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BRIEF REPORT

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

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Stimuli with strong affective valence capture attention. This can impede the self-regulation of impulses. That is, preoccupation with a tempting stimulus such as alcohol may lead to a continued activation of automatic affective responses to that stimulus, increasing the likelihood of approach and consumption. Self-regulation may, thus, benefit from variables that weaken the relation between salient stimuli and cognitive preoccupation with those stimuli. Recent research shows that mindfulness and executive control reduce the link between automatic affective responses to alcohol and alcohol consumption. In this study, the authors examined whether mindfulness and executive control may similarly decouple the relation between automatic affective responses and difficulty in disengaging attention from alcohol-related thoughts. Participants completed measures of trait mindfulness, executive control (a working memory task), automatic alcohol–valence associations, and preoccupation with alcohol-related thoughts. Results showed that (a) both trait mindfulness and executive control are inversely related with alcohol preoccupation, and (b) both mindfulness and executive control weaken a positive relation between automatic alcohol–valence associations and alcohol preoccupation.

Keywords: addiction, mindfulness, implicit cognition, executive control and self-regulation

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Anyone who has experienced the *earworm* phenomenon of having a piece of music stuck in one's mind knows how difficult it can be to disengage attention from a salient stimulus. Difficulty in disengaging attention from salient stimuli has been implicated in failures to self-regulate impulses. This is demonstrated with evidence that attentional bias measures such as visual-probe tasks, the modified Stroop, and auditory dual-processing vigilance tasks predict alcohol and other substance use behavior, including difficulty in abstaining after treatment (Cox, Hogan, Kristian, & Race, 2002; Field, Mogg, & Bradley, 2005; Sayette et al., 1994).

The influence of attentional biases on self-regulation failure can be understood from dual-process models of the mind. For example, one model proposes (a) an *impulsive* system in which information elements are related through associative links such that the presence of a stimulus automatically (unintentionally and quickly) activates an associated element (e.g., *alcohol → good*); and (b) a *reflective* system in which information elements are related through volitional (and relatively slow) assigning of truth value to propositions (e.g., "I don't [do] have to work early tomorrow, so consuming alcohol is [not] good"; Strack & Deutsch, 2004).

As can be seen from the example above, the impulsive system can influence the content on which the reflective system operates. This influence occurs through several pathways. First, the impulsive system can affect the ease with which content enters the reflective system. Dual-process models propose that stronger associative links increase the accessibility of the content in the impulsive system, making it more likely to enter the reflective system (Strack & Deutsch, 2004). Once the associations have been transformed into propositions, processing in the reflective system can lead to either endorsement ("I don't have to work early tomorrow, so consuming alcohol is good") or rejection ("I do have to work early tomorrow, so consuming alcohol is not good"). In the case of rejection, the strength of the associations in the impulsive system is proposed to influence the ability to inhibit and disengage from alcohol-related thoughts. Both emotion (Lang, Davis, & Öhman, 2000) and addiction (Field & Cox, 2008) researchers suggest that a stronger association between a stimulus and valence (i.e., salience) will increase the likelihood of cognitive preoccupation with that stimulus. This idea is supported with evidence that explicit and implicit measures of smoking stimuli–

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valence associations predict difficulty in disengaging attention from smoking stimuli (Mogg, Bradley, Field, & de Houwer, 2003).

From this perspective, a positive feedback loop can be created such that an automatic appetitive response for alcohol in the impulsive system influences the content of conscious thought, which, in turn, activates automatic appetitive elements in the impulsive system (Field & Cox, 2008; Strack & Deutsch, 2004). This positive feedback loop can increase the likelihood of volitional use when there is a reflective system endorsement of the idea that drinking is good (Kavanagh, Andrade, & May, 2005). In the case of a reflective system rejection of the idea that drinking is good, a positive feedback loop may remain if the reflective system is not strong enough to disengage from alcohol-related thoughts (because of the salience of the thought, weak inhibitory ability, or a combination of both).

