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Comparing Three Cognitive Biases for Alcohol Cues in Alcohol Dependence

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Abstract

Aims: There is accumulating evidence that automatic processes play a large role in alcohol dependence, which may be related to alcohol craving and consumption. The aim of this study is to investigate associations between cognitive biases in alcohol-dependent patients, and how these measures relate to drinking behavior.

Methods: Thirty alcohol-dependent patients and 15 healthy controls (matched for age, intelligence and education; all male) completed three cognitive bias tasks: the Implicit Association Test (IAT: alcohol-approach association), Approach Avoidance Task (AAT: alcohol approach bias) and Dot Probe Task (DPT: alcohol attentional bias). Task scores were compared between groups and correlated with each other, as well as with craving scores and drinking behavior.

Results: Patients with alcohol dependence showed stronger alcohol-approach associations on the IAT compared with controls, but there were no group differences for approach or attentional biases. Within the patient group, the alcohol approach bias (AAT) correlated positively with the attend-alcohol attentional bias (DPT), but negatively with alcohol-approach associations (IAT). IAT scores were positively associated with lifetime alcohol intake.

Conclusions: This study demonstrates for the first time that alcohol-dependent patients have stronger alcohol-approach association scores on the IAT as compared to controls, and that this bias is associated with drinking behavior. Despite the absence of group differences for the approach and attentional biases, the positive correlation between these biases in alcoholics is in line with incentive salience models of addiction that propose that attentional and approach tendencies have a common underlying mechanism, distinct from that underlying alcohol-approach associations measured by the IAT.

Short Summary: The study investigates associations between cognitive biases involving alcohol cues. Patients with alcohol dependence showed stronger alcohol-approach associations on an

Implicit Association Test than controls, but there were no group differences for approach or attentional biases. Alcohol-approach and attentional bias correlated positively in the patient group.

INTRODUCTION

There is a wide literature demonstrating that automatically triggered cognitive biases for substance-related cues play an important role in substance abuse and dependence (see Stacy and Wiers, 2010 for a review). Heavy drinkers and alcohol-dependent patients have been shown to (a) automatically associate alcohol with approach and arousal (i.e. association bias; Wiers *et al.*, 2002; Palfai and Ostafin, 2003), although a lack of relationships with various drinking measures has also been reported within a student population (den Uyl *et al.*, 2015); (b) allocate attention towards alcohol cues quickly (i.e. attentional bias; Field *et al.*, 2013, but see Townshend and Duka, 2007 who report an attentional bias away from alcohol cues in alcohol-dependent inpatients) and (c) faster approach rather than avoid alcohol cues with a joystick (i.e. approach bias; Wiers *et al.*, 2009, 2011; Ernst *et al.*, 2014; Wiers *et al.*, 2014), as compared with socially drinking control groups. These automatic processes are thought to occur largely outside of conscious awareness and may play a role in the continuation of drinking despite knowledge of negative consequences; paradoxical behavior that is typical for addiction (Stacy and Wiers, 2010). Although many studies have studied one type of bias in alcohol-dependent populations versus control groups, no study to date has studied all three biases in patients versus controls together, and associated its findings with clinical variables such as drinking history, craving and abstinence.

The incentive sensitization theory of addiction suggests a common underlying mechanism of cognitive biases. All drugs of abuse, including alcohol, release dopamine in mesolimbic brain areas, causing these regions to become increasingly sensitive to this stimulation (Koob and Volkow, 2016). As a result, with repeated use drug cues acquire incentive salience: they attract attention and evoke approach responses (Robinson and Berridge, 2003). Therefore, drug attentional biases, approach biases and drug cue-approach associations would be expected to covary. Previous studies in smokers have found that the strength of smoking attentional bias and approach bias was positively correlated (Mogg *et al.*, 2003; Mogg *et al.*, 2005), but this effect was not replicated in a later study by Bradley *et al.* (2008). Sharbanee *et al.* (2013) aimed to disentangle alcohol attentional and approach processes in social drinkers on a combined 'Selective-Attention/Action-Tendency Task' and found no significant association between these two biases. Further evidence for associations between cognitive biases in alcohol-dependent patients comes from studies on the effects of Approach Avoidance Task (AAT)-based cognitive bias modification (CBM) training. The AAT-based CBM aims to retrain alcohol approach biases by implicitly pushing away alcohol cues, which not only reduces behavioral approach bias scores, but effects also generalized to other implicit biases such as the association bias measured on the Implicit Association Test (IAT) in heavy-drinking students (Wiers *et al.*, 2010) and alcohol-dependent patients (Wiers *et al.*, 2011). Furthermore, these biases have been found to mediate effects of CBM on relapse (Gladwin *et al.*, 2015). However, no study to date has systematically investigated associations between different cognitive biases in alcohol-dependent patients.

