Associations Between Dispositional Mindfulness, Craving, and Drinking in Alcohol-Dependent Patients

An Ecological Momentary Assessment Study

Szeto, E.H.; Schoenmakers, T.M.; van de Mheen, D.; Snelleman, Michelle; Waters, A.J.

DOI
10.1037/adb0000473

Publication date
2019

Document Version
Final published version

Published in
Psychology of Addictive Behaviors

American Psychological Association

Psychology of Addictive Behaviors

In the public domain

2019, Vol. 33, No. 5, 431–441
http://dx.doi.org/10.1037/adb0000473

Associations Between Dispositional Mindfulness, Craving, and Drinking in Alcohol-Dependent Patients: An Ecological Momentary Assessment Study

Edwin H. Szeto
Uniformed Services University of the Health Sciences

Tim M. Schoenmakers, Dike van de Mheen, and Michelle Snelleman
IVO Addiction Research Institute, Rotterdam, the Netherlands

Andrew J. Waters
Uniformed Services University of the Health Sciences

Hazardous alcohol use remains a significant global public health problem. A better understanding of relapse may assist the development of new interventions. Low levels of dispositional mindfulness may be a risk factor for craving and alcohol use, but few studies have examined these associations prospectively in an alcohol-dependent sample. In an ecological momentary assessment (EMA) study, Dutch alcohol dependent patients ($N = 43$) carried around a personal digital assistant for 4 weeks while trying to maintain abstinence. Participants completed assessments at random times 3 times per day, and when they felt a strong urge to drink or came to the brink of drinking without doing so. At each assessment, stress, negative affect, craving, recent drinking, and attentional or approach bias were assessed. Dispositional mindfulness was assessed at baseline with the Mindful Attention Awareness Scale (MAAS). More mindful individuals (higher MAAS scores) reported lower craving than less mindful individuals. There was no evidence that stress, negative affect, attentional bias, or approach bias mediated the association between MAAS and craving. However, there was evidence for an indirect path from MAAS to drinking such that higher mindfulness was associated with lower craving ratings that in turn were associated with less drinking. There was no evidence that MAAS significantly moderated associations between stress/negative affect/cognitive biases and craving, or between craving and drinking. In sum, more mindful recovering alcohol dependent patients reported lower craving ratings than less mindful patients, and this association appeared to be independent of stress/negative affect and cognitive biases.

Keywords: ecological momentary assessment, mindfulness, attentional bias, approach bias, craving

Supplemental materials: http://dx.doi.org/10.1037/adb0000473.supp

Excessive or hazardous drinking of alcohol is a significant public health problem both in the U.S. and worldwide (World Health Organization, 2014). Relapse is the most common outcome of an attempt to limit drinking, even with the use of behavioral or pharmacology therapies (e.g., Dennis, Foss, & Scott, 2007; Weisner, Matzger, & Kaskutas, 2003), and new interventions are needed. To develop more effective interventions, a better understanding of craving and relapse, and the predictors of craving and relapse, may be required. This study focuses on the relationships between dispositional mindfulness, a possible protective factor for alcohol use or dependence, and craving and drinking (e.g., Adams et al., 2015; Karyadi, VanderVeen, & Cyders, 2014).

Many Western practitioners and researchers believe that mindfulness involves the psychological processes of attention and awareness (Bishop et al., 2004; Brown & Ryan, 2003; Brown, Ryan, & Creswell, 2007; Shapiro, Brown, Thoresen, & Plante, 2011; Shapiro, Carlson, Astin, & Freedman, 2006), and mindfulness has been defined as "a receptive attention to and awareness of present events and experiences" (Brown & Ryan, 2003; Brown et al., 2007). Awareness has been described as the conscious registration of internal and external stimuli, while attention was referred to as the initial orientation of attention toward such stimuli. In addition to attention and awareness, mindfulness also can refer to other processes such as observing,

This article was published Online First July 11, 2019.

Edwin H. Szeto, Department of Medical and Clinical Psychology, Uniformed Services University of the Health Sciences; Tim M. Schoenmakers, Dike van de Mheen, and Michelle Snelleman, IVO Addiction Research Institute, Rotterdam, the Netherlands; Andrew J. Waters, Department of Medical and Clinical Psychology, Uniformed Services University of the Health Sciences.

Tim M. Schoenmakers is now at the Department of Clinical Psychology, University of Amsterdam. Dike van de Mheen is now at the Department Tranzo, Tilburg University.

The study was funded by an internal research grant from Erasmus Medical Center awarded to Dike van de Mheen. The authors have no conflict of interests to declare. Data in the article were presented in a doctoral dissertation completed by the first author.

Correspondence concerning this article should be addressed to Andrew J. Waters, Department of Medical and Clinical Psychology, Uniformed Services University of the Health Sciences, Bethesda, MD 20814. E-mail: andrew.waters@usuhs.edu

describing, nonreacting, acting with awareness, and to the quality of those processes being nonjudgmental, curious, open, accepting, and intentional (Baer et al., 2008).

Mindfulness may vary greatly between individuals and stay relatively stable within individuals. Trait, or dispositional, mindfulness refers to an individual's general level of mindful tendencies (Brown & Ryan, 2003). Conceptualizations of dispositional mindfulness vary between self-report measures (Brown et al., 2007; Grossman & Van Dam, 2011). The Mindful Attention Awareness Scale (MAAS), used in the current study, focuses on assessing a single factor that captures the degree to which an individual is or is not attentive and aware of his or her experiences or surroundings (e.g., "I tend to walk quickly to get to where I'm going without paying attention to what I experience along the way"). A low mindful state produces habitual, automatic, or injudicious patterns in thought and action (Brown & Ryan, 2003). Most relevant here, a meta-analysis revealed a significant negative association between trait mindfulness and substance use (i.e., higher levels of trait mindfulness are associated with lower levels of substance use), the magnitude of which was larger for alcohol and tobacco use than marijuana use behaviors, for problematic (vs. nonproblematic) substance use behaviors, and for clinical (vs. outpatient and nonclinical) samples (Karyadi et al., 2014).

Association Between Mindfulness and Alcohol Craving/Drinking

More specifically, research has examined the association between dispositional mindfulness and craving/drinking alcohol. Many studies (Pearson, Brown, Bravo, & Witkiewitz, 2015; Shorey, Brasfield, Anderson, & Stuart, 2014; Smith et al., 2011), but not all (Lyvers, Makin, Toms, Thorberg, & Samios, 2014), have reported that higher MAAS scores are associated with less drinking or alcohol dependence severity, and one study reported that different facets of mindfulness had different associations with risky alcohol use (Brooks, Carter, McMillen, & Couillou, 2018). Three studies have examined the association between dispositional mindfulness (assessed using the Five Facet Mindfulness Questionnaire, FFMQ), and craving for alcohol, and reported that higher levels mindfulness were associated with lower craving ratings (Chakroun-Baggioni, Corman, Spada, Caselli, & Gierski, 2017; Garland, Roberts-Lewis, et al., 2014; Karyadi & Cyders, 2015). Chakroun-Baggioni et al. (2017) reported that three facets of mindfulness (observation of experience, acting with awareness, nonjudgement of experience) were univariably associated with craving in university students (overall trait mindfulness was not used in their analyses). Karyadi and Cyders (2015) reported a negative association between cued alcohol craving and overall trait mindfulness as well as three facets of mindfulness (describing emotional experiences, acting with awareness, nonjudgement) in high-risk undergraduate social drinkers. Garland, Roberts-Lewis, et al. (2014) reported a negative association between craving and trait mindfulness as well as four facets of mindfulness (nonreactivity, describing, nonjudgment, acting with awareness) in a sample of individuals entering residential treatment for substance use disorders.

Psychological Mechanisms Linking Mindfulness and Alcohol Craving/Drinking (Mediation)

The mechanisms linking dispositional mindfulness and alcohol addiction have not been widely examined. At a theoretical level, dispositional mindfulness may reduce craving and drinking by reducing stress/negative affect. Specifically, by increasing awareness of mind and body (e.g., Hölzel et al., 2011), mindfulness increases the detection of maladaptive cognitive and affective processes. Mindfulness may enable distraction from these processes or inhibit reactivity to those processes (Hölzel et al., 2011; Shapiro et al., 2006). Empirically, higher MAAS scores have been associated with lower stress and negative affect assessed in the laboratory in dependent smokers (e.g., Waters et al., 2009; see also Garland, Roberts-Lewis, et al., 2014). In addition, theory and data suggest that stress and negative affect can provoke alcohol craving and consumption through multiple mechanisms (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Fox, Bergquist, Hong, & Sinha, 2007; Litten et al., 2015; Sinha et al., 2009), and modulate information processing in a way that promotes motivation to use drugs, to include increased levels of craving. Indeed, Adams et al. (2015) reported that the association between MAAS score and the likelihood of an alcohol use disorder was mediated by perceived stress. That is, higher levels of mindfulness were associated with lower levels of perceived stress, which in turn was associated with a lower likelihood of an alcohol use disorder.

