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Alcohol Cue Exposure Effects on Craving and Attentional Bias in Underage College Student Drinkers

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Abstract

The effect of alcohol cue exposure on eliciting craving has been well documented and numerous theoretical models assert that craving is a clinically significant construct central to the motivation and maintenance of alcohol-seeking behavior. Furthermore, some theories propose a relationship between craving and attention, such that cue-induced increases in craving bias attention towards alcohol cues, which in turn perpetuates craving. This study examined the extent to which alcohol cues induce craving and bias attention towards alcohol cues among underage college student drinkers. Thirty-nine undergraduate college drinkers (ages 18–20) completed a within-subjects design that included cue reactivity and visual probe tasks to assess *in vivo* alcohol cue exposure effects on craving and attentional bias. Participants expressed greater subjective craving to drink alcohol following *in vivo* cue exposure to a commonly consumed beer compared to water exposure. Furthermore, following alcohol cue exposure, participants exhibited greater attentional biases towards alcohol cues as measured by a visual probe task. In addition to the cue exposure effects on craving and attentional bias, within-subject differences in craving across sessions marginally predicted within-subject differences in attentional bias. Implications for both theory and practice are discussed.

Keywords

Alcohol; College Student Drinking; Craving; Cue Reactivity; Attentional Bias

There is a wealth of empirical evidence demonstrating that exposure to cues associated with alcohol consumption elicits reports of subjective craving among various populations of alcohol users including alcohol-dependent individuals, social drinkers, and adolescent drinkers (Carter & Tiffany, 1999; Ramirez & Miranda, 2014; Schulze & Jones, 2000). Further, cue-elicited craving is critical to a number of theories of addictive behavior (e.g., de Wit & Phan, 2009). One such theory, the incentive-sensitization theory of addictive behavior, asserts that the brain circuitry of drug users undergoes changes resulting in sensitization to incentive motivational effects of drugs and drug-associated cues (Robinson

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& Berridge, 1993). This incentive sensitization increases the salience of drug-associated cues and may result in a pathological motivation or craving for the drug and the cues themselves. An extension of this theory asserts that cues induce not only craving but also changes in cognitive processes such that attention becomes biased towards drug cues (Franken, 2003). This theory posits that a reciprocal relationship between enhanced craving and attentional biases towards drug cues underlies drug-seeking behavior. Specifically, initial attention paid to drug cues increases craving, which in turn strengthens attentional bias to drug cues themselves. This results in a positive feedback loop maintaining high levels of craving and ultimately motivating drug-seeking behavior.

The attentional bias approach receives support from a meta-analysis (Field, Munafò, & Franken, 2009) that found a small, but significant positive relationship between craving and attention towards illicit drugs ($r = .19$). Moreover, Franken's model (2003) predicts that this relationship should be strengthened following cue exposure, which would enhance craving and initiate the proposed positive feedback loop between craving and attention. Indeed, Field, Munafò, and Franken (2009) found a stronger relationship between craving and attention in studies that included experimental manipulations intended to increase craving ($r = .23$). For example, studies that induced craving by including stress induction techniques (Field & Powell, 2007) and delivering priming doses of alcohol (Schoenmakers, Wiers, & Field, 2008) also observed increases in attentional bias towards alcohol. With regards to alcohol cue exposure, one study found greater attentional biases to alcohol cues among heavy drinkers when in an alcohol-associated context (Cox, Yeates, & Regan, 1999). This study did not assess craving however, leaving unanswered questions regarding the positive relationship between cue-elicited craving and attentional bias towards alcohol as predicted by Franken (2003).

The present study implemented a within-subjects design to examine alcohol cue exposure effects on both craving and attentional bias in underage college student drinkers (UCSDs); a population of drinkers who report drinking excessive amounts of alcohol (Wechsler, Lee, Nelson, & Kuo, 2002), and less intention to drink responsibly than legal college student drinkers (Barry, Stelfox, & Woolsey, 2014). We first hypothesized that UCSDs would report increases in craving following *in vivo* alcohol cue exposure based on well-established findings from the cue reactivity literature. Also, consistent with previous studies demonstrating attentional biases to alcohol among college student drinkers (e.g., Field, Mogg, Zettler, & Bradley, 2004; Sharma, Albery, & Cook, 2001; Townshend & Duka, 2001), we hypothesized that the current sample would exhibit an attentional bias, and that this bias would be strengthened after alcohol cue exposure. Consistent with Franken's attentional bias model (2003), we hypothesized that craving would mediate the relationship between cue type and attentional bias as evidenced by within-subject differences in craving across sessions (alcohol cues vs. water cues) positively predicting within-subject changes in attentional biases across sessions (Judd, Kenny, & McClelland, 2001).