Cognitive biases are related to other addiction-related symptoms and phenomena. For example, cognitive biases have been positively associated with drug craving in smokers (Mogg *et al.*, 2003, 2005; Watson *et al.*, 2013; Wiers *et al.*, 2013a), predict relapse in alcohol-dependent patients (Waters *et al.*, 2003; Janes *et al.*, 2010), future drinking in problem drinkers (Martin Braunstein *et al.*, 2016), smoking in smokers (Waters and Feyerabend, 2000) and cannabis addiction severity in cannabis smokers (Cousijn *et al.* 2011). In alcohol-dependent inpatients, alcohol approach bias scores correlated positively with alcohol consumption and self-reported alcohol approach preferences (Barkby *et al.*, 2012), but no study to date has reported a significant association with subjective craving (e.g. Wiers *et al.*, 2014 did not find such an association). Nevertheless, both attentional and approach bias predicted alcohol consumption in the study of Sharbanee *et al.* (2013).

Whether automatic biases decay after drug abstinence is largely unknown. According to the incentive salience theory, sensitization to drugs is (semi-) permanent (Robinson and Berridge, 2003), which could imply that they serve a causal role in relapse after abstinence, unless they can be changed by suitable interventions (Wiers *et al.*, 2011; Eberl *et al.*, 2013; Gladwin *et al.*, 2015). Dual process models of addiction also suggest that persistent automatic drug-seeking tendencies play a role in addiction, but emphasize that successfully refraining from a drug requires also the ability and willingness to control these tendencies (Gladwin *et al.*, 2016).

The first goal of this study was to investigate whether alcohol-dependent patients had stronger cognitive biases related to alcohol cues compared with healthy controls on three different tasks. A group of alcohol-dependent patients and healthy controls (matched for age, intelligence and years of education) completed the IAT to assess the relative strength of their alcohol-approach associations, the AAT to measure alcohol approach bias and the Dot Probe Task (DPT) to assess their attentional bias for alcohol. We hypothesized that alcohol-dependent patients showed stronger biases on all three measures compared with healthy controls. The second goal was to investigate whether the strengths of these biases covaried with each other; for which we predicted positive correlations. The third goal was to determine whether the biases were positively related to craving and drinking behavior (i.e. lifetime drinking history and abstinence). For alcohol-dependent patients, we expected positive correlations of the biases with drinking history and craving, but a negative association with abstinence.

MATERIALS AND METHODS

Participants

Forty-five participants completed the study: n = 30 alcohol-dependent inpatients were recruited from the Salus Clinic (Lindow, Germany) and n = 15 healthy control subjects were recruited via online advertisements. All participants were male. Exclusion criteria for all participants were axis I psychiatric disorders according to DSM-IV criteria (other than alcohol and nicotine dependence), screened with the M.I.N.I. International Neuropsychiatric Interview plus interview (Sheehan *et al.*, 1998). Alcohol-dependent patients were abstinent from alcohol shorter than 4 months before participation (mean = 56.03 ± 46.10 SD) and free from psychoactive medication or other drugs at least 6 months before testing. Healthy control participants were excluded if scores on the Alcohol Use Disorder Identification Test (AUDIT; Saunders *et al.*, 1993) were over 8 (mean score = 2.93 ± 1.71; range 1–7), which was screened by a telephone interview before participation. Groups were matched for age, years of education and intelligence (assessed with the Matrix Reasoning of the Wechsler Adult Intelligence Scale; Kaufman and Lichtenberger, 2006). Demographic and clinical variables are summarized in Table 1. The Ethical Committee of the Charité, Universitätsmedizin-Berlin approved the study. After complete description of the study to the subjects, written informed consent was obtained.