Given that mindfulness involves control of attentional processes (e.g., Shapiro et al., 2006), theory suggests that mindfulness may also exert its influence through effects on cognitive processes, specifically attentional processes. In a systematic review, Chiesa, Calati, and Serretti (2011) note that a causal effect of mindfulness on selective attention and attention switching has not been definitely established, but is likely. For example, whereas no randomized studies have shown that mindfulness training increases selective attention and attention switching, long-term mindfulness practitioners are better in switching and selection than nonmeditating or novice controls. Most relevant to the current paper, several studies show a relationship between dispositional mindfulness and attentional control in general and "attentional bias" in addiction (Garland, Froeliger, & Howard, 2014).

An "attentional bias" to drug cues occurs when a person orients to, and sustains attention on, drug-related cues more than neutral cues (Field & Cox, 2008). An "approach bias" refers to the tendency to automatically approach drug-related stimuli more than neutral stimuli. Research has generally found that attentional bias to drug cues is present in drug users but absent in non-drug users (Cox, Pothos, & Hosier, 2007). A meta-analysis has revealed that attentional bias is positively associated with craving (Field, Munafò, & Franken, 2009). Some studies have reported that attentional bias to drug cues is correlated with drug use and relapse in studies of alcohol dependence (e.g., Cox, Hogan, Kristian, & Race, 2002; Cox et al., 2007), cigarette smoking (e.g., Janes et al., 2010; Powell, Dawkins, West, Powell, & Pickering, 2010), and cocaine use (Carpenter, Schreiber, Church, & McDowell, 2006), but other studies did not find this relationship (e.g., Rinck, Wiers, Becker, & Lindenmeyer, 2018; Snelleman, Schoenmakers, & van de Mheen, 2015). For example, Snelleman et al. (2015) reported no association between attentional bias assessed in the laboratory and subsequent relapse in alcohol-dependent participants that overlapped with

the sample in the current study, and Rinck et al. reported that change in attentional bias from baseline to posttreatment did not predict treatment outcome. Approach bias has been shown to be related to relapse in some studies (Eberl, Wiers, et al., 2013) but not in others (Snelleman et al., 2015), and yet another study reported that avoidance was predictive of relapse (Spruyt et al., 2013). Most pertinent to the current study, Garland, Boettiger, Gaylord, Chanon, and Howard (2012) examined the relationship between mindfulness and attentional bias in alcohol-dependent individuals. Individuals with higher MAAS scores exhibited less attentional bias to alcohol cues. That is, more mindful individuals disengaged attention from alcohol cues more readily than less mindful individuals. In another study in alcohol dependent patients, Garland et al. (2010) found that mindfulness training decreased attentional bias.

Mindfulness as Moderator Variable

In sum, mindfulness may reduce drinking by reducing stress/negative affect or cognitive biases that are themselves related to craving and drinking. From a second theoretical perspective, mindfulness may also act as a moderator variable, influencing the impact of stress/negative affect and cognitive biases when they occur (Ostafin, Kassman, & Wessel, 2013; Ostafin & Marlatt, 2008; see also Elwafi, Witkiewitz, Mallik, Thornhill, & Brewer, 2013, and Enkema & Bowen, 2017, for evidence of moderating effect of mindfulness treatment), possibly by decreasing reactivity to these experiences (Hölzel et al., 2011). For example, Adams et al. (2015) reported that mindfulness moderated the association between perceived stress and alcohol use. Stress increased alcohol use in participants with low levels of mindfulness but did not increase alcohol use in participants with high levels of mindfulness (see also Christopher, Ramsey, & Antick, 2013). Hochster, Block-Lerner, Marks, and Erblich (2018) reported that higher dispositional mindfulness weakened the association between cue-induced craving and a behavioral economic measure of alcohol demand. In sum, more mindful individuals may be less likely to experience elevated stress/negative affect/craving and less likely to exhibit elevated cognitive biases in the first place, and if elevated stress/negative affect/craving and/or elevated cognitive biases do occur, their impact may be diminished in these individuals.

Use of Ecological Momentary Assessment (EMA)

Most studies have examined these relationships using laboratory assessments. Ecological momentary assessment (EMA) is a useful approach for examining these relationships as it permits examination of both between-subjects and within-subject associations in the natural environment. EMA has been used to study between-subjects associations between mindfulness and emotional outcomes. For example, Brown and Ryan (2003) reported that MAAS scores were associated with positive emotional states, and other EMA studies have reported that mindfulness was associated with increased self-reported inner peace (Liu et al., 2015), improved global emotional tone (Garland et al., 2010), and decreased emotional lability (Hill & Updegraff, 2012). EMA can be used to examine if mindfulness moderates between- and within-subject associations between stress/negative affect/cognitive biases and drinking, and between craving and drinking, which have been reported using EMA. Litt, Cooney, and Morse (2000) reported that mean urge ratings were positively correlated with proportion of drinking days, and Todd, Armeli, and Tennen (2009) reported that negative affect assessed in the morning predicted time to first drink later the same day. Some EMA studies on relapse (Fatseas et al., 2015; Litt et al., 2000), but not all (Cooney et al., 2007; Holt, Litt, & Cooney, 2012), have reported significant associations between craving and drinking.

To summarize, low dispositional mindfulness is a possible risk factor for alcohol dependence and relapse. However, the mechanisms underlying the influence of dispositional mindfulness in alcohol dependence have not been extensively examined, and, to the best our knowledge, no study has used EMA to investigate these mechanisms. The first study aim was to examine whether dispositional mindfulness was associated with craving and drinking in alcohol-dependent individuals attempting to maintain abstinence assessed using EMA. We hypothesized that more mindful individuals would report lower craving ratings and less drinking. The second aim was to examine possible mediators of an effect of dispositional mindfulness on craving and drinking. We hypothesized that more mindful individuals would report less stress/negative affect, and/or lower attentional and approach biases, which in turn would be associated with lower craving and drinking. The third aim was to examine dispositional mindfulness as a moderator variable. Specifically, high dispositional mindfulness was expected to weaken the relationship between a) stress/negative affect and craving, b) cognitive biases and craving, and c) craving and drinking.

Method

Participants

Participants were 43 Dutch outpatients recruited at three sites (Leiden, Zoetermeer, Hoofddorp) of an addiction treatment facility in the Netherlands. The inclusion criteria were (a) at least 18 years old; (b) a diagnosis of alcohol dependence (current) as defined in the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, text revision (*DSM–IV–TR*; American Psychiatric Association, 2000) and Section J of the *Composite International Diagnostic Interview* (Dutch version; Robins et al., 1988); (c) an 8th-grade reading level; and (d) reporting being abstinent for at least two weeks before the first study visit of the parent study (described later). The exclusion criteria were (a) diagnosis with an Axis II disorder according to the *DSM–IV*; (b) diagnosis with a disorder in the psychotic spectrum; or (c) regular use of other addictive substances (except nicotine).

All procedures performed in the study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. The study was approved by the Medical Ethical Committee of the Erasmus Medical Center, Rotterdam, The Netherlands (MEC-2012–346).

Procedure

This study was part of a larger parent study ($n = 59$) examining relapse (Snelleman et al., 2015). Recruitment occurred in an outpatient detoxification program. Participants completed a six-week

residential addiction treatment, attending two group therapy sessions using cognitive–behavioral therapy and motivational interviewing per week, in addition to pharmacotherapy. After the six weeks of group therapy, therapists and patients decided together on the further course of treatment: Of the 43 participants, 12 continued with group therapy and 28 switched to individual treatment. Another 3 patients decided to terminate their treatment. In addition, 17 participants used medication (see online supplemental materials for further details). After enrollment in the parent study, the treatment goals could be modified, such that controlled drinking could be permitted. In the current study, 41 of the 43 participants were trying to maintain complete abstinence during the study period, and 2 were allowed to engage in controlled drinking.

Participants were given the opportunity to volunteer for the EMA study, and 43 of the 59 participants volunteered. There were no significant differences on age, gender, educational level, number of dependence symptoms, and use of medication (all p values $>.09$) between the 43 volunteers and the 16 individuals who declined to participate. At the orientation visit for the EMA study, eligible participants completed baseline assessments, which included the MAAS, and the participant was trained on how to use the personal digital assistant (PDA, model HP1920). The PDA was programmed to signal the participants (with an audible beep) three times a day at random times (random assessment; RA) between a participant-determined "wake-up time" and "bed-time." Participants could prevent the device from presenting RAs (e.g., if they had a meeting to attend) by pressing a "suspend" button on the PDA. RAs that were scheduled during a "suspend" were not presented by the PDA. Participants were also instructed to complete a participant-initiated assessment whenever they experienced a temptation, defined as "an acute increase in the urge to drink or an occasion when they felt that they came to the brink of drinking without actually doing so" (temptation assessment; TA). At each assessment (RA or TA), participants completed items that assessed subjective variables (e.g., mood and craving) and drinking. After completing these items, participants completed either an alcohol Stroop task or an alcohol approach–avoidance implicit association test (IAT; described later). More specifically, the program alternated between presenting the alcohol Stroop task and the IAT (e.g., at the first assessment the alcohol Stroop would be presented, at the second the IAT would be presented, at the third the alcohol Stroop would be presented, etc.); it was considered too burdensome to present both tasks at each assessment. The current article does not report the effect of assessment type (TA vs. RA) on study variables, which will be addressed in another article. After four weeks, participants returned the PDA to the research team, and received compensation for their participation (€4.45 per day, max €125).