Method

Participants

Undergraduate students were invited to participate in the study as an opportunity to fulfill course requirements. Students recruited from introductory level psychology courses were between the ages of 18 and 20 years of age, and were eligible to participate if they drank at least one beer on a weekly basis over the past month. Individuals were ineligible if currently seeking treatment for alcohol problems or if having received treatment in the past 30 days.

Procedure

The study design is outlined in Table 1. Participants completed two sessions separated by at least one week, and occurring at the same time of day. Depending on the session, participants completed either an *in vivo* water or alcohol cue reactivity protocol followed by a visual probe task to assess attentional bias towards alcohol. Additional individual difference measures were collected after the visual probe task due to the concern that the nature of these assessments (e.g., recalling drinking episodes) might affect craving and attentional bias to alcohol. All participants signed informed consent before beginning the study. The Brown University institutional review board approved this study.

Cue Reactivity (CR)—The CR procedure followed well-established procedures with modifications made to separate alcohol and water cue exposure across sessions (e.g., Monti et al., 1987, 2001). Participants were asked to abstain from drinking the morning of the study and were breath-tested to ensure a Blood Alcohol Content (BAC) of 0.00 prior to receiving standardized instructions about the CR assessments (all participants had a BAC of 0.00). Participants indicated which one of three beer options they most commonly drink and whether they were more likely to drink that beer from a cup or glass with these selections matching their *in vivo* alcohol exposure. The beer options represented the spectrum of beer choices popular among college students and covered the beer preferences of the participants.

Sessions began with a 3-min relaxation period, in which participants sat quietly. In one session, participants were then instructed to hold and smell a glass of water for two consecutive 3-min periods. In the other session, participants were instructed to hold and smell a cup or glass of beer for two consecutive 3-min periods. Participants smelled the beverage for 5 seconds each time a tone sounded with 13 tones delivered during each 3-min period with variable intervals. Participants completed craving assessments after each 3-min period with craving reported after the relaxation period representing the baseline measure of craving, and craving reported after the final period of beverage exposure representing the CR measure of craving.

Visual Probe—Following the CR procedure in each session, participants completed a visual probe task to assess attentional bias to alcohol cues. Participants sat in front of a laptop computer and were instructed to identify the location of a probe stimulus, which always followed the presentation of a pair of pictorial stimuli. The pictorial stimuli have been used in previous work evidencing robust attentional bias effects (Miller & Fillmore, 2010) and consisted of ten alcohol pictures of solitary alcoholic beverages matched with ten

neutral pictures of similarly sized non-alcoholic beverages. The task began with six practice trials, in which neutral picture pairs were presented. Following a short break, two buffer trials were presented, followed by 80 critical trials, in which alcohol-neutral picture pairs were presented. Each trial began with a central fixation cross presented for 500 ms, followed by a bilateral picture pair presentation for 1000 ms. Immediately following picture offset, the probe stimulus was presented on the left or right side of the screen where a picture stimulus was presented. The probe stimulus was an “X” and participants were instructed to press one of two keys on the keyboard indicating on which side the probe appeared. After making a response, there was an intertrial interval of 500 ms before the next fixation cross appeared. Throughout the critical trials, each picture pair was presented eight times, with the alcohol picture presented four times on each side of the screen. Probes replaced each picture and appeared on each side of the screen with equal frequency. Attentional bias to alcohol was indicated by faster reaction times to probes that replaced alcohol pictures. Following the visual probe task, participants reported post-task levels of craving.

Measures

To assess alcohol craving, participants completed the Alcohol Urge Questionnaire (AUQ; Bohn, Krahn & Staehler, 1995), an 8-item measure of momentary craving with higher summary scores representing greater craving. The 90-day timeline follow-back interview (TLFB; Sobell & Sobell, 1992) was used to assess baseline (pre-study) drinking levels and was scored for the percentage of drinking days and heavy drinking days (5 standard drinks for males, 4 standard drinks for females) in the last 90 days, and the number of standard drinks per drinking day. To assess alcohol-related problems and misuse, participants completed the Rutgers Alcohol Problem Index (RAPI; White & Labouvie, 1989); and the Alcohol Use Disorders Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001).