All participants completed the Desire for Alcohol Questionnaire (DAQ; Love *et al.*, 1998) to assess alcohol craving and the Life Time Drinking History (LTDH) scale (Skinner and Sheu, 1982) to measure lifetime alcohol intake (see Table 1).

Experimental tasks

Alcohol-approach association: IAT

The IAT was programmed according to the paradigm used in Wiers *et al.* (2011) based on Ostafin and Palfai (2006). In all phases of the IAT, words were presented in the middle of the screen, which had to be sorted with a left or right key-press. In the first block, participants practiced sorting words of alcohol-containing drinks (e.g. beer, vodka, wine) and soft drinks (e.g. fanta, coke, juice) with a left and right key-press. In the second block, they practiced sorting approach and avoid words with the same left and right keys. In the third block, they practiced the first combined sorting task (e.g. alcohol and approach words left and soft drink and avoid words right), which was subsequently assessed in the fourth block. This generates the first mean reaction time (sorting alcohol and approach together). In the fifth block, participants practiced the reverse assignment for the drinks (e.g. alcohol words right, soft drinks left), followed in the sixth practice block by the other combined sorting-condition (soft drink and approach words press left, alcohol and avoid press right), followed by the seventh assessment block. This generates the second mean reaction time (sorting alcohol and avoid words together). The two combined sorting conditions were presented in a balanced order: either condition (a) combining alcohol with approach, and soft drink with avoidance or condition (b) combining alcohol with avoidance, and soft drink with approach. Alcohol approach associations were defined as the extent to which participants responded faster to blocks in which alcohol was paired with approach and soft drinks were paired with avoidance compared with blocks with the opposite pairing. Responses were analyzed using the D-score algorithm described in Greenwald *et al.* (2003), which combines reaction times (RTs) and error-scores of the combination blocks. Positive D-scores represent stronger alcohol approach associations.

Alcohol approach bias: AAT

The zoom version of the AAT was used to measure the behavioral alcohol approach bias, programmed in Matlab with the Psychtoolbox (Wiers *et al.*, 2013a). Participants pushed and pulled a joystick (Logitech Attack 3), in response to the format of the cue (landscape or portrait) and had to respond to a cue within 2 seconds. Pulling and pushing the joystick increased and decreased the size of the cue, respectively. In the task, 20 practice trials were followed by 80 test trials, presented over two blocks. Picture format to response assignment was counterbalanced: half of the participants pulled landscape and pushed portrait cues, and vice versa. A set of 40 alcohol and 40 soft drink images was used (Wiers *et al.*, 2014). RTs were computed per trial as the time required from the onset of stimulus presentation until the joystick reached a maximum (push) or minimum (pull) position. Responses that were missed or incorrect were discarded based on each participant's performance. Alcohol approach bias scores were calculated by subtracting median difference scores of push–pull trials of alcohol and soft drink cues [(alcohol push–pull) − (soft drink push–pull)]. Positive alcohol approach bias scores indicate an alcohol approach bias (i.e. the tendency to faster pull than push alcohol cues, relative to soft drinks), whereas negative approach bias scores indicate an avoidance bias for alcohol (i.e. faster push than pull alcohol compared with soft drinks). Data on this task from a subset of patients have previously been reported (Wiers *et al.*, 2015a, 2015b).