Measures

Baseline assessment: Dispositional mindfulness. The Mindful Attention Awareness Scale (MAAS) is a 15-item self-report survey that assessed dispositional mindfulness (Brown & Ryan, 2003). The MAAS has been described as a measure of ". . . [the] attention, informed by a sensitive awareness of what is occurring in the present, simply observes what is taking place" (Brown & Ryan, 2003). The MAAS has been validated and normed in both nonclinical and clinical samples, with a one-factor structure. Cronbach's alphas have ranged from .80 to .90 (Brown & Ryan, 2003; Carlson & Brown, 2005). The Dutch version (MAAS-D) exhibits good reliability (alpha ranging from .81 to .87), and also has a one-factor structure (Schroevers, Nykliček, & Topman, 2008).

EMA assessments.

Stress, negative affect, and craving. Stress was assessed using a single item: "I feel stressed right now" (Stressed Now) on a 7-point scale (1 = *not at all* to 7 = *extremely*). The International Positive Affect and Negative Affect—Short Form (I-PANAS-SF) (Thompson, 2007), a 10-item assessment consisting of five negative (I-PANAS-SF-NA) and five positive (I-PANAS-SF-PA) affective states, assessed affect. Participants indicated whether they agreed with a statement (e.g., "I feel upset right now") on a 5-point scale (1 = *not at all* to 5 = *extremely*). In the current dataset, Cronbach's alpha was good for both I-PANAS-SF-PA (alpha = .90) and I-PANAS-NA (alpha = .89). Only I-PANAS-SF-NA was examined in the current study.

One item assessed participants' current temptation to drink on a 7-point Likert scale: "I feel the inclination to drink right now" (Inclined Now). Participants indicated to what degree they agreed with this statement on a 7-point scale (1 = *not at all* to 7 = *very much*). Craving was assessed using the item "In the past hour I felt an urge (craving) to drink" (Craving) on a 7-point scale (1 = *not at all* to 7 = *very much*). Responses to Inclined Now and Craving were highly correlated ($r = .91$). The current article reports results from Craving, although similar findings were obtained from the Inclined Now item.

Drinking. One item (Drinking) assessed number of drinks consumed since the previous assessment using the following 5-point scale: 1 = *no drinks*; 2 =*1–2 glasses*; 3 =*3–4 glasses*; 4 =*5–6 glasses*; 5 =*7 or more glasses*. Reports of binge drinking (defined as an alcohol consumption of five or more standard glasses [males] or three or more standard glasses [females] since the previous EMA assessment) were corroborated by reports at the weekly laboratory assessments. Overall, 16 participants were designated as having reported any drinking during the study (including the 2 controlled drinkers), and 27 were designated as abstainers. Both controlled drinkers reported that they drank 2–3 days per week, and that they consumed a maximum of three glasses during these days.

Cognitive assessments. The Alcohol Stroop task assesses "attentional bias" to alcohol cues (Cox, Fadardi, & Pothos, 2006; see online supplemental materials for details). A participant was presented with words in different colors on the PDA screen. The participant was required to respond by pressing one of three buttons on the PDA that corresponded to the color of the word (see Waters, Marhe, & Franken, 2012). He or she was instructed to respond as rapidly as possible to the color, and to ignore the meaning of the word. During each alcohol Stroop task, the participant completed a block of 33 neutral words and a block of 33 alcohol words, with order of block counterbalanced. The alcohol Stroop effect was defined as the median reaction time (RT) on alcohol words minus median RT on neutral words. A positive alcohol Stroop effect reflects slower responses on alcohol words than on neutral words, which indicates an attentional bias to alcohol words. In the current dataset, the estimated internal reliability of the alcohol Stroop effect, computed using a split-half approach (odd and even trials), was $r = .62$.

The Approach-Avoidance Implicit Association Test (AA-IAT) assesses the degree to which a person associates drug cues with the concept of approach. Participants were presented with words from four different categories, in this case the following: ALCOHOL, nonalcohol (NEUTRAL), approach, avoid. All ALCOHOL and NEUTRAL words were presented in capital letters, whereas all approach and avoid words were presented in lower case. The AA-IAT involves two tasks. In Task 1, a participant is required to respond quickly by pressing a certain PDA key for items (words) relating to two concepts (e.g., ALCOHOL + approach), and with a second (different) PDA key for items (words) from two other concepts (e.g., NEUTRAL + avoid). In Task 2, the assignment of one concept was switched such that "NEUTRAL" + "approach" shared the same key response, and "ALCOHOL" + "avoid" shared the other response. The idea underlying the IAT is that it is easier to perform the IAT when the two concepts are strongly associated in memory than when the two concepts are unrelated (De Houwer, 2002). The IAT effect is the difference in RTs on Task 1 versus Task 2. It can be interpreted as an index of the relative strength of mental associations. In the example above, it indicates whether associations are stronger between ALCOHOL and approach, and NEUTRAL and avoid, than between NEUTRAL and approach, and Alcohol and avoid. Higher (more positive) scores (i.e., faster responses when ALCOHOL is paired with "approach" compared to when ALCOHOL is paired with "avoid") are interpreted as indicating an approach bias.

On each trial, a stimulus (word) was presented on the PDA screen (in the center of the screen). Labels were on the top left and top right of the screen to remind the participant of the categories assigned to each key for the current task (Task 1 or Task 2). A participant was instructed to categorize each stimulus (word) into the appropriate category by pressing an "L" or "R" key on the PDA as quickly and as accurately as possible. If the participant responded correctly, the program presented the next trial, with a 150 ms interval between trials. If the participant made an error, an "X" written in red appeared below the stimulus (word) until the participant responded correctly. The participant was instructed to correct his or her errors as quickly as possible.

At each AA-IAT assessment, participants completed two blocks of Task 1 and two blocks of Task 2 (see Waters et al., 2012). The AA-IAT was scored using the algorithm described by Greenwald, Nosek, and Banaji (2003) to derive the IAT effect ("D score"). The scoring algorithm divides the difference in RTs on Task 1 and 2 by the pooled standard deviation of RTs of all trials from Tasks 1 and 2. The algorithm also eliminated assessments with RTs $<$ 300 ms on more than 10% of the trials. In addition, trials with RT $>$ 10,000 ms were excluded, and RTs on incorrect responses were replaced by the mean RT from the correct responses of the block, plus 600 ms (Greenwald et al., 2003). Using a split-half reliability measure (IAT D score computed from blocks 1 & 3 vs. IAT D score computed from blocks 2 & 4) and the Spearman-Brown correction, the estimated internal reliability of the IAT effect (D score) was $r = .76$.

Analytic Plan

Linear Mixed Models (LMMs) were used in primary analyses. SAS PROC MIXED was used for continuous outcomes assumed to be normally distributed in the population (conditional on model covariates), and SAS PROC GLIMMIX was used for binary, ordinal, or non-normal outcomes. LMMs can handle the fact that 1) data are clustered by participant, and 2) participants have different numbers of assessment. As is typical for analyses of EMA data, each LMM had two levels: Subject (level 2) and Assessment (level 1; Bolger & Laurenceau, 2013). Each LMM used a random intercept, and, for the R matrix, an autoregressive model of order 1 for the residuals within subjects (continuous outcomes). All LMMs included Day of Study (continuous variable) and Assessment Type (TA vs. RA) as level 1 covariates. As expected, Assessment Type was associated with Inclined Now ($PE = 0.98$, $SE = 0.24$, $p = .0002$) and Craving ($PE = 0.84$, $SE = 0.23$, $p = .001$); Assessment Type was not associated with MAAS ($p = .95$). Age and gender were both included as level 2 covariates in all models as MAAS has been positively associated with age in multiple studies of heavy alcohol users (e.g., Adams et al., 2015; Lyvers et al., 2014; Shorey, Gawrysiak, Anderson, & Stuart, 2015), and studies reported that women have higher MAAS scores than men (Lyvers et al.,2014; Shorey et al., 2014; see online supplemental materials for consideration of other level 2 covariates). For all models, the parameter estimate provides an (unstandardized) measure of effect size. All tests used $\alpha = .05$, and were 2-tailed.

