline days of use	−.17	−0.12 [−0.35, 0.07]
	PACS 2 months on PACS baseline	.21	0.22 [0.06, 0.39]*
	BDI postintervention on BDI baseline	.74	0.84 [0.71, 0.95]**
b	Days of use on PACS 2 months	.57	7.45 [3.14, 11.10]**
c_1	Days of use on BDI postintervention	−.28	−0.29 [−0.70, 0.03]
c_2	Days of use on intervention (TAU = 0, MBRP = 1)	.18	5.93 [−1.42, 14.40]
a_1	PACS 2 months on BDI postintervention	.30	0.03 [0.01, 0.05]*
a_2	PACS 2 months on group (TAU = 0, MBRP = 1)	−.17	−0.44 [−0.90, −0.08]*
a_1^*b	Indirect effect: Days of use on BDI via PACS	.12	0.23 [0.08, 0.40]*
a_2^*b	Indirect effect: Days of use on group via PACS	−.24	−3.24 [−6.99, −0.46]**

Note. $N = 168$. CI = confidence interval; days of use = alcohol or other drug use days over the 4 months following intervention; PACS = Penn Alcohol Craving Scale; BDI = Beck Depression Inventory; TAU = treatment as usual; MBRP = mindfulness-based relapse prevention.
* $p < .05$. ** $p < .01$.

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4-month follow-up period. Second, results from mediation analyses supported the hypothesis that craving significantly mediated the relation between depressive symptoms and alcohol or drug use days following intervention. Thus, the relation between depressive symptoms and intervention outcomes can be partially explained by craving. Third, moderation analyses indicated that depressive symptoms moderated the relation between intervention assignment and craving, such that individuals in MBRP showed virtually no association between depressive symptoms and craving but individuals in TAU evinced a strong association between depressive symptoms and craving. Finally, moderated mediation analyses showed an interaction between depressive symptoms and intervention assignment in the prediction of craving and subsequent substance use, indicating that the relation between depressive symptoms and postintervention days of use was mediated by craving among the TAU participants but not among those in the MBRP group.

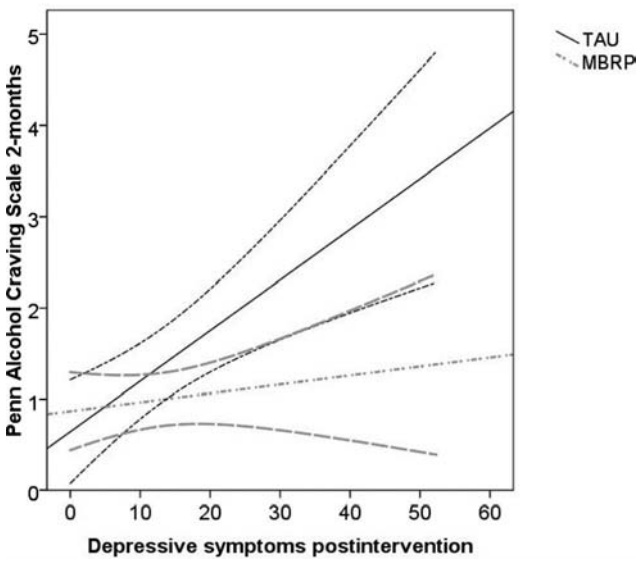

Figure 3. Moderating effect of depression by intervention predicting craving with 95% confidence bands ($n = 140$). TAU = treatment as usual; MBRP = mindfulness-based relapse prevention.

Further evaluation of the moderated mediation effect, shown in Figure 4b, suggested a potential disordinal interaction between intervention group and depressive symptoms in prediction of substance use days: Individuals with more depressive symptoms used substances on fewer days if they were in the MBRP condition than the TAU condition, whereas individuals with minimal or mild depressive symptoms used substances on more days if they were in the MBRP condition than the TAU condition. Supplementary analyses controlling for meditation practice 4 months postintervention indicated that all of the MBRP participants who continued meditation practice ($n = 46$, 63% of MBRP participants) were abstinent (i.e., zero days of use) 4 months following the intervention, regardless of depressive symptoms. These findings suggest that the practice of mindfulness meditation is associated with lower risk for substance use relapse; however, a causal relation has not been established.