Results

Descriptives and bivariate correlations

Table 2 shows descriptive information for the sample. 20 males and 19 females were distributed evenly, to the extent permitted, across order of cue reactivity sessions (alcohol or water first). To test whether participants' drinking behavior or severity of alcohol problems were associated with craving or attentional bias, these measures were investigated using bivariate correlations and are presented in Table 3. Significant correlations were present between all measures of alcohol problems and measures of baseline alcohol use (all p values < .05). None of the individual-level measures had significant correlations with measures of craving or attention with the exception of AUDIT scores, which negatively correlated with attentional bias to alcohol cues during the water session.

Craving for alcohol

Figure 1 presents mean levels of subjective craving (AUQ scores) measured at the three time points separated by each session type. A repeated measures ANOVA revealed main effects of Time ($F(1,38) = 18.58, p < .001$) and Session ($F(1,38) = 17.53, p < .001$) subsumed under a Time x Session interaction ($F(1,38) = 17.30, p < .001$). Bonferroni corrected ($\alpha = 0.025$)

post hoc *t*-tests revealed a significant increase in craving between baseline and cue reactivity within the alcohol cue reactivity session ($t(38) = 7.23, p < .001, d = 1.28$), with no change in craving between baseline and cue reactivity within the water cue reactivity session ($t(38) = 0.66, p = .513, d = 0.11$). There were no significant differences in craving reported at baseline between alcohol and water cue reactivity sessions ($p > 0.10$), nor were there differences in craving between participants who first received alcohol cue exposure and those who first received water cue exposure ($p > 0.10$).

Attentional bias

For the visual probe task, trials with errors (incorrect identification of probe side) were removed (1.6%) and due to significant positive skewness, individual median reaction times were determined to probes that replaced alcohol cues or neutral cues. Figure 2 presents the means of individual median reaction times to probes that replace alcohol and neutral cues in both the alcohol and water cue reactivity sessions. A repeated measures ANOVA revealed a main effect of Trial Type ($F(1,38) = 15.50, p < .001$), subsumed under a Session x Trial Type interaction ($F(1,38) = 5.26, p = .027$). Bonferroni corrected ($\alpha = 0.025$) post hoc *t*-tests revealed a significant attentional bias towards alcohol cues with faster reaction times to probes that replaced alcohol cues during alcohol cue reactivity sessions ($t(38) = 4.39, p < .001, d = 0.72$). Participants did not show a significant attentional bias to probes that replaced alcohol cues during water cue reactivity sessions ($t(38) = 1.49, p = .146, d = 0.31$). To test whether alcohol cue exposure increased attentional bias, the bias scores between alcohol and water cue reactivity sessions were compared to each other. Attentional bias to alcohol was significantly stronger during alcohol cue reactivity sessions than during water cue reactivity sessions ($t(38) = 2.29, p = .027$). There was no significant difference in attentional bias between participants who first received alcohol cue exposure and those who first received water cue exposure ($p > 0.10$).

Craving and attentional bias

To examine the relationship between craving and attentional bias, we ran a series of regression analyses. These demonstrated that craving reported after cue reactivity did not significantly predict attentional bias to alcohol cues in either the alcohol session ($r = .28, p = .081$) or the water session ($r = .02, p = .929$). However, craving difference scores between the alcohol and water session marginally predicted attentional bias change scores between sessions such that greater increases in craving from the water to the alcohol session predicted greater increases in attentional bias from the water to the alcohol session ($r = .31, p = .054$) as shown in Figure 3.

Discussion

Using a within-subjects *in vivo* alcohol cue reactivity paradigm, the effects of alcohol cue exposure on subjective craving and attentional bias to alcohol were examined among underage college student drinkers. Three main results were obtained. First, exposure to *in vivo* alcohol cues increased subjective reports of craving. Second, alcohol cue exposure strengthened attentional biases towards alcohol pictures in a visual probe task. Third, the relationship between craving and attentional bias was strengthened following alcohol cue

exposure and within-subject differences in craving across sessions marginally predicted within-subject differences in attentional bias. These results are consistent with a core assertion of Franken's (2003) attentional bias model that drug craving positively predicts attentional bias to drug cues.