To Test MAAS as a predictor variable, MAAS was entered as an independent variable into an LMM. To test mediation, for conceptual simplicity each mediator (Stress, Negative Affect, Stroop, IAT) was tested in a separate model using "single-equation" methods (Kline, 2015, p. 233). Using Baron and Kenny's (1986) terminology, analyses provided estimates of a and b paths (see online supplemental materials for details). To Test MAAS as a moderator variable, MAAS was entered in an LMM, along with a second independent variable (Stress, Negative Affect, Stroop, IAT, or Craving) and the interaction term between MAAS and the second independent variable. In all cases, the moderation models involve a level 2 moderator (MAAS) influencing the relationship between two level 1 variables (i.e., a 2 $\times$ (1 $\rightarrow$ 1) model). Analyses tested both between-subjects moderation and within-subject moderation (Preacher, Zhang, & Zyphur, 2016; see online supplemental materials for details).

Results

All 43 participants provided at least one week of EMA data, and 39 (90.7%) completed all four weeks (see Table 1 for summary statistics). Overall, the 43 participants provided PDA data on an average of 26.07 days ($SD = 7.09$) and initiated 2,020 assessments (1,870 RAs; 150 TAs). The mean time of day for assessments was 3:38 p.m. ($SD = 4.61$ hr); 36.29% occurred before 1:00 p.m.; 27.67% occurred between 1:00 p.m. and 7:00 p.m., and 36.04% occurred after 7;00 p.m. Pearson correlations between MAAS and mean scores on EMA variables is reported in Table S2 (online supplemental materials).

Participants reported not drinking (since the previous assessment) on 89.95% of assessments. Of the 43 participants, 6 reported non-abstinence at baseline. Those 6 participants reported continued drinking during the study. Of the 37 abstinent at baseline, 35 set a goal of maintaining complete abstinence during the study period, and, as noted above, 2 reported attempting to be "controlled drinkers." Of the 35 participants attempting to remain

Table 1
Summary Statistics

Variable	n_1	n_2	*Mean/%*	*SD*	Min	Max
Baseline data						
Age (years)	n/a	43	48.47	10.82	25	56
Gender	n/a	43				
Male			69.77%			
Female			30.23%			
Education	n/a	43				
High school			25.58%			
Vocational education			25.58%			
Community college			27.91%			
University			16.28%			
Other			4.65%			
Smoking						
Yes	n/a	43	65.12%			
No			34.88%			
Baseline MAAS (1–6)	n/a	43	3.94	.91	1.73	6.00
Compliance data*						
Number RAs completed	n/a	43	43.99	20.03	3	75
Compliance on RAs (%)	n/a	43	71.29	20.95	24.14	100.00
Number TAs completed	n/a	43	3.49	4.66	0	21
Total number assessments completed	n/a	43	46.98	20.08	5	91
EMA Data						
Inclined Now (1–7)	2020	43	1.77	1.50	1	7
Craving (1–7)	2019	43	1.78	1.50	1	7
Drinking (1–5)	2019	43	1.23	.78	1	5
Stress (1–5)	2018	43	1.52	.84	1	5
Negative affect (1–5)	2019	43	1.41	.67	1	5
Alcohol stroop effect (ms)	1037	42	15.42	99.01	−378.00	610.50
IAT (D Score)	931	43	−.021	.47	−1.48	1.40

Note. MAAS = Mindful Attention Awareness Scale; RA = Random Assessment; TA = Temptation Assessment; N_1 = number of assessments (Level 1); N_2 = number of subjects (Level 2). Participants were recruited from three locations: Leiden (n = 19), Zoetermeer (n = 14), and Hoofddorp (n = 10).
* Four participants did not complete the four-week protocol but provided partial data.

abstinent, 8 reported at least one drink during the study, and 27 reported complete abstinence. Of the 8 participants who reported some drinking, 6 reported at least one binge episode, and 2 reported occasional drinking.

Aim 1: Association Between MAAS and Craving/Drinking

MAAS scores were significantly associated with Craving ratings, $F(1, 1974) = 5.64$, $PE = -0.43$, $SE = 0.18$, $p = .02$ (see Figure 1), but not Drinking, $F(1, 1974) = 2.59$, $PE = -0.18$, $SE = 0.11$, $p = .11$ (see online supplemental materials for additional analyses), when controlling for all other variables (Age, Gender, Day, Assessment Type) in the model. As MAAS scores increased by 1 unit, predicted Craving scores decreased by 0.43 units.

Aim 2: Tests of Mediation

We tested whether participants with higher MAAS scores reported less stress/negative affect assessed, and whether stress/negative affect assessed was associated with lower Craving ratings and Drinking assessed. Table 2 reports coefficients for the pertinent a paths and b paths. As can be seen, the a paths (a1) for the association between MAAS and stress, and between MAAS and negative affect, were not significant. Therefore, according to the Baron and Kenny (1986) causal steps approach to testing mediation, there was no evidence for mediation through stress/negative affect. We also estimated the indirect effect (using multilevel path analysis in MPlus Version 8). The indirect effect was not significant for either "MAAS → Stress → Craving" or "MAAS → Negative Affect → Craving" (see Table S3, online supplemental materials).

We also tested whether participants with higher MAAS scores reported lower attentional and approach biases (alcohol Stroop task and IAT), which in turn will be associated with lower Craving ratings and drinking alcohol assessed. As can be seen, the a paths (a1) for the association between MAAS and attentional bias/approach bias were not significant, and the paths from attentional bias/approach bias to craving were also not significant. Therefore, there was no evidence that attentional bias or approach bias mediated an effect of MAAS on Craving or Drinking.

MAAS may reduce Craving ratings, which in turn reduce Drinking. For mediation to occur via this pathway, the a2 path needs to be significant, as does the b2 path (Figure S1). The values for a2 and b2 vary according to which mediator (Stress, Negative Affect, Attentional Bias, Approach Bias) is included in the model. However, as shown in Table 3, in all cases that included all 43 participants the a2 and b2 paths were significant. Therefore, there is evidence that the indirect path from MAAS to Craving to Drinking is significant.

To examine this mediation pathway (MAAS → Craving → Drinking) in further detail, we used multilevel path analysis in MPlus Version 8 to examine the significance of the a2.b2 path (see online supplemental materials). Using this approach, the indirect path a2.b2 was significant (indirect effect = −0.394, 95% CI [−0.789, −0.073], $p = .008$, 1-tailed; Table S3).

Aim 3: MAAS as Moderator Variable

In a 2 × (1 → 1) design, the moderator may plausibly influence the between-subjects association and/or the within-subject association (Preacher et al., 2016; see online supplemental materials). Therefore, Table 3 reports the results of the between-subjects moderation (*Mean* scores) and within-subject moderation (*Deviation* scores) separately. For both between- and within-subjects, there was no evidence that MAAS scores moderated the associa-

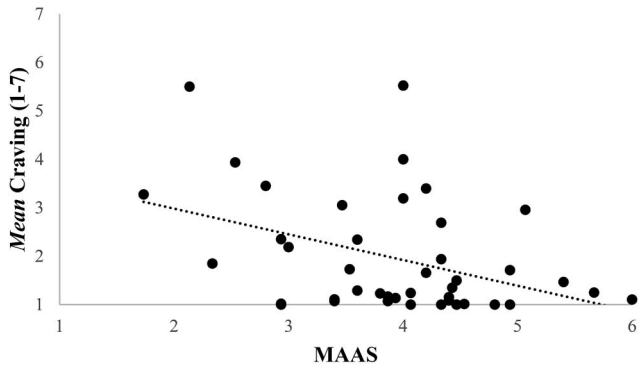

Figure 1. Association between MAAS and Craving.