This analysis suggests that self-regulation can be improved by weakening the relation between the impulsive system and preoccupation with alcohol-related thoughts. Both mindfulness and executive control represent potential moderators of this relation. *Mindfulness* can be defined as consisting of both an awareness of immediate experience and a nonjudgmental and accepting attitude toward that experience (Bishop et al., 2004; Gunaratana, 2002). Mindfulness has been proposed to change the relation with internal experience from one of individuals "simply being their emotions, or identifying personally with negative thoughts and feelings," to one in which mental content is experienced as "passing thoughts and feelings" (Teasdale et al., 2002, p. 276). With mindfulness, mental content generated by the impulsive system could be accepted and allowed to come and go without having to be acted upon, either through overt behavior or cognitive elaboration in the reflective system. Recent research suggests that a relation between automatic alcohol-affect associations and alcohol consumption is weaker in those with higher trait mindfulness (Ostafin & Marlatt, 2008) and after mindfulness training (Ostafin, Bauer, & Myxter, 2012). This delinking of automatic processes and subsequent responses could partly account for the efficacy of mindfulness interventions for substance use (Bowen et al., 2009; Brewer et al., 2011; Zgierska et al., 2008).

Executive control as assessed by working memory tasks is the ability to voluntarily control attention to maintain or suppress information (Engle, 2002). From this perspective, executive control can inhibit the influence of automatic responses generated by the impulsive system on subsequent thinking and behavior (Barrett, Tugade, & Engle, 2004). Previous findings demonstrate that executive control moderates the relation between automatic alcohol-affect associations and alcohol consumption (Thush et al., 2008).

Although both mindfulness and executive control have been found to moderate the relation between automatic alcohol-affect associations and behavior, no research has examined whether these variables similarly moderate the relation between alcohol-affect associations and difficulty in disengaging attention from alcohol-related thoughts. The current study was designed to examine these questions. We predicted that both mindfulness and executive control would weaken a positive relation between automatic alcohol–valence associations and preoccupation with alcohol-related thoughts.

Method

Participants

Sixty-one undergraduate students who were fluent in English participated as partial fulfillment of a class requirement. The sample was primarily male ($n = 34$) and White ($n = 58$) and had a mean age of 19.6 ($SD = 1.9$). Participants reported drinking a mean of 1.2 ($SD = 1.4$) days per week, 6.8 ($SD = 6.4$) drinks per occasion, and 0.8 ($SD = 1.4$) binge-drinking episodes per week over the previous year.

Measures and Materials

Drinking behavior. Frequency of alcohol consumption, average drinks per occasion, and frequency of binge-drinking episodes (as 5+ servings over 2 hr for males and 4+ over 2 hr for females) for the last year were assessed with Likert-type items (National Institute on Alcohol Abuse and Alcoholism Task Force [NIAAA], 2003). The drinking behavior variables demonstrated positive skew and were subsequently log-transformed.

Preoccupation with alcohol-related thoughts. The Cognitive Preoccupation scale of the Temptation and Restraint Inventory (Collins & Lapp, 1992) was administered to assess the preoccupation with alcohol-related thoughts. This scale is scored as the mean of three items ("Is it hard to distract yourself from thinking about drinking?" "At times, do you find yourself unable to stop thinking about drinking?" "Do thoughts about drinking intrude into your daily activities?") assessed with a Likert-type scale ranging from 1 (*never*) to 9 (*always*). The scale demonstrated good internal consistency (Cronbach's $\alpha = .91$).

Mindfulness. The Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) is scored as the mean of 39 items using a Likert-type scale ranging from 1 (*never or very rarely true*) to 5 (*almost always or always true*) to assess trait mindfulness. The questionnaire assesses five subscales of mindfulness that can be broadly construed as representing both the awareness component of mindfulness with items such as "When I'm walking, I deliberately notice the sensations of my body moving" (Observing subscale), "I find it difficult to stay focused on what's happening in the present" (Acting with awareness; reverse-scored item), and "Even when I'm feeling terribly upset, I can find a way to put it into words" (Describing) and the nonjudgmental acceptance of experience component of mindfulness with items such as "I think some of my emotions are bad or inappropriate and I shouldn't feel them" (Nonjudging of inner experience; reverse-scored item) and "I perceive my feelings and emotions without having to react to them" (Nonreactivity to inner experience). The FFMQ score demonstrated good internal consistency (Cronbach's $\alpha = .80$). (Internal consistency of each subscale follows: Observing = .75; Acting with awareness = .76; Describing = .74; Nonjudging = .82; Nonreactivity = .58.).