The moderation and moderated mediation effects observed in the current study are consistent with the purpose and hypothesized mechanisms of MBRP. The mindfulness practices employed in the course are designed to help clients increase awareness of and change the relation to challenging situations, including negative emotional states, without "automatically" or habitually reacting. Clients thereby effectively alter the conditioned response of drug craving in response to negative affect. In combination with findings from other mindfulness- and acceptance-based interventions (e.g., Dahl, Wilson, & Nilsson, 2004; Gifford et al., 2004; Hayes et al., 1999; Levitt, Brown, Orsillo, & Barlow, 2004), the current data suggest these interventions may be effective in helping clients successfully modify responses to challenging or aversive internal experience. The current sample, similar to that in Teasdale et al. (2000), reported subclinical depression scores and treatment focused on recognition of these more subtle states before they trigger full-blown depressive or substance use relapse. The levels of depressive symptoms across intervention groups did not differ;

Table 3
Results From Moderated Mediation Analyses

Path	Direct and indirect effects	β	*B* [95% CI]
a_1	PACS 2 months on BDI postintervention	.49	0.05 [0.01, 0.09]*
a_2	PACS 2 months on group (TAU = 0, MBRP = 1)	−.20	−0.53 [−1.01, −0.07]*
a_3	PACS 2 months on Group × BDI postintervention	−.27	−0.05 [−0.09, −0.01]*
b	Days of use on PACS 2 months	.71	1.23 [0.52, 2.17]**
c_1	Days of use on BDI postintervention	−.43	−0.08 [−0.25, 0.15]
c_2	Days of use on group (TAU = 0, MBRP = 1)	.27	1.28 [−0.39, 2.98]
c_3	Days of use on Group × BDI postintervention	.12	0.04 [−0.16, 0.20]
a_1^*b	Indirect effect: Days of use on BDI via PACS	.35	0.06 [0.01, 0.14]*
a_2^*b	Indirect effect: Days of use on group via PACS	−.51	−0.65 [−1.45, −0.07]*
a_3^*b	Indirect effect: Days of use on Group × BDI via PACS	−.44	−0.06 [−0.13, −0.01]*

Note. $N = 168$. CI = confidence interval; days of use = alcohol or other drug use days over the 4 months following intervention; PACS = Penn Alcohol Craving Scale; BDI = Beck Depression Inventory; TAU = treatment as usual; MBRP = mindfulness-based relapse prevention.
* $p < .05$. ** $p < .01$.

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thus, it may be the reaction to the experience of negative emotional states, rather than the emotional states themselves, that is problematic. Furthermore, mindfulness-based treatment may help interrupt the repeated association of subclinical depressive thinking or symptomatology with affective or cognitive aspects of craving that perpetuate the relapse cycle.

If we draw from neurobiological data and the neuroimaging literature, there are several plausible mechanisms by which MBRP might be affecting the relation between depressive symptoms and craving. Areas of the brain that have been associated with both substance use disorders and depression, including the anterior cingulated cortex, prefrontal cortex (dorsolateral, ventromedial, and medial), amygdale, and subareas of the insula, have also been shown to be affected by mindfulness training (Lutz, Brefczynski-Lewis, Johnsone, & Davidson, 2008). Bonson et al. (2002) found deactivation of the medial prefrontal cortex in cocaine abusers during exposure to cocaine cues that elicited craving; Hölzel et al. (2008) found that experienced meditators, in comparison to nonmeditators, showed increased activation in the medial prefrontal cortex during a mindful breathing exercise. The neurobiological investigation of meditation is relatively young, but data point to common neural substrates implicated in substance use and affective disorders that may also be affected by meditation (Brewer, Smith, Bowen, Marlatt, & Potenza, in press). Combining MBRP with medication that further regulates neurotransmitter functioning could produce even stronger effects and more relief from craving.