Alcohol attentional bias: DPT

The DPT was programmed and analyzed in line with previous studies (Townshend and Duka, 2007). A fixation cross was presented for 500 ms, followed by a picture pair (one alcohol and one soft drink cue) for 500 ms and a dot under one of the cues (either left or right). Participants had to respond according to the position of this cue using the arrow keys (left/right). Responses that were missed,

Table 1. Demographic and clinical data of alcohol-dependent patients and healthy controls

Characteristic	Alcohol-dependent patients (N = 30)		Healthy controls (N = 15)		
	Mean	SD	Mean	SD	P-value
Age (years)	43.83	7.12	41.33	8.57	0.306
Years of education	10.43	1.04	11.27	1.75	0.106
WAIS score Matrix Reasoning	15.89[a]	4.28	18.33	5.00	0.121
DAQ	14.70[b]	6.52	5.47	4.39	0.000
LTDH (kg)	1384.96	977.98	175.14[c]	234.32	0.000
Length of abstinence (days)	56.03	46.10			
Duration of dependence (years)	15.90	7.87			

[a] N = 28.
[b] N = 29.
[c] N = 14.
Abbreviations: DAQ, Desire for Alcohol Questionnaire; LTDH, Lifetime Drinking History; WAIS, Wechsler Adult Intelligence Scale.

incorrect, below 100 ms or over 1000 ms, were discarded based on each participant's performance. The attentional bias score was calculated by subtracting the mean RT when the dot was in the same location as the alcohol cue from the mean RT when the probe was in the soft drink for (soft drink—alcohol). That is, positive scores indicated increased attention for alcohol cues relative to soft drink cues. The same 40 alcohol and 40 soft drink images were used for both the AAT and DPT.

Statistical analyses

Data analyses were carried out using SPSS 20 (IBM, Armonk, NY, USA). Significance levels were set at an alpha of 0.05 and effects with significance levels of $P < 0.1$ were reported as trends.

Group comparisons

All bias scores were distributed normally in both groups (Kolmogorov–Smirnov test: all $P > 0.66$). Error rates on the tasks were ranging from 0% to 11%, and were below an *a priori* set error rate threshold of 30%.

The alcohol-approach association (assessed with the IAT), alcohol approach bias (AAT) and alcohol attentional bias (DPT) as well as DAQ craving and LTDH scores were compared between the two groups using two-sided *t*-tests. Higher values represent stronger alcohol biases for all three measures.

Correlations

Within both groups, we performed Pearson's *r* correlations between the three implicit bias scores, DAQ craving and LTDH drinking history. Correlations were compared between groups using Fisher's *r*-to-*z* transformations.

RESULTS

Group comparisons

As expected, alcohol-dependent patients drank more alcohol throughout their life (LTDH, $t_{35.4} = 6.39$, $P < 0.0001$) and had higher DAQ alcohol craving scores ($t_{43} = 4.94$, $P < 0.0001$), compared with healthy controls (see Table 1) [Levene's test for equality of variance was not met ($F = 14.95$, $P < 0.0001$) and group comparisons were tested using the Mann–Whitney *U*-test]. LTDH scores and DAQ scores were positively correlated in alcohol-dependent patients ($r = 0.364$, $P = 0.048$) and at trend-level in healthy controls ($r = 0.498$, $P = 0.07$).

The alcohol-approach association measured with the IAT was stronger in alcohol-dependent patients compared with controls ($t_{43} = 2.39$, $P = 0.021$; Table 2; Fig. 1). Note that although the alcohol-dependent group had stronger alcohol-approach (soft drink-avoid) associations than controls, their scores were still negative, suggesting that their alcohol-avoid associations were weaker relative to the controls but still stronger than their alcohol-approach associations (see Fig. 1).

There were no between-group differences for the alcohol approach bias ($t_{43} = 0.26$, $P = 0.98$) or the alcohol attentional bias ($t_{43} = 1.14$, $P = 0.26$).

Correlations

In the group of alcohol-dependent patients, alcohol attentional and approach bias scores correlated positively with each other ($r = 0.460$, $P = 0.011$). This was not the case for the control group ($r = -0.293$, $P = 0.29$) and the correlation was significantly different from the correlation in controls (Fisher's $z = 2.3$, $P = 0.021$; see Fig. 2). Attentional and approach bias scores did not, however, correlate with DAQ craving scores, LTDH or abstinence in either group (all $P > 0.27$).