Automatic alcohol-valence associations. An Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) was presented on Inquisit software (Draine, 2004). Participants pressed one of two response keys to categorize verbal stimuli as being related to the target categories of *alcohol* (alcohol, beer, cocktail, liquor, or wine) or *softdrink* (iced-tea, juice, lemonade, soda pop, or soft drink) and the attribute categories of *positive* (enjoyable, good, happy, like, pleasant) or *negative* (awful, bad, dislike, unhappy, unpleasant). During the combination blocks, each response key is paired with one target and one attribute category. The IAT was presented in seven blocks: (a) 20 trials of alcohol versus soft drink; (b) 20 trials of positive versus negative; (c) 40 trials of alcohol + positive versus soft drink + negative; (d) a second 40-trial combination block with the same pairing as (c); (e) a

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Table 1
Bivariate Correlations Among Study Variables

Variable	1	2	3	4	5	6	7
1. Preoccupation with alcohol-related thoughts	—						
2. IAT	.25*	—					
3. Trait mindfulness	−.45**	−.11	—				
4. Executive control	−.41**	−.07	.40**	—			
5. Alcohol frequency	.42**	.38**	−.10	.02	—		
6. Alcohol quantity	.27*	.31*	−.09	−.06	.58**	—	
7. Alcohol binges	.34**	.42**	−.10	.12	.63**	.67**	—

Note. IAT = Implicit Association Test (larger scores = stronger automatic alcohol-positive valence associations).
* $p < .05$. ** $p < .01$.

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20-trial block in which the attribute categories were reversed (negative vs. positive); (f) 40 trials of alcohol + negative versus soft drink + positive; and (g) a second 40-trial reversed combination block with the same pairing as (f). Errors led to an error message after which participants were required to make the correct response before the next trial. The IAT score was calculated with the D_1 algorithm (Greenwald, Nosek, & Banaji, 2003) such that larger scores indicate stronger alcohol-positive relative to alcohol-negative associations. In order to assess internal consistency, two IAT scores were calculated (blocks c and f and blocks *d* and g), $r(61) = .43$, $p = .0006$.

Executive control. The Sternberg working memory task (Sternberg, 1975) was used as a measure of executive control and was presented on Inquisit software (Draine, 2004). The task consisted of two blocks of 24 trials each with each block consisting of eight trials for each of three set sizes (four, six, or eight letters). In each trial, a series of white letters was presented one at a time for 1,000 ms. The stimuli consisted of all consonants except the letters F and J. After each series of white letters, a blank screen was presented for 300 ms, after which a yellow probe letter was presented. Participants were instructed to memorize the series of letters and to indicate, as quickly and accurately as possible, whether the probe was positive (appeared in the series) by pressing the *F* key or negative (did not appear in the series) by pressing the *J* key. The probe remained on the screen until the participant responded or a maximum of 2,000 ms. An equal number of positive and negative probes were presented for this task. A 300 ms feedback followed each trial indicating whether the response was correct (a green "O") or incorrect (a red "X"). After the feedback, a prompt to "Get ready" was displayed for 500 ms and was followed by a blank screen for 500 ms before the next trial began. The task was scored as number of correct trials so that larger values represent better executive control. Internal consistency was assessed as the bivariate correlation between the number of errors in each of the blocks, $r(61) = .60$, $p = 3 \times 10^{-7}$.

Procedure

Participants were run in groups consisting of one to five participants seated in private workstations. Participants first completed the IAT and Sternberg working memory task and then completed a set of measures assessing demographic information, drinking-related variables, and mindfulness.

Results

We first examined the bivariate correlations between the study variables. As Table 1 shows, preoccupation with alcohol-related thoughts was positively related with automatic alcohol–valence associations and negatively related with both trait mindfulness and executive control.

Our main hypotheses regarded the moderators of a relation between automatic affective responses to alcohol and cognitive preoccupation with alcohol. We hypothesized that the relation between automatic alcohol–valence associations and preoccupation with alcohol-related thoughts would be moderated by both mindfulness and executive control. These hypotheses were examined with regression analyses on preoccupation with alcohol-related thoughts. All variables were standardized for the analyses. Drinking frequency, quantity, and binge were entered as Step 1 (in order to provide a clearer relation between the IAT and alcohol preoccupation),[1] the IAT and mindfulness (or executive control) entered as Step 2, and a product of the values of the IAT and mindfulness (or executive control) variables as Step 3. The results indicated that the relation between preoccupation with alcohol-related thoughts and the IAT was moderated by both trait mindfulness ($\beta = -.25$, $t = -2.3$, $p = .03$, $f^2 = .10$)[2] and executive control ($\beta = -.26$, $t = -2.4$, $p = .02$, $f^2 = .10$; see Table 2). Simple slopes analyses (Aiken & West, 1991) indicated a positive relation between alcohol preoccupation and the IAT for individuals low (−1 *SD*) in mindfulness, $t = 1.97$, $p = .05$, and a nonsignificant relation for those high (+1 *SD*) in mindfulness, $t = -1.3$, $p = .20$ (see Figure 1). The results similarly indicated a positive relation between alcohol preoccupation and the IAT for individuals low (−1 *SD*) in executive control, $t = 2.16$, $p = .04$, and a nonsignificant relation for those high (+1 *SD*) in executive control, $t = -1.22$, $p = .23$ (see Figure 2).