Limitations

Several limitations of the current study are worth noting. The most significant design limitation is the brevity of the postintervention follow-up period. The majority (75.6%) of participants for whom follow up data were available were abstinent at the 4-month follow-up, and information on differences between intervention groups in abstinence rates beyond that 4-month window was not available in the study. Future research with a more extensive follow-up period is clearly needed. The rates of substance use across intervention groups indicated significant differences during the intervention ($\eta^2 = .09$) and 2 months following the intervention ($\eta^2 = .04$); however, these effects were not maintained at the 4-month follow-up ($\eta^2 = .02$). We have hypothesized that the lack of ongoing meditation support (e.g., mindfulness "sitting" groups) following the intervention resulted in the attenuation of MBRP effects (Bowen et al., 2009), and this is an important area for future research. It also suggests that a brief mindfulness intervention without continued support might not be sufficient for maintaining long-term change.

Missing data at follow-up assessment points is another serious limitation. Although studies of similarly severe populations evince similar attrition rates (Edwards & Rollnick, 1997), this shortcoming merits concern, and of note, the 75.6% abstinence rate reflects only those participants who were successfully followed. It is important to note that more than half of participants in both groups (62.7% of TAU, 52.8% of MBRP) were court mandated to treatment or had some level of legal involvement related to substance use; thus, the low rates of substance use in this sample could be reflective of mandatory drug testing during the follow-up period. Court/legal involvement was not significantly different between groups, $\chi^2(1) = 0.25$, $p = .29$; nonetheless, the rates of abstinence in the current study might not generalize to nonmandated treatment populations.

Measurement issues in the current study raise additional concern. The use of retrospective, self-reported days of use is one potential limitation, although self-reported use of alcohol or other drugs has been shown to be relatively reliable and valid (e.g., Babor, Steinberg, Anton, & Del Boca, 2000). The subjective, self-report measurement of craving is also problematic (Drummond, Litten, Lowman, & Hunt, 2000), and future studies would benefit from implicit, physiological and neurobiological measures of craving to further assess the relations observed in the current study. Finally, as noted above, the measure of mindfulness skills included in the main outcomes trial did not mediate the relation between intervention group and substance use outcomes (Bowen et al., 2009). Analyses also indicated that increased mindfulness skills did not relate to changes in depressive symptoms or craving; thus, the findings in the current study cannot be explained by changes in mindfulness as measured by the Five Factor Mindfulness Questionnaire. Alternative measures of mindfulness or other related constructs may help future studies better identify specific mechanisms of MBRP.

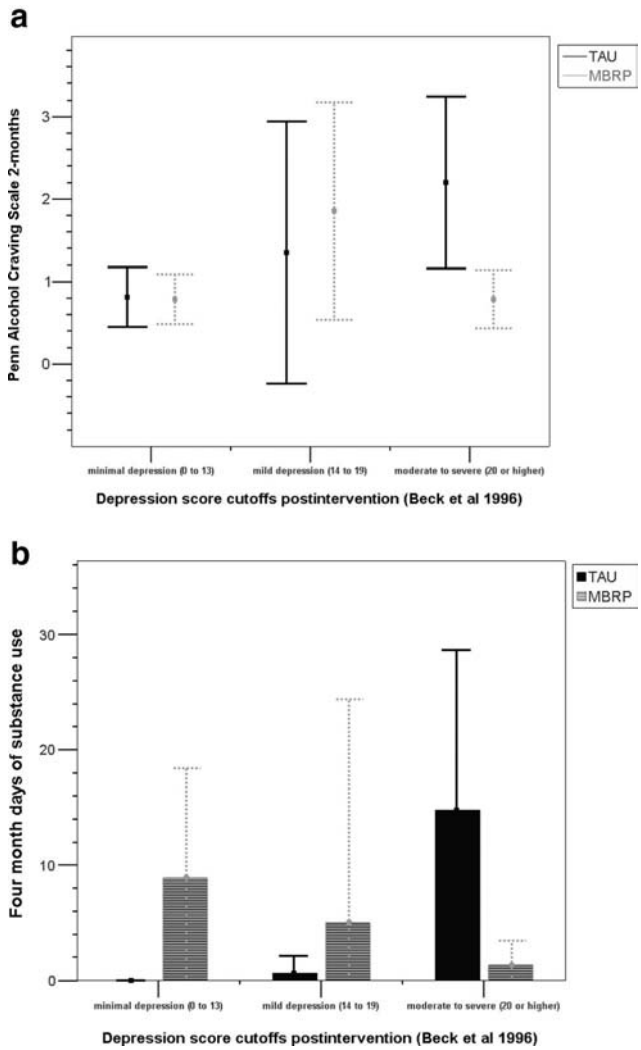

Figure 4. a: Craving scores by level of depression and intervention group (n = 140). b: Days of use by level of depression and intervention group (n = 140). TAU = treatment as usual; MBRP = mindfulness-based relapse prevention.