Table 2
Results of LMMs for Aim 2

					a					b				
Path → IV ↓	DV	Path	n_1	n_2	*df*	*PE*	*SE*	*F*	*p*	*df*	*PE*	*SE*	*F*	*p*
Mediation														
MAAS	Stress	a1	2018	43	1,1973	−.08	.11	.65	.42	n/a	n/a	n/a	n/a	n/a
MAAS	NA	a1	2019	43	1,1974	−.12	.09	1.59	.21	n/a	n/a	n/a	n/a	n/a
MAAS	Stroop	a1	1037	42	1,993	3.74	4.55	.68	.41	n/a	n/a	n/a	n/a	n/a
MAAS	IAT	a1	931	43	1,886	−.05	.06	.56	.45	n/a	n/a	n/a	n/a	n/a
MAAS	Craving	a2[a]	2019	43	1,1974	−.36	.17	4.69	**.03**	n/a	n/a	n/a	n/a	n/a
MAAS	Craving	a2[b]	2019	43	1,1973	−.36	.18	4.10	**.04**	n/a	n/a	n/a	n/a	n/a
MAAS	Craving	a2[c]	2009	42	1,1974	−.34	.18	3.53	**.06**	n/a	n/a	n/a	n/a	n/a
MAAS	Craving	a2[d]	2019	43	1,1974	−.41	.18	5.00	**.03**	n/a	n/a	n/a	n/a	n/a
Mean Stress	Craving	a3	2019	43	1,1974	.72	.25	8.53	**.004**	n/a	n/a	n/a	n/a	n/a
Mean NA	Craving	a3	2019	43	1,1973	.58	.29	4.10	**.04**	n/a	n/a	n/a	n/a	n/a
Mean Stroop	Craving	a3	1009	42	1,1965	.002	.006	.13	.71	n/a	n/a	n/a	n/a	n/a
Mean IAT	Craving	a3	2019	43	1,1974	.42	.47	.81	.37	n/a	n/a	n/a	n/a	n/a
Mean Stress	Drinking	b1	2019	43	n/a	n/a	n/a	n/a	n/a	1,1974	−.17	.11	2.21	.14
Mean NA	Drinking	b1	2019	43	n/a	n/a	n/a	n/a	n/a	1,1973	−.19	.12	2.44	.12
Mean Stroop	Drinking	b1	2009	42	n/a	n/a	n/a	n/a	n/a	1,1965	.002	.003	.39	.53
Mean IAT	Drinking	b1	2019	43	n/a	n/a	n/a	n/a	n/a	1,1973	.22	.18	1.45	.23
Mean Craving	Drinking	b2[1]	2019	43	n/a	n/a	n/a	n/a	n/a	1,1974	.50	.07	55.27	**.001**
Mean Craving	Drinking	b2[2]	2019	43	n/a	n/a	n/a	n/a	n/a	1,1973	.48	.06	58.69	**.001**
Mean Craving	Drinking	b2[3]	2009	42	n/a	n/a	n/a	n/a	n/a	1,1965	.44	.07	45.20	**.001**
Mean Craving	Drinking	b2[4]	2019	43	n/a	n/a	n/a	n/a	n/a	1,1973	.44	.06	52.27	**.001**

Note. n_1 = number of assessments; n_2 = number of subjects; PE = parameter estimate; SE = standard error; F = F value from LMM. Covariates were Age, Gender, Day, and Assessment Type (TA vs. RA) (parameter estimates for covariates not shown). a1 paths reflects paths from MAAS to primary mediator (MAAS → Stress, MAAS → Negative Affect, MAAS → Stroop, or MAAS → IAT). a2 path reflects paths from Mediator to Craving (Stress → Craving, Negative Affect → Craving, Stroop → Craving, or IAT → Craving). b1 path reflects paths from Mediator to Drinking independent of Craving (Stress → Drinking, Negative Affect → Drinking, Stroop → Drinking, or IAT → Drinking). b2 path reflects paths from Craving to Drinking independent of mediator (Craving → Drinking); Bold numbers indicate statistical significance.
[a] When Stress is in the model. [b] When NA is in the model. [c] When Stroop is in the model. [d] When IAT is in the model.

tion between stress/negative affect and Craving ratings, or the association between Stroop/IAT and Craving ratings. Similarly, there was no evidence that MAAS moderated the association between Craving ratings and Drinking. In supplementary analyses, for both between- and within-subjects, there was no evidence that MAAS scores moderated the association between stress/negative affect and Drinking, or the association between Stroop/IAT and Drinking (supplemental Table S4).

Discussion

The main findings of this study were as follows. First, in individuals being treated for alcohol dependence, higher levels of dispositional mindfulness, assessed by the MAAS, were associated with lower levels of craving ratings, but not drinking, during an attempt to maintain abstinence. Second, there was no evidence that stress, negative affect, attentional bias, or approach bias mediated the relationship between mindfulness and craving or drinking.

Table 3
Results of LMMs for Aim 3

			Craving					Drinking				
DV → IV ↓	n_1	n_2	*df*	*PE*	*SE*	*F*	*p*	*df*	*PE*	*SE*	*F*	*p*
MAAS as Moderator												
MAAS × *Mean* Stress	2018	43	1,1936	.03	.39	.01	.93	n/a	n/a	n/a	n/a	n/a
MAAS × *Deviation* Stress	2018	43	1,1935	−.07	.10	.47	.49	n/a	n/a	n/a	n/a	n/a
MAAS × *Mean* NA	2019	43	1,1932	−.18	.36	.22	.64	n/a	n/a	n/a	n/a	n/a
MAAS × *Deviation* NA	2019	43	1,1932	−.09	.20	.18	.67	n/a	n/a	n/a	n/a	n/a
MAAS × *Mean* Stroop	1037	42	1,955	−.002	.008	.08	.78	n/a	n/a	n/a	n/a	n/a
MAAS × *Deviation* Stroop	1037	42	1,955	−.0005	.0004	1.58	.21	n/a	n/a	n/a	n/a	n/a
MAAS × *Mean* IAT	931	43	1,944	−.90	.62	2.10	.15	n/a	n/a	n/a	n/a	n/a
MAAS × *Deviation* IAT	931	43	1,944	−.14	.13	1.13	.29	n/a	n/a	n/a	n/a	n/a
MAAS × *Mean* Craving	2019	43	n/a	n/a	n/a	n/a	n/a	1,1893	−.08	.07	1.25	.26
MAAS × *Deviation* Craving	2019	43	n/a	n/a	n/a	n/a	n/a	1,1892	−.002	.02	.01	.93

Note. n_1 = number of assessments; n_2 = number of subjects'; *PE* = parameter estimate; *SE* = standard error; *F* = *F* value from LMM. Covariates are Age, Gender, Day, Assessment Type (TA vs. RA). Coefficients for Day and Assessment Type were fixed. Coefficients for the *Deviation* scores were random. When Drinking was used as a DV, Craving ratings were lagged such that they occurred before the Drinking ratings, and the lagged value of the Drinking was included in the model.

However, there was evidence for an indirect effect from mindfulness to craving to drinking, such that higher levels of mindfulness were associated with lower levels of craving, which in turn were associated with lower levels of drinking. Last, there was no evidence that mindfulness moderated the association between stress/negative affect and craving, between cognitive biases and craving, or between craving and drinking.

To the best of our knowledge, this is the first study to report a prospective association between dispositional mindfulness and craving in a sample of individuals being treated specifically for alcohol dependence. In cross-sectional studies, Chakroun-Baggioni et al. (2017) and Karyadi and Cyders (2015) reported an association between trait mindfulness and craving in college students, and Garland, Roberts-Lewis, et al. (2014) reported an association between trait mindfulness and craving in a sample of individuals entering treatment for substance use (47% had received a diagnosis of alcohol dependence, but results were not presented by subgroup). Because MAAS was significantly associated with craving but not drinking in the current study, one may wonder whether the association between MAAS and craving is more robust than the association between MAAS and drinking in this population. However, interpretation is not straightforward as the low drinking rate may have made it more difficult to detect associations with drinking due to restricted range. For example, 27 subjects were designated as abstinent and therefore reported no drinking. More concretely, there was less variability in drinking data than craving data. For example, mean drinking scores had a standard deviation that was just over half the standard deviation of mean craving scores (not shown in Table 1).

As noted above, there was no evidence that stress, negative affect, attentional bias, or approach bias mediated the relationship between mindfulness and craving or drinking. Indeed, the data beg the question as to how MAAS may reduce craving independent of stress and negative affect. It is possible that the association between MAAS and craving is mediated by psychological processes not assessed in the current study, such as a detached perspective (Ruscio, 2012; Shapiro et al., 2006), reappraisal (Garland, Roberts-Lewis, et al., 2014), or social anxiety (Clerkin, Sarfan, Parsons, & Magee, 2017). There may be some attribute of craving that is particularly sensitive to dispositional mindfulness. Craving has certainly long been a target for mindfulness-based interventions (Tapper, 2018), and it is possible that targets of interventions such as present moment awareness and acceptance, or even nonspecific working memory/extinction processes (Tapper, 2018), may play a role in dispositional mindfulness. Interestingly, Garland, Roberts-Lewis, et al. (2014) also reported an association between trait mindfulness and craving that was independent of negative affect (as well as reappraisal and readiness to change). Another issue is that craving ratings had more variability than stress ratings, perhaps due to the presence of temptation assessments. The standard deviation of mean stress scores was 0.67, which compares with the standard deviation of the mean craving rating of 1.20 (not shown in Table 1). Therefore, the greater variability of craving (vs. stress) may have made it easier to detect an association with MAAS scores.

The data reveal evidence of an indirect effect from MAAS to craving to drinking (MAAS → Craving → Drinking) that occurs in the absence of a significant total effect (MAAS → Drinking). Although counterintuitive, this pattern of data (i.e., presence of a significant indirect effect, a.b, together with a nonsignificant total effect, c path) can occur due to relative power of tests (Kenny & Judd, 2014; see also O'Rourke & MacKinnon, 2018). Specifically, Kenny and Judd (2014) note that "the test of a and b very often has more power than tests of both c and c′" (p. 337). Karyadi and Cyders (2015) reported that the association between trait mindfulness and problematic alcohol use was mediated by cued craving in high-risk undergraduate drinkers, although in Karyadi and Cyders the c path was also significant.