The present study found that underage college student drinkers reported robust increases in subjective craving following *in vivo* alcohol cue exposure. Within-session increases in craving were observed following exposure to *in vivo* alcohol cues, with no changes in craving reported following water cue exposure. Although the sample included both heavy and light drinkers, craving to alcohol cues was robust with an effect size ($d = 1.28$) larger than typically observed in adult populations ($d = 0.53$ Carter & Tiffany, 1999). Despite previous findings that cue reactivity responses distinguish heavy drinkers from light drinkers (Ihssen, Cox, Wiggett, Fadardi, & Linden, 2011) and alcoholics from nonalcoholics (Monti et al, 1987; Tapert et al. 2003), cue-elicited craving in the current study was not predicted by baseline rates of drinking or alcohol-related problems. However, it should be noted that alcohol use disorder (AUD) status was not assessed and that 76.9% of the sample reported AUDIT scores below 16, a threshold indicating a high level of alcohol problems (Babor et al., 2001). Future studies with greater proportions of problematic underage college student drinkers should formally assess AUD status to see if cue-elicited craving responses distinguish students with AUDs from students without AUDs.

Exposure to *in vivo* alcohol cues also strengthened attentional biases to pictorial alcohol stimuli presented in a visual probe task. A previous study found that average weekly alcohol consumption positively correlated with attentional bias among participants who received *in vivo* alcohol cue exposure but not among participants exposed to control cues (Cox, Brown, & Rowlands, 2003). However, the current results are the first to demonstrate that exposure to *in vivo* alcohol cues strengthens attentional bias to alcohol. Of particular interest, reaction times to probes that replaced alcohol cues were nearly identical across session types. However, participants exhibited slower reaction times to probes that replaced neutral cues during the alcohol cue exposure sessions. Therefore, we conclude that exposure to *in vivo* alcohol cues resulted in delayed disengagement of attention from alcohol cues when probes replace neutral cues. This disengagement mechanism is consistent with other interpretations of attentional bias during probe tasks when stimulus durations are 500ms or longer allowing participants sufficient time to shift attention between stimuli (Field, Schoenmakers, & Wiers, 2008).

The measurement of both craving and attentional bias allowed us to examine the relationship between these two constructs. First, regression analyses revealed no relationship between craving and attentional bias following water cue exposure ($r = .02$). However, Franken's model (2003) posits that increases in craving lead to increased attentional biases. Indeed, we found a stronger predictive relationship when craving was greater during the alcohol cue exposure session ($r = .28$). These findings are in line with previous findings (Field, Munafò, & Franken, 2009), in which the relationship between these two constructs was stronger among studies that manipulated craving ($r = .23$ in high craving conditions, $r = .08$ in low craving conditions). Another regression analysis tested the possibility that craving mediates the relationship between cue exposure and attention by using within-subject differences in

craving across sessions to predict within-subject differences in attentional bias (Judd, Kenny, & McClelland, 2001). Craving change scores between sessions marginally predicted attentional bias scores between sessions ($r = .31, p = .054$) lending further support to a positive relationship between these two constructs.

Field, Munafo, and Franken (2009) identified two factors that moderate the relationship between craving and attentional bias, and may contribute to the modest effect sizes found in the current study. First, the magnitude of positive correlations between craving and attention is weaker in alcohol studies compared to studies with other drugs of abuse, although explanations for this finding are unclear. Second, weaker associations are found between craving and attention among studies utilizing indirect measures of attention such as reaction times from visual probe tasks. Measures that infer attentional bias on the basis of reaction times may not provide a measure sensitive enough to capture a potential relationship with craving. Future studies would benefit from the use of direct measures of attention such as eye movement monitoring. Finally, although effect sizes were comparable to the modest but significant positive correlations found in the meta-analysis of studies measuring craving and attention (Field, Munafo, & Franken, 2009), our study may have lacked sufficient power to detect a statistically significant association. Despite the consistency in effect sizes between the current study and previous research, much of the variance in attentional bias remains unexplained. It remains possible that alcohol cues may be automatically detected and can influence alcohol-seeking behavior in the absence of subjective craving as suggested by theories that posit alcohol use as largely automatized (Tiffany, 1990).

In summary, this study demonstrated that underage college student drinkers express greater subjective craving following exposure to *in vivo* alcohol cues, and that attention becomes biased to subsequent alcohol cues. Furthermore, the enhanced attentional bias appears to be the result of a disengagement mechanism as suggested by slower reaction times to probes that replace neutral cues during alcohol cue sessions. Finally, the strength of the relationship between craving and attentional bias was consistent with past research indicating a small, but potentially meaningful positive relationship. Despite this relationship, much of the variance in attentional bias remains unaccounted for and warrants future research if clinical interventions aimed at reducing these biases are to advance.