There was a negative correlation between the alcohol-approach association and alcohol approach bias in alcohol-dependent patients ($r = -0.463$, $P = 0.011$), which, however, did not differ significantly from the correlation of healthy controls ($r = -0.032$, $P = 0.91$; Fisher's $z = -1.35$, $P = 0.18$). Furthermore, the alcohol-approach association correlated with lifetime drinking ($r = 0.460$, $P = 0.01$), and trend-wise with abstinence ($r = -0.318$, $P = 0.087$) in the alcohol-dependent group only.

A correlation matrix with all regression coefficients between these variables in alcohol-dependent patients is provided in Table 3.

For controls, there was a trend-wise effect of alcohol approach bias scores and DAQ craving ($r = 0.446$, $P = 0.096$) and with LTDH and DAQ craving ($r = 0.498$, $P = 0.07$). All other variables were non-significant ($P > 0.24$).

DISCUSSION

This study is the first in comparing three cognitive bias scores in a group of alcohol-dependent patients and controls. These scores measure visuospatial attentional biases, motoric approach biases and alcohol-approach memory associations, which may reflect both shared and distinct processes related to alcohol dependence. The results demonstrate that alcohol-approach associations were the only bias that significantly differed between the alcohol-dependent group and controls. That is, alcohol-dependent patients had relatively stronger associations between alcohol-related and 'approach'-related words, compared with 'avoidance'-related words, in comparison to a healthy control group. Although an earlier report showed that a joystick-based CBM training decreased automatic associations between approach and alcohol (Wiers *et al.*, 2010, 2011; Eberl *et al.*, 2013; Gladwin *et al.*, 2015), the present study is the first in reporting a group comparison on this task between alcohol-dependent patients and controls. Moreover, the relative

Table 2. Task performance in mean reaction times on cognitive bias tasks per group

Cognitive bias	Alcohol-dependent patients ($N = 30$)		Healthy controls ($N = 15$)		*P*-value
	Mean	SD	Mean	SD	
Alcohol-approach association (IAT)	−0.12	0.41	−0.40	0.31	0.021
Alcohol approach bias (AAT)	5.02	102.36	5.83	91.65	0.98
Alcohol attentional bias (DPT)	4.18	17.38	−1.88	15.62	0.26

Abbreviations: AAT, Approach Avoidance Task; DPT, Dot Probe Task; IAT, Implicit Association Test.

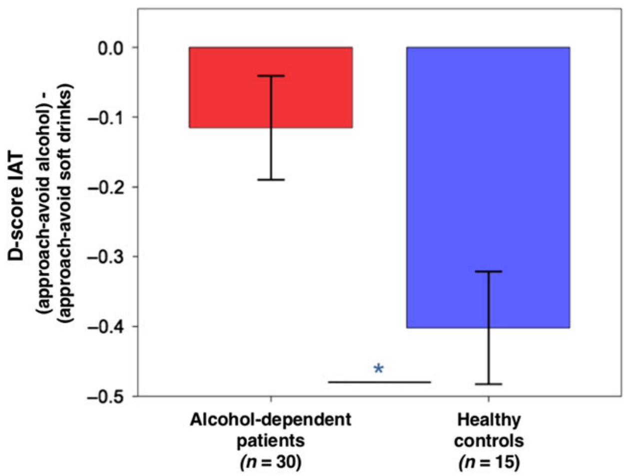

Fig. 1. D-scores of alcohol-approach associations on the IAT, which were stronger in alcohol-dependent patients compared with the control group ($P < 0.05$).