The findings for the moderation analysis yielded no evidence for moderation either between or within subjects. For the within-subject moderation analyses, one should note that the use of random coefficients may have rather low power in cases where few subjects show variability in the IV or DV (e.g., drinking). Future research using larger sample sizes is required to examine between- and within-subject moderation. In addition, from a theoretical perspective, and from the perspective of maximizing power, there may be value in examining the moderating effects of mindfulness in a population that reports greater variability in drinking, particularly regarding the moderation of within-subject associations involving drinking. Alternatively, one could monitor the participants for a longer period, which may enable more drinking episodes to be detected.

The study had limitations. First, the relatively small sample size (for level 2 units) and relatively low variability in some measures may have limited power for detecting between-subjects associations, as well as moderation effects. Second, the data are correlational. It is not known whether higher dispositional mindfulness causes lower craving ratings. Relatedly, it is possible that an unmeasured third (level 2) variable is responsible for the association between mindfulness and craving (e.g., Chakroun-Baggioni et al., 2017). Third, a relatively large number of hypotheses were tested, which increases the probability of making a Type I error when alpha is fixed at .05. With regard to Aims 2 and 3, the examination of multiple mediation and moderation analyses without correction of alpha means that the data should be considered as hypothesis-generating, to be followed up by confirmatory studies. Fourth, participants self-selected into the study, which reduces generalizability and may introduce bias.

Fifth, as is most commonly done, mindfulness is measured by self-report. Thus, an assumption of the methodology is that individuals' perception of attentiveness correlates with their actual attentiveness; on an individual level, this may not be the case (Grossman & Van Dam, 2011). Sixth, dispositional mindfulness was measured with a single-factor scale. Recent clinical studies involving dispositional mindfulness have increasingly recognized its multidimensional nature (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Baer et al., 2008). More specifically, the MAAS does not capture the acceptance component of mindfulness (Sauer et al., 2013) nor nonjudgmental awareness (Baer et al., 2006), and only allows investigation of mechanisms involving a specific aspect of mindfulness, namely mindful attention and awareness. Pertinent to the current study, there is evidence that nonjudging, one of the facets of the FFMQ, may be more strongly associated with substance abuse than other facets of mindfulness (Karyadi et al., 2014). Moreover, in a sample of undergraduate students, Ostafin and Marlatt (2008) reported that nonjudging, one of the facets of the FFMQ, weakened the positive association between approach bias and hazardous drinking. Nonetheless, the MAAS shares variance with other mindfulness assessments (Siegling & Petrides, 2014; see also Bergomi, Tschacher, & Kupper, 2013) and has been previously used in EMA studies.

Seventh, the data only speak to dispositional mindfulness, and therefore may not reflect mindfulness attained through "training" (Li, Howard, Garland, McGovern, & Lazar, 2017; Tapper, 2018), such as that attained by skilled practitioners. Stated simply, mindfulness that results from mindfulness training may have very different effects than dispositional mindfulness assessed in unselected individuals. For example, Davis et al. (2018) reported that the effect of Mindfulness-Based Relapse Prevention (MBRP) on substance use outcomes was partially mediated by stress, and Enkema and Bowen (2017) reported that formal mindfulness practice using MBRP moderated the association between craving and substance use.

A strength of the study is that it is one of a few EMA studies to be conducted in this understudied population. A second strength was the inclusion of both self-report and cognitive assessments using EMA. One should note that scores on the cognitive assessments were not strongly associated with drinking at the between-subjects level (Table S2), although this does not preclude associations with outcomes at the within-subjects level. Third, examination of multilevel moderation permitted a comprehensive analysis of moderation hypotheses (Preacher et al., 2016).

In sum, more mindful recovering alcohol dependent patients reported lower craving ratings than less mindful patients in the field, and this association appeared to be independent of stress/negative affect and cognitive biases. Furthermore, there was evidence for a between-subjects association between mindfulness and drinking through craving. To better understand this relationship, further research should examine other mediators of the relationship between dispositional mindfulness and craving/drinking.

References

Adams, C. E., Cano, M. A., Heppner, W. L., Stewart, D. W., Correa-Fernández, V., Vidrine, J. I., . . . Wetter, D. W. (2015). Testing a moderated mediation model of mindfulness, psychosocial stress, and alcohol use among African American smokers. *Mindfulness, 6,* 315–325. http://dx.doi.org/10.1007/s12671-013-0263-1

Aguinis, H., Gottfredson, R. K., & Culpepper, S. A. (2013). Best-practice recommendations for estimating cross-level interaction effects using multilevel modeling. *Journal of Management, 39,* 1490–1528. http://dx.doi.org/10.1177/0149206313478188

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

Atkins, D. C., Baldwin, S. A., Zheng, C., Gallop, R. J., & Neighbors, C. (2013). A tutorial on count regression and zero-altered count models for longitudinal substance use data. *Psychology of Addictive Behaviors, 27,* 166–177. http://dx.doi.org/10.1037/a0029508

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13,* 27–45. http://dx.doi.org/10.1177/1073191105283504

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., . . . Williams, J. M. G. (2008). Construct validity of the Five Facet Mindfulness Questionnaire in meditating and nonmeditating samples. *Assessment, 15,* 329–342. http://dx.doi.org/10.1177/1073191107313003

Baker, T. B., Piper, M. E., McCarthy, D. E., Majeskie, M. R., & Fiore, M. C. (2004). Addiction motivation reformulated: An affective processing model of negative reinforcement. *Psychological Review, 111,* 33–51. http://dx.doi.org/10.1037/0033-295X.111.1.33

Baron, R. M., & Kenny, D. A. (1986). The moderator -mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51,* 1173–1182. http://dx.doi.org/10.1037/0022-3514.51.6.1173

Bauer, D. J., Preacher, K. J., & Gil, K. M. (2006). Conceptualizing and testing random indirect effects and moderated mediation in multilevel models: New procedures and recommendations. *Psychological Methods, 11,* 142–163. http://dx.doi.org/10.1037/1082-989X.11.2.142

Bergomi, C., Tschacher, W., & Kupper, Z. (2013). The assessment of mindfulness with self-report measures: Existing scales and open issues. *Mindfulness, 4,* 191–202. http://dx.doi.org/10.1007/s12671-012-0110-9

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., . . . Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11,* 230–241. http://dx.doi.org/10.1093/clipsy.bph077

Bolger, N., & Laurenceau, J. P. (2013). *Intensive longitudinal methods*. New York, NY: Guilford Press.

Brooks, J. J., Carter, A., McMillen, N., & Couillou, R. J. (2018). "It's complicated": Exploring the mindfulness-alcohol use connection in undergraduate students. *International Journal of Mental Health and Addiction*. Advance online publication. http://dx.doi.org/10.1007/s11469-018-9886-8

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84,* 822–848. http://dx.doi.org/10.1037/0022-3514.84.4.822

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18,* 211–237. http://dx.doi.org/10.1080/10478400701598298

Carlson, L. E., & Brown, K. W. (2005). Validation of the Mindful Attention Awareness Scale in a cancer population. *Journal of Psychosomatic Research, 58,* 29–33. http://dx.doi.org/10.1016/j.jpsychores.2004.04.366

Carpenter, K. M., Schreiber, E., Church, S., & McDowell, D. (2006). Drug Stroop performance: Relationships with primary substance of use and treatment outcome in a drug-dependent outpatient sample. *Addictive Behaviors, 31,* 174–181. http://dx.doi.org/10.1016/j.addbeh.2005.04.012

Chakroun-Baggioni, N., Corman, M., Spada, M. M., Caselli, G., & Gierski, F. (2017). Desire thinking as a confounder in the relationship between mindfulness and craving: Evidence from a cross-cultural validation of the Desire Thinking Questionnaire. *Psychiatry Research, 256,* 188–193. http://dx.doi.org/10.1016/j.psychres.2017.06.051

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review, 31,* 449–464. http://dx.doi.org/10.1016/j.cpr.2010.11.003

Christopher, M., Ramsey, M., & Antick, J. (2013). The role of dispositional mindfulness in mitigating the impact of stress and impulsivity on alcohol-related problems. *Addiction Research & Theory, 21,* 429–434. http://dx.doi.org/10.3109/16066359.2012.737873

Clerkin, E. M., Sarfan, L. D., Parsons, E. M., & Magee, J. C. (2017). Mindfulness facets, social anxiety, and drinking to cope with social anxiety: Testing mediators of drinking problems. *Mindfulness, 8,* 159–170. http://dx.doi.org/10.1007/s12671-016-0589-6

Cooney, N. L., Litt, M. D., Cooney, J. L., Pilkey, D. T., Steinberg, H. R., & Oncken, C. A. (2007). Alcohol and tobacco cessation in alcohol-dependent smokers: Analysis of real-time reports. *Psychology of Addictive Behaviors, 21,* 277–286. http://dx.doi.org/10.1037/0893-164X.21.3.277