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Figure 1.

Cumulative AUQ scores at Time 1 (before cue reactivity), Time 2 (after cue reactivity and before visual probe task), and Time 3 (after visual probe task) separated by alcohol cue exposure sessions in white bars and water cue exposure sessions in gray bars. Values are sample means $\pm$ SEM. ** = significant difference in subjective craving between Time 1 and Time 2 during alcohol cue exposure sessions at $p < .001$

Figure 2.

Attentional bias reaction times to probes that replace neutral cues in white bars and to probes that replace alcohol cues in gray bars separated by alcohol and water cue exposure sessions. Values are sample means of individual median reaction times $\pm$ SEM. ** = significant difference in reaction time to probes that replaced neutral cues and alcohol-related cues during alcohol cue exposure sessions at $p < .001$.

Figure 3.

Observed between-session changes in attentional bias (milliseconds) from changes in craving (cumulative AUQ scores). Change scores were quantified by subtracting values obtained during water cue exposure sessions from values obtained during alcohol cue exposure sessions with positive scores indicating greater attentional biases and craving during alcohol sessions. The best fitting line is illustrated.

Table 1

Experimental Design

	Time 1 Baseline	Cue Reactivity Protocol				Time 2 Post CR	Attentional Bias Assessment	Time 3 Post VP	Additional Measures
		Block 1	Block 2	Block 3					
Session 1	AUQ	Rest	Water (n = 19) Alcohol (n = 20)	Water (n = 19) Alcohol (n = 20)		AUQ	Visual Probe	AUQ	Demographics TLFB
Session 2	AUQ	Rest	Alcohol (n = 19) Water (n = 20)	Alcohol (n = 19) Water (n = 20)		AUQ	Visual Probe	AUQ	RAPI AUDIT

Notes: Participants completed two separate sessions at least a week apart that differed on the basis of cue type during the cue reactivity protocol, and on the individual difference measures administered at the end of each session. Participants received alcohol cue exposure in one session and received water cue exposure in the other session in a counterbalanced order. Craving was assessed at Time 1, Time 2, and Time 3. CR = Cue Reactivity; VP = Visual Probe; AUQ = Alcohol Urge Questionnaire; TLFB = 90 Day Timeline Follow Back; RAPI = Rutgers Alcohol Problem Index; AUDIT = Alcohol Use Disorders Identification Test.

Table 2

Participant Characteristics (N = 39)

Variable	Mean (SD)/Percentage
Age	19.1 (0.8)
Race ^a	
Caucasian	71.8%
African-American	10.3%
Hispanic	12.8%
Asian	18.0%
Native Hawaiian/Pacific Islander	2.6%
American Indian/Native Alaskan	2.6%
RAPI	8.9 (8.0)
AUDIT	12.1 (5.1)
Percent Drinking Days ^b	30.8 (15.4)
Percent Heavy Drinking Days ^b	15.8 (13.5)
Drinks Per Drinking Day ^b	5.2 (2.5)

Note.

^a Races were not considered mutually exclusive

^b Derived from the 90-day Timeline Follow-Back interview conducted at baseline; RAPI = Rutgers Alcohol Problem Index; AUDIT = Alcohol Use Disorders Identification Test.

Table 3

Correlation Matrix for Study Outcome and Predictor Variables

Measure	1	2	3	4	5	6	7	8
1. Craving (A)	—							
2. Craving (W)	.20	—						
3. Attentional Bias (A)	.27	.01	—					
4. Attentional Bias (W)	-.07	-.14	.14	—				
5. RAPI	.24	.14	.19	-.25	—			
6. AUDIT	.21	.13	.06	-.36*	.71**	—		
7. Drinking Days (%) ^a	-.01	.06	.06	-.08	.36*	.40*	—	
8. Drinks Per Drinking Day ^a	.01	.04	-.17	-.29	.41*	.75**	.26	—

Note. (A) = Assessed during alcohol sessions; (W) = Assessed during water sessions; Craving reflects subjective ratings scored during cue reactivity and prior to the visual probe task. Attentional bias reflects the bias of median reaction times during visual probe task; RAPI = Rutgers Alcohol Problem Index (higher scores indicate greater severity of alcohol-related problems); AUDIT = Alcohol Use Disorders Identification Test (higher scores indicate greater severity of alcohol-related problems);

^a derived from the 90-day Timeline Follow-Back interview conducted during first session;

* $p < .05$,

** $p < .01$.