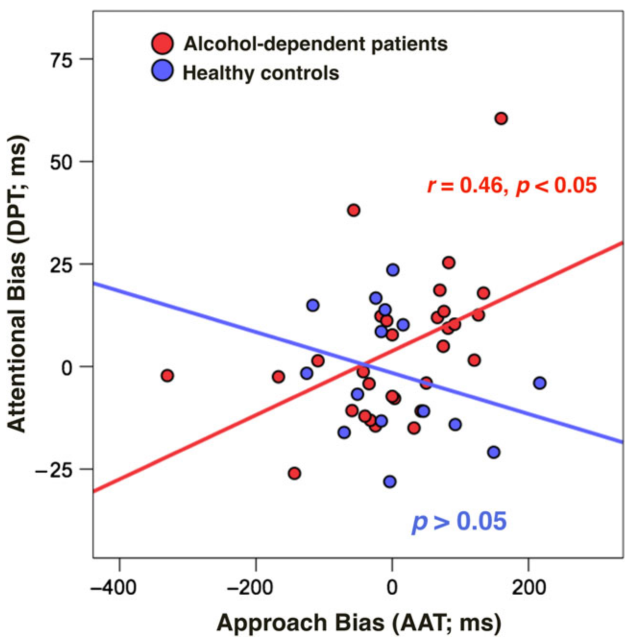

Fig. 2. Regression slopes of the attentional and approach bias in both groups. The alcohol attentional and approach bias correlated positively in the alcohol-dependent patient group ($r = 0.46$, $P < 0.05$), but not in controls ($P > 0.05$). Correlations differed significantly between groups (Fisher's $z = 2.3$, $P < 0.05$).

strength of the alcohol-approach associations was positively associated with lifetime drinking history, and—trend-wise—negatively with duration of abstinence. This suggests that alcohol-approach associations are directly associated with drinking behavior, and may decrease over a period of abstinence. Alternatively, individuals with stronger alcohol-approach associations may be less likely to achieve long periods of abstinence. Longitudinal studies on abstinence are necessary to further study such relationships. The lack of group differences in attentional and approach bias scores was not in line with our hypotheses that patients would show stronger biases than controls. Previous studies generally found stronger biases in patients versus controls (attentional bias: Field *et al.*, 2013; approach bias: Ernst *et al.*, 2014; Wiers *et al.*, 2014). Some inpatients may have had conflicts with drinking given their explicit wish to remain abstinent, which may have diminished group differences. In line with this, Townshend and Duka (2007) and Noel *et al.* (2006) reported slow-process alcohol attentional bias away from alcohol cues in abstinent alcohol-dependent inpatients compared with controls, and inconsistent attentional biases have been reported in heavier drinkers (Gladwin, 2016). Furthermore, Wiers et al. (2013a) found that abstinent smokers had tendencies to avoid smoking cues, whereas active smokers stronger approached these same cues. Therefore, active drinking status may have influenced group differences on cognitive bias tasks. One theoretical interpretation of the findings regarding attentional bias could be that this bias indicates personal relevance, which could be appetitive (approach) in some, but a sign of danger in other patients. These effects could annihilate each other in the patients (Field *et al.*, in press). This conflict may also be represented in our IAT scores: although the AD group had relatively stronger alcohol-approach (soft drink-avoid) associations compared with controls, their alcohol-avoid associations were slightly stronger than alcohol-approach (see Fig. 1). This, however, requires assuming for simplicity that the IAT provides an interpretable zero-point (for discussion, see Greenwald *et al.*, 2006).

In line with our hypotheses and with theoretical models on addiction, the approach and attentional bias were positively associated with each other in the alcohol-dependent patient group. This correlation was also significantly different from the control group. This association is directly in line with incentive salience models of addiction that propose that cognitive biases have a common underlying mechanism (Robinson and Berridge, 2003). However, in contrast to our hypotheses and previous reports, there were no group differences for the approach and attentional bias. Moreover, neither the approach nor the attentional biases revealed positive associations with drinking behavior or craving. The AAT used in this study makes use of an irrelevant feature instruction, in which participants are asked to respond to a feature that is irrelevant to the task; the format rather than content of the stimuli. This feature is thought to make the AAT relatively implicit in both instruction as well as outcome measure, which makes it less likely that participants are aware of the task and hence, more likely to measure more automatic processes. However, a recent study in social drinkers showed that a relevant feature AAT, in which participants are explicitly instructed to approach/avoid cues according to the content of the cue (alcohol/soft drink), was the only predictor for alcohol consumption (Kersbergen *et al.*, 2014). In general, irrelevant feature tasks have a lower reliability than relevant feature tasks (Wiers *et al.*, 2013b). A further factor is that of temporal dynamics of automatic processes. In the current AAT and DPT tasks, there was a constant interval between the biasing stimulus and the stimulus feature requiring a response (simultaneous for the AAT and after 500 ms for the DPT). However, especially for the attentional bias, effects are highly dependent on such timing parameters (Noel *et al.*, 2006; Townshend and Duka, 2007; Vollstadt-Klein *et al.*, 2009), with some evidence suggesting a vigilance avoidance pattern in alcohol-dependence (i.e. attracting attention early in the process and triggering avoidance slightly later in the process). Such effects are as yet understudied for the AAT (Gladwin *et al.*, 2014). Note that temporal factors may differ between groups, e.g. leading to differences in the optimal timing for detecting approach biases. Hence, future research is needed into associations between approach bias assessed