Cox, W. M., Fadardi, J. S., & Pothos, E. M. (2006). The Addiction-Stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin, 132,* 443–476. http://dx.doi.org/10.1037/0033-2909.132.3.443

Cox, W. M., Hogan, L. M., Kristian, M. R., & Race, J. H. (2002). Alcohol attentional bias as a predictor of alcohol abusers' treatment outcome. *Drug and Alcohol Dependence, 68,* 237–243. http://dx.doi.org/10.1016/S0376-8716(02)00219-3

Cox, W. M., Pothos, E. M., & Hosier, S. G. (2007). Cognitive-motivational predictors of excessive drinkers' success in changing. *Psychopharmacology, 192,* 499–510. http://dx.doi.org/10.1007/s00213-007-0736-9

Davis, J. P., Berry, D., Dumas, T. M., Ritter, E., Smith, D. C., Menard, C., & Roberts, B. W. (2018). Substance use outcomes for mindfulness based relapse prevention are partially mediated by reductions in stress: Results from a randomized trial. *Journal of Substance Abuse Treatment, 91,* 37–48. http://dx.doi.org/10.1016/j.jsat.2018.05.002

De Houwer, J. (2002). The Implicit Association Test as a tool for studying dysfunctional associations in psychopathology: Strengths and limitations. *Journal of Behavior Therapy and Experimental Psychiatry, 33,* 115–133. http://dx.doi.org/10.1016/S0005-7916(02)00024-1

Dennis, M. L., Foss, M. A., & Scott, C. K. (2007). An eight-year perspective on the relationship between the duration of abstinence and other aspects of recovery. *Evaluation Review, 31,* 585–612. http://dx.doi.org/10.1177/0193841X07307771

Eberl, C., Wiers, R. W., Pawelczack, S., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2013). Approach bias modification in alcohol dependence: Do clinical effects replicate and for whom does it work best? *Developmental Cognitive Neuroscience, 4,* 38–51. http://dx.doi.org/10.1016/j.dcn.2012.11.002

Elwafi, H. M., Witkiewitz, K., Mallik, S., Thornhill, T. A., IV, & Brewer, J. A. (2013). Mindfulness training for smoking cessation: Moderation of the relationship between craving and cigarette use. *Drug and Alcohol Dependence, 130,* 222–229. http://dx.doi.org/10.1016/j.drugalcdep.2012.11.015

Enkema, M. C., & Bowen, S. (2017). Mindfulness practice moderates the relationship between craving and substance use in a clinical sample. *Drug and Alcohol Dependence, 179,* 1–7. http://dx.doi.org/10.1016/j.drugalcdep.2017.05.036

Fatseas, M., Serre, F., Alexandre, J. M., Debrabant, R., Auriacombe, M., & Swendsen, J. (2015). Craving and substance use among patients with alcohol, tobacco, cannabis or heroin addiction: A comparison of substance- and person-specific cues. *Addiction, 110,* 1035–1042. http://dx.doi.org/10.1111/add.12882

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence, 97,* 1–20. http://dx.doi.org/10.1016/j.drugalcdep.2008.03.030

Field, M., Munafò, M. R., & Franken, I. H. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin, 135,* 589–607. http://dx.doi.org/10.1037/a0015843

Fox, H. C., Bergquist, K. L., Hong, K. I., & Sinha, R. (2007). Stress-induced and alcohol cue-induced craving in recently abstinent alcohol-dependent individuals. *Alcoholism: Clinical and Experimental Research, 31,* 395–403. http://dx.doi.org/10.1111/j.1530-0277.2006.00320.x

Garland, E. L., Boettiger, C. A., Gaylord, S., Chanon, V. W., & Howard, M. O. (2012). Mindfulness is inversely associated with alcohol attentional bias among recovering alcohol-dependent adults. *Cognitive Therapy and Research, 36,* 441–450. http://dx.doi.org/10.1007/s10608-011-9378-7

Garland, E. L., Fredrickson, B., Kring, A. M., Johnson, D. P., Meyer, P. S., & Penn, D. L. (2010). Upward spirals of positive emotions counter downward spirals of negativity: Insights from the broaden-and-build theory and affective neuroscience on the treatment of emotion dysfunctions and deficits in psychopathology. *Clinical Psychology Review, 30,* 849–864. http://dx.doi.org/10.1016/j.cpr.2010.03.002

Garland, E. L., Froeliger, B., & Howard, M. O. (2014). Mindfulness training targets neurocognitive mechanisms of addiction at the attention-appraisal-emotion interface. *Frontiers in Psychiatry, 4,* 173. http://dx.doi.org/10.3389/fpsyt.2013.00173

Garland, E. L., Roberts-Lewis, A., Kelley, K., Tronnier, C., & Hanley, A. (2014). Cognitive and affective mechanisms linking trait mindfulness to craving among individuals in addiction recovery. *Substance Use & Misuse, 49,* 525–535. http://dx.doi.org/10.3109/10826084.2014.850309

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology, 85,* 197–216. http://dx.doi.org/10.1037/0022-3514.85.2.197

Grossman, P., & Van Dam, N. T. (2011). Mindfulness, by any other name . . .: Trials and tribulations of *sati* in western psychology and science. *Contemporary Buddhism, 12,* 219–239. http://dx.doi.org/10.1080/14639947.2011.564841

Hedeker, D., & Gibbons, R. D. (2006). *Longitudinal data analysis*. New York, NY: Wiley.

Hedeker, D., Mermelstein, R. J., Berbaum, M. L., & Campbell, R. T. (2009). Modeling mood variation associated with smoking: An application of a heterogeneous mixed-effects model for analysis of ecological momentary assessment (EMA) data. *Addiction, 104,* 297–307. http://dx.doi.org/10.1111/j.1360-0443.2008.02435.x

Hill, C. L., & Updegraff, J. A. (2012). Mindfulness and its relationship to emotional regulation. *Emotion, 12,* 81–90. http://dx.doi.org/10.1037/a0026355

Hochster, A., Block-Lerner, J., Marks, D. R., & Erblich, J. (2018). Mindfulness buffers the effects of cue-induced craving on alcohol demand in college drinkers. *Addictive Behaviors, 84,* 53–56. http://dx.doi.org/10.1016/j.addbeh.2018.03.013

Holt, L. J., Litt, M. D., & Cooney, N. L. (2012). Prospective analysis of early lapse to drinking and smoking among individuals in concurrent alcohol and tobacco treatment. *Psychology of Addictive Behaviors, 26,* 561–572. http://dx.doi.org/10.1037/a0026039

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science, 6,* 537–559. http://dx.doi.org/10.1177/1745691611419671

Janes, A. C., Pizzagalli, D. A., Richardt, S., Frederick, B. D., Chuzi, S., Pachas, G., . . . Kaufman, M. J. (2010). Brain reactivity to smoking cues prior to smoking cessation predicts ability to maintain tobacco abstinence. *Biological Psychiatry, 67,* 722–729. http://dx.doi.org/10.1016/j.biopsych.2009.12.034

Karyadi, K. A., & Cyders, M. A. (2015). Elucidating the association between trait mindfulness and alcohol use behaviors among college students. *Mindfulness, 6,* 1242–1249. http://dx.doi.org/10.1007/s12671-015-0386-7

Karyadi, K. A., VanderVeen, J. D., & Cyders, M. A. (2014). A meta-analysis of the relationship between trait mindfulness and substance use behaviors. *Drug and Alcohol Dependence, 143,* 1–10. http://dx.doi.org/10.1016/j.drugalcdep.2014.07.014

Kenny, D. A., & Judd, C. M. (2014). Power anomalies in testing mediation. *Psychological Science, 25,* 334–339. http://dx.doi.org/10.1177/0956797613502676

Kline, R. B. (2015). *Principles and practice of structural equation modeling* (4th ed.). New York, NY: Guilford Press.

Li, W., Howard, M. O., Garland, E. L., McGovern, P., & Lazar, M. (2017). Mindfulness treatment for substance misuse: A systematic review and meta-analysis. *Journal of Substance Abuse Treatment, 75,* 62–96. http://dx.doi.org/10.1016/j.jsat.2017.01.008

Litt, M. D., Cooney, N. L., & Morse, P. (2000). Reactivity to alcohol-related stimuli in the laboratory and in the field: Predictors of craving in treated alcoholics. *Addiction, 95,* 889–900. http://dx.doi.org/10.1046/j.1360-0443.2000.9568896.x

Litten, R. Z., Ryan, M. L., Falk, D. E., Reilly, M., Fertig, J. B., & Koob, G. F. (2015). Heterogeneity of alcohol use disorder: Understanding mechanisms to advance personalized treatment. *Alcoholism: Clinical and Experimental Research, 39,* 579–584. http://dx.doi.org/10.1111/acer.12669

Liu, X., Xu, W., Wang, Y., Williams, J. M., Geng, Y., Zhang, Q., & Liu, X. (2015). Can inner peace be improved by mindfulness training: A randomized controlled trial. *Stress and Health, 31,* 245–254.