[1] Both moderator analyses remain statistically significant when conducted without the drinking variables as covariates.

[2] Moderator analyses were conducted on each FFMQ subscale to give a fuller picture of the aspects of mindfulness that may decouple the relation between automatic alcohol–valence associations and alcohol preoccupation. The results follow: Nonjudging of inner experience, $\beta = -.22$, $t = -1.97$, $p = .05$; Acting with awareness, $\beta = -.19$, $t = -1.52$, $p = .13$; Describing, $\beta = -.14$, $t = -1.22$, $p = .23$; Observing, $\beta = -.08$, $t = -0.6$, $p = .55$; Nonreactivity to inner experience, $\beta = -.03$, $t = -0.2$, $p = .84$.

Table 2
Analyses of Mindfulness and Executive Control as Moderators of the Relation Between Automatic Alcohol-Valence Associations and Preoccupation With Alcohol-Related Thoughts

Predictor	ΔR^2	ΔF	*Beta*
Step 1	.19	$F(3, 57) = 4.38^{**}$	
Alcohol frequency			$.36^{*}$
Alcohol quantity			$-.03$
Alcohol binge			.13
Mindfulness as a moderator			
Step 2	.17	$F(2, 55) = 7.35^{**}$	
IAT Score			.06
Mindfulness			$-.41^{**}$
Step 3	.06	$F(1, 54) = 5.29^{*}$	
IAT × Mindfulness			$-.25^{*}$
Executive control as a moderator			
Step 2	.16	$F(2, 55) = 6.75^{**}$	
IAT Score			.08
Executive control			$-.40^{**}$
Step 3	.06	$F(1, 54) = 5.61^{*}$	
IAT × Executive control			$-.26^{*}$

Note. Implicit Association Test (IAT) score (larger scores = stronger automatic alcohol-positive valence associations).
$^{*}p < .05$. $^{**}p < .01$.

Mindfulness and executive control have been proposed to be overlapping processes in that mindfulness training involves the control of attention and should, thus, improve attentional skills (Lutz, Slagter, Dunne, & Davidson, 2008). Recent studies support this idea with findings that mindfulness training improves performance on measures of executive control (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). The idea of an overlap between mindfulness and executive control is additionally supported by the correlation between the two variables in this study. In order to further explore the nature of the moderating effect of mindfulness, we examined whether the interaction effect would remain when controlling for executive control. A regression on preoccupation with alcohol-related thoughts was conducted with drinking frequency, quantity and binge entered as Step 1, executive control, the IAT and mindfulness variables entered as Step 2, and a product of the values of the IAT and mindfulness variables as Step 3. The results indicated that when controlling for executive control, the relation between alcohol preoccupation and the IAT continued to be moderated by mindfulness ($\beta = -.21$, $t = -2.03$, $p = .047$, $f^2 = .07$; see Table 3).

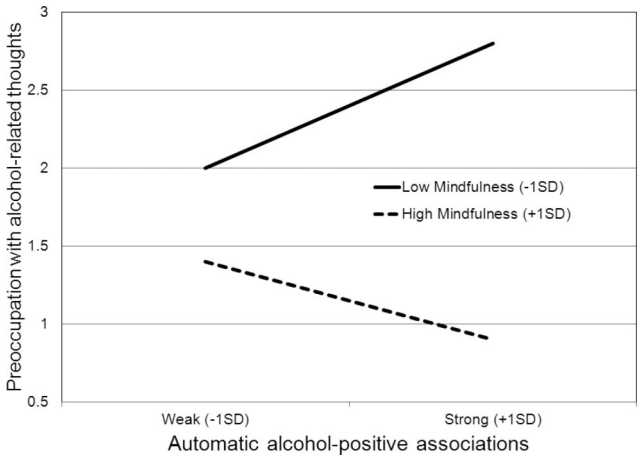

Figure 1. Mindfulness moderates the relation between automatic alcohol–valence associations and preoccupation with alcohol-related thoughts.