Table 3. Correlation matrix of all variables of interest in alcohol-dependent patients

	Approach bias (AAT)	Attentional bias (DPT)	Craving (DAQ)	LTDH (kg)	Abstinence (days)
Alcohol-approach Association (IAT)	**−0.463*** **	−0.106	0.005	**0.460*** **	**−0.318†**
Alcohol Approach Bias (AAT)	1	**0.460** **	0.210	−0.013	0.092
Alcohol Attentional Bias (DPT)		1	0.096	0.049	0.095
Alcohol craving (DAQ)			1	**0.364***	−0.071
LTDH (kg)				1	

Correlations in bold: ***P = 0.010, **P = 0.011, *P = 0.048, †P = 0.087. Abbreviations: AAT Approach Avoidance Task, DAQ Desire for Alcohol Questionnaire, DPT Dot Probe Task, IAT Implicit Association Test, LTDH Lifetime Drinking History.

on the AAT with a relevant feature instruction, and attentional biases, taking possible time dependencies of each into account.

In contrast to our hypothesis, we found a strong negative association between IAT and AAT scores in alcohol-dependent patients. Both tasks measure automatic processes related to approach, but differ in outcome measure. While the IAT measures associations in long-term memory between words and approach concepts, the AAT measures automatic approaching action tendencies towards alcohol. It may be that the IAT is more explicit about the outcome measure, since it involves the reading and interpretation of words. This may have explained the strong negative association between the two variables. That is, all patients reported an explicit wish to remain abstinent, which may have been captured in the IAT. The IAT may also reflect associations other than personal approach action tendencies, for instance an association between alcohol and approach being salient but undesirable. In line with this, the D-score for the alcohol-approach association was negative rather than positive (although we acknowledge that care must be taken in interpreting IAT scores in terms of their sign). Thus, having a strong automatic action tendency towards alcohol may result in having an association with the intention to avoid alcohol. Such interpretations require further study to be tested, but have been posited previously as a possible explanation for apparent paradoxes involving biases (Wiers *et al.*, 2013b).

A limitation to our study is that all participants were male, which reduces generalization to the general population. We only included male patients to minimize potential confounding factors. That is, gender effects have been reported on reactivity to alcohol cues (Seo *et al.*, 2011) and on clinical effects of CBM (Eberl *et al.*, 2013). An interesting but yet unexplored direction of future studies, however, may be to study gender differences in cognitive biases. Another limitation is that our sample size is relatively small, especially in the control group, which lead to fairly strong correlations (e.g. the correlations of approach bias scores with drinking history and craving were in the 0.4–0.5 range), yet statistically only significant at trend-level. We did not correct for multiple comparisons and hence see our data as exploratory and in need of replication. Lifetime drinking history results were furthermore missing from the healthy control group, all healthy control subjects were social drinkers and had AUDIT scores below 8 (mean AUDIT = 2.9; range 1–7) indicating they were below a problematic drinking threshold. They also did not meet criteria for alcohol abuse or dependence according to DSM-IV. A final limitation was that the use of the same 40 alcohol and 40 neutral pictures for the DPT and AAT may lead to a potential method bias.

In sum, this study compared different cognitive biases for alcohol in alcohol-dependent patients. The results corroborate that different measures of implicit attentional and approach bias are related, but in a more complex way than current theory appears to predict. Moreover, it showed for the first time that alcohol-dependent patients have stronger alcohol-approach associations compared with controls, and that their associations are related to drinking behavior.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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