Another potential confound is the disparate levels of training of the therapists, with those facilitating MBRP having higher levels of education than those in TAU. Although previous research has generally indicated that therapist's level of training is unrelated to substance use outcomes (see Najavits & Weiss, 1994), it is nonetheless important to consider that some of the effects of MBRP could be explained by the qualitative differences between the MBRP therapists (mostly master's level) and the TAU counselors (mostly chemical dependency counselors). The difference between groups in number of treatment hours per week, although covaried in all analyses, also presents a potential confound. Preliminary analyses indicated treatment hours were not strongly associated with outcomes; however, future research should examine whether providing the same amount of treatment to both TAU and MBRP changes the outcomes. Similarly, there were different structures of the treatments: MBRP was delivered in closed cohorts but TAU was administered in a rolling-admission structure, thus allowing potential nonindependence of individual outcomes in the MBRP group. It could be the case that alliance between participants within a closed cohort group could explain the difference in outcomes between MBRP and TAU, particularly with respect to psychological distress (Gillaspy, Wright, Campbell, Stokes, & Adinoff, 2002). In addition, the therapists, participants, and graduate research assistants were not blind to intervention group assignment. However, it would not be possible to blind the therapists or the participants because of the nature of the intervention. With respect to the research assistants, all assessments were conducted online, reducing the likelihood of biases due to nonblinding.

A final consideration is that testing moderated mediation is a relatively new area of quantitative inquiry. Although we have conducted analyses using the best practices described by recent quantitative studies (Fairchild & MacKinnon, 2009; MacKinnon, 2008; Morgan-Lopez & MacKinnon, 2006; Preacher et al., 2007), replication of the current findings is necessary. The small sample size yielded sufficient power to detect effects, and the sample size to model parameters ratio was 9:1 for the mediation analysis (8:1 for the moderated mediated analysis), which is greater than the minimum 5:1 ratio (Bentler & Chou, 1987). Nonetheless, the results should be considered preliminary until replicated in subsequent studies with larger samples. Likewise, a more stringent test of the mediation effect would have controlled for posttreatment days of use prior to the measurement of craving in the prediction of days of use following the measurement of the mediator (MacKinnon, 2008). Finally, the current study compared MBRP to an active treatment control group, but it did not provide a test of whether MBRP differed from other empirically supported active treatments (e.g., relapse prevention or coping skills training).

Clinical Implications and Future Directions

Although direct effects of treatment on substance use outcomes evident at the 2-month follow-up assessment were not evident at 4 months, data from the current study offer some preliminary empirical support for the benefits of integrating mindfulness training with relapse prevention treatment and identify one potential mechanism of change following MBRP. The sample's racial diversity (only 53.6% of participants were White) and severity (41.3% unemployed, 19% polysubstance abusers) suggest these findings will generalize to a wide group of substance users. The current study specifically examined one potential mechanism by which practicing mindfulness skills may lead to reductions in substance use following intervention. The results suggest that mindfulness training might help clients by attenuating the relation between negative cognitive and emotional states and subjective experiences of craving. Although there are a multitude of studies on the roles of negative affect and craving in the relapse process, the current study provides a novel examination of the mediating role of the relation between depressive symptoms and craving, which has received less attention in the research literature. Although future studies will be needed to determine the treatment's effectiveness and mechanisms of action, the results suggest that incorporating mindfulness training as part of substance use treatment (either as the 8-week MBRP course or as an additive component to another existing treatment) could help clients

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cope more effectively with affective discomfort during early abstinence. Future studies would benefit from additional and varied measures of these factors and interrelations, such as physiological measures of affect and craving, and functional imaging techniques identifying neurocorrelates of these processes. Additionally, studies of related behaviors, such as pathological gambling and binge eating, could shed light on a potentially common role of the relation between negative affective states and craving across a broader class of addictive behaviors.

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