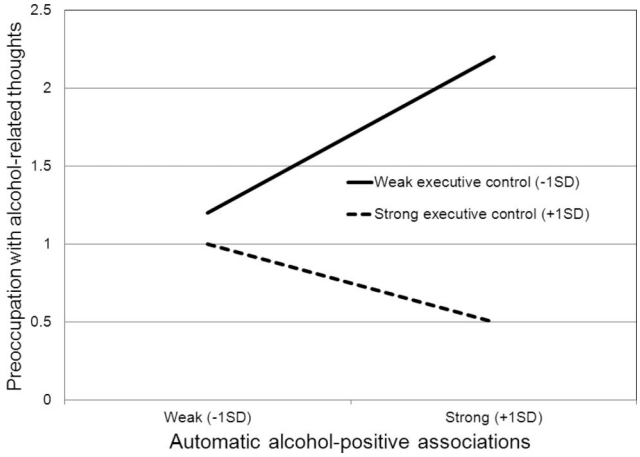

Figure 2. Executive control moderates the relation between automatic alcohol–valence associations and preoccupation with alcohol-related thoughts.

Discussion

The results of this study demonstrate that the relation between automatic alcohol–valence associations and preoccupation with alcohol-related thoughts can be reduced by mindfulness and executive control. The current study contributes to a growing body of research on the ability of mindfulness and executive control to moderate the influence of the automatic alcohol-affect associations

Table 3
Mindfulness as a Moderator of the Relation Between Automatic Alcohol-Valence Associations and Preoccupation With Alcohol-Related Thoughts Controlling for Executive Control

Predictor	ΔR^2	ΔF	*Beta*
Step 1	.19	$F(3, 57) = 4.38^{**}$	
Alcohol frequency			$.36^{*}$
Alcohol quantity			$-.03$
Alcohol binge			.13
Step 2	.23	$F(3, 54) = 7.20^{**}$	
Executive control			$-.28^{*}$
IAT Score			.06
Mindfulness			$-.30^{*}$
Step 3	.04	$F(1, 53) = 4.13^{*}$	
IAT × Mindfulness			$-.21^{*}$

Note. Implicit Association Test (IAT) score (larger scores = stronger automatic alcohol-positive valence associations).
$^{*}p < .05$. $^{**}p < .01$.

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on behavior by showing that these variables also weaken the relation between the impulsive system and preoccupation with alcohol-related thoughts.

The results showed a positive relation between mindfulness and executive control, supporting previous research (Jha et al., 2010; Zeidan et al., 2010). However, the moderating effect of mindfulness remained when controlling for individual differences in executive control, suggesting that the effect of mindfulness is not simply a function of executive control. This result should be interpreted with caution, as the cross-sectional design in this study prevented a true mediation analysis (Maxwell & Cole, 2007). Future research should address this question with an experimental design. The variety of inhibitory and updating processes involved in executive control (Miyake, Friedman, Emerson, & Howerter, 2000) suggests that future research would also benefit from including other measures of the construct to examine moderation and mediation. Potential tasks would include those that more purely assess inhibition of prepotent responses or resistance to proactive interference (Friedman & Miyake, 2004). Alternatively, it may be that variables other than executive functions explain the ability of mindfulness to moderate the influence of automatic processes. Future research would also benefit from examining potential mediators such as *decentering* (Teasdale et al., 2002) or *cognitive defusion* (Hoyer, Hacker, & Lindenmeyer, 2007), which would involve the ability to objectively observe cognitive and affective responses to alcohol as mental content that comes and goes instead of identifying with and getting swept away by those responses.

Future research should expand on the current findings in several other ways so that their clinical implications can be more fully elaborated. For example, future work should use an experimental (control vs. mindfulness or executive control training) and longitudinal design with a clinical sample (that is larger and more diverse than the current study's sample) in order to increase confidence that mindfulness and executive control training are indeed useful in reducing the influence of automatic and reflective processes on substance use behavior (e.g., reductions in relapse).

Despite its limitations, the current study makes several contributions. First, the results support the idea that the affective salience of substance-related stimuli is related to their ability to capture attention (Mogg et al., 2003). Additionally, despite promising evidence for mindfulness interventions for substance use disorders (Zgierska et al., 2009), little is known about how mindfulness influences the psychological processes involved in addiction. The current study indicates that mindfulness moderates the relation between the impulsive system and ability to disengage from alcohol-related thoughts, which could break what would otherwise be a positive feedback loop of automatic alcohol impulses leading to alcohol-related thoughts, in turn leading to the activation of additional alcohol impulses and so on (Field & Cox, 2008). The results also demonstrated a negative bivariate relation between preoccupation with alcohol-related thoughts and both mindfulness and executive control. In sum, these results offer initial evidence for ways in which mindfulness may help to reduce addictive behavior.

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