Lyvers, M., Makin, C., Toms, E., Thorberg, F. A., & Samios, C. (2014). Trait mindfulness in relation to emotional self-regulation and executive function. *Mindfulness, 5,* 619–625. http://dx.doi.org/10.1007/s12671-013-0213-y

O'Rourke, H. P., & MacKinnon, D. P. (2018). Reasons for testing mediation in the absence of an intervention effect: A research imperative in prevention and intervention research. *Journal of Studies on Alcohol and Drugs, 79,* 171–181. http://dx.doi.org/10.15288/jsad.2018.79.171

Ostafin, B. D., Kassman, K. T., & Wessel, I. (2013). Breaking the cycle of desire: Mindfulness and executive control weaken the relation between an implicit measure of alcohol valence and preoccupation with alcohol-related thoughts. *Psychology of Addictive Behaviors, 27,* 1153–1158. http://dx.doi.org/10.1037/a0032621

Ostafin, B. D., & Marlatt, G. A. (2008). Surfing the urge: Experiential acceptance moderates the relation between automatic alcohol motivation and hazardous drinking. *Journal of Social and Clinical Psychology, 27,* 404–418. http://dx.doi.org/10.1521/jscp.2008.27.4.404

Powell, J., Dawkins, L., West, R., Powell, J., & Pickering, A. (2010). Relapse to smoking during unaided cessation: Clinical, cognitive and motivational predictors. *Psychopharmacology, 212,* 537–549. http://dx.doi.org/10.1007/s00213-010-1975-8

Preacher, K. J., Zhang, Z., & Zyphur, M. J. (2016). Multilevel structural equation models for assessing moderation within and across levels of analysis. *Psychological Methods, 21,* 189–205. http://dx.doi.org/10.1037/met0000052

Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods, 15,* 209–233. http://dx.doi.org/10.1037/a0020141

Pearson, M. R., Brown, D. B., Bravo, A. J., & Witkiewitz, K. (2015). Staying in the moment and finding purpose: The associations of trait mindfulness, decentering, and purpose in life with depressive symptoms, anxiety symptoms, and alcohol-related problems. *Mindfulness, 6,* 645–653. http://dx.doi.org/10.1007/s12671-014-0300-8

Rinck, M., Wiers, R. W., Becker, E. S., & Lindenmeyer, J. (2018). Relapse prevention in abstinent alcoholics by cognitive bias modification: Clinical effects of combining approach bias modification and attention bias modification. *Journal of Consulting and Clinical Psychology, 86,* 1005–1016. http://dx.doi.org/10.1037/ccp0000321

Robins, L. N., Wing, J., Wittchen, H. U., Helzer, J. E., Babor, T. F., Burke, J., . . . Towle, L. H. (1988). The Composite International Diagnostic Interview: An epidemiologic instrument suitable for use in conjunction with different diagnostic systems and in different cultures. *Archives of General Psychiatry, 45,* 1069–1077. http://dx.doi.org/10.1001/archpsyc.1988.01800360017003

Ruscio, A. C. (2012). *Mindfulness and tobacco dependence in cigarette smokers: Mediating mechanisms* (Unpublished Master's Thesis, Uniformed Services University of Health Sciences, Bethesda, MD).

Sauer, S., Walach, H., Schmidt, S., Hinterberger, T., Lynch, S., Büssing, A., & Kohls, N. (2013). Assessment of mindfulness: Review on state of the art. *Mindfulness, 4,* 3–17. http://dx.doi.org/10.1007/s12671-012-0122-5

Schroevers, M., Nykliček, I., & Topman, R. (2008). Validatie van de nederlandstalige versie van de Mindful Attention Awareness Scale (MAAS) [Validation of the Dutch version of the Mindful Attention Awareness Scale (MAAS)]. *Gedragstherapie, 41,* 225–240.

Schwartz, J. E., & Stone, A. A. (2007). The analysis of real-time momentary data: A practical guide. In A. Stone, S. Shiffman, A. Atienza, & L. Nebeling (Eds.), *The science of real-time data capture: Self-reports in health research* (pp. 76–113). New York, NY: Oxford University Press.

Shapiro, S. L., Brown, K. W., Thoresen, C., & Plante, T. G. (2011). The moderation of mindfulness-based stress reduction effects by trait mindfulness: Results from a randomized controlled trial. *Journal of Clinical Psychology, 67,* 267–277. http://dx.doi.org/10.1002/jclp.20761

Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology, 62,* 373–386. http://dx.doi.org/10.1002/jclp.20237

Shorey, R. C., Brasfield, H., Anderson, S., & Stuart, G. L. (2014). Mindfulness deficits in a sample of substance abuse treatment seeking adults: A descriptive investigation. *Journal of Substance Use, 19,* 194–198. http://dx.doi.org/10.3109/14659891.2013.770570

Shorey, R. C., Gawrysiak, M. J., Anderson, S., & Stuart, G. L. (2015). Dispositional mindfulness, spirituality, and substance use in predicting depressive symptoms in a treatment-seeking sample. *Journal of Clinical Psychology, 71,* 334–345. http://dx.doi.org/10.1002/jclp.22139

Siegling, A. B., & Petrides, K. V. (2014). Measures of trait mindfulness: Convergent validity, shared dimensionality, and linkages to the five-factor model. *Frontiers in Psychology, 5,* 1164. http://dx.doi.org/10.3389/fpsyg.2014.01164

Sinha, R., Fox, H. C., Hong, K. A., Bergquist, K., Bhagwagar, Z., & Siedlarz, K. M. (2009). Enhanced negative emotion and alcohol craving, and altered physiological responses following stress and cue exposure in alcohol dependent individuals. *Neuropsychopharmacology, 34,* 1198–1208. http://dx.doi.org/10.1038/npp.2008.78

Smith, B. W., Ortiz, J. A., Steffen, L. E., Tooley, E. M., Wiggins, K. T., Yeater, E. A., . . . Bernard, M. L. (2011). Mindfulness is associated with fewer PTSD symptoms, depressive symptoms, physical symptoms, and alcohol problems in urban firefighters. *Journal of Consulting and Clinical Psychology, 79,* 613–617. http://dx.doi.org/10.1037/a0025189

Snelleman, M., Schoenmakers, T. M., & van de Mheen, D. (2015). Attentional bias and approach/avoidance tendencies do not predict relapse or time to relapse in alcohol dependency. *Alcoholism: Clinical and Experimental Research, 39,* 1734–1739. http://dx.doi.org/10.1111/acer.12817

Spruyt, A., De Houwer, J., Tibboel, H., Verschuere, B., Crombez, G., Verbanck, P., . . . Noël, X. (2013). On the predictive validity of automatically activated approach/avoidance tendencies in abstaining alcohol-dependent patients. *Drug and Alcohol Dependence, 127,* 81–86. http://dx.doi.org/10.1016/j.drugalcdep.2012.06.019

Tapper, K. (2018). Mindfulness and craving: Effects and mechanisms. *Clinical Psychology Review, 59,* 101–117. http://dx.doi.org/10.1016/j.cpr.2017.11.003

Thompson, E. R. (2007). Development and validation of an internationally reliable short-form of the Positive and Negative Affect Schedule (PANAS). *Journal of Cross-Cultural Psychology, 38,* 227–242. http://dx.doi.org/10.1177/0022022106297301

Todd, M., Armeli, S., & Tennen, H. (2009). Interpersonal problems and negative mood as predictors of within-day time to drinking. *Psychology of Addictive Behaviors, 23,* 205–215. http://dx.doi.org/10.1037/a0014792

Waters, A. J., Marhe, R., & Franken, I. H. A. (2012). Attentional bias to drug cues is elevated before and during temptations to use heroin and cocaine. *Psychopharmacology, 219,* 909–921. http://dx.doi.org/10.1007/s00213-011-2424-z

Waters, A. J., Reitzel, L. R., Cinciripini, P., Li, Y., Marcus, M. T., Vidrine, J. I., & Wetter, D. W. (2009). Associations between mindfulness and implicit cognition and self-reported affect. *Substance Abuse, 30,* 328–337. http://dx.doi.org/10.1080/08897070903252080

Weisner, C., Matzger, H., & Kaskutas, L. A. (2003). How important is treatment? One-year outcomes of treated and untreated alcohol-dependent individuals. *Addiction, 98,* 901–911. http://dx.doi.org/10.1046/j.1360-0443.2003.00438.x

World Health Organization. (2014). *Global Status Report on Alcohol and Health 2014*. Retrieved from http://apps.who.int/iris/bitstream/10665/112736/1/9789240692763_eng.pdf?ua=1

Received September 23, 2018
Revision received April 29, 2019
Accepted April 29, 2019 ■