Craving and Attentional Bias Respond Differently to Alcohol Priming: A Field Study in the Pub

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Abstract

Background: Several experimental laboratory studies have shown that subjective craving for alcohol increases as a result of low-to-moderate levels of alcohol consumption. Less is known about alcohol prime effects on relatively automatic appetitive motivational processes such as attentional bias (AB). Also, it is not known whether the effects from laboratory studies can be generalized to real-life drinking environments, and whether effects change after higher alcohol doses than those that have been administered in lab studies.

Method: In two pubs, we investigated alcohol prime dose effects in self-reported craving and AB, measured by a modified Flicker Paradigm. We included an opportunistic sample of 72 social drinkers who had been drinking various amounts of alcohol.

Results: Self-reported craving was positively predicted by dose of alcohol consumed, from one up to 16 drinks. In contrast, AB was negatively predicted by dose consumed in participants who had been binge drinking.

Conclusion: This field study validates earlier experimental research on alcohol prime effects in a real drinking situation. Further, it demonstrates prime effects up to much higher alcohol doses than in previous lab studies.

Key Words
Alcohol · Prime dose · Craving · Attentional bias · Appetitive motivation

Introduction

Binge drinking increases the risk of alcohol-related problems. Potential problems as a direct result of one binge episode include aggressiveness, sexual risk taking, school or work-related problems, and medical problems [1]. Although social drinkers are aware of these negative consequences, their motivation to drink does not necessarily decrease after a few glasses of alcohol. This continued drinking might partly result from an increased desire or motivation to drink as an acute prime effect of alcohol intake. Alcohol prime effects have been hypothesized to be classical conditioned responses to alcohol cues, instrumentally learned responses to the act of drinking, and/or unlearned motivational responses to appetitive stimuli like alcohol. Additionally, drinking alcohol might activate positive memories of past drinking, which act as motivators to drink [2].
receive a disproportional amount of attention, which potentially leads to increased craving and drinking [5, 6].

Although subjective craving and AB are both related to the motivation to drink alcohol, they do not necessarily react in a similar way to alcohol prime doses [7]. In addition, the evidence for correlations between the two constructs, measured in sober participants, is rather mixed. A number of studies found that craving and AB were correlated (see [8] for an overview), but there have also been several studies reporting no significant correlation [9–13]. In brief, since craving and AB do not appear to be consistently related, they might also react differently to various prime doses.

As for subjective craving or desire for alcohol, prime effects seem to be fairly robust and dose dependent. In most studies, effects after ingestion of different amounts of alcohol are compared to a placebo drink (containing no alcohol). With prime doses ranging from low (0.05–0.3 g alcohol per kg bodyweight) to moderate (0.5–0.6 g/kg) and high (0.8 g/kg), subjective craving has been found to be higher for larger doses at different time intervals up to 1 h after intake [12, 14–18]. In contrast to these findings, two studies found no prime effects on craving [7, 19]. Prime effects on other indicators of the desire to drink have also been reported, for instance on choosing alcohol over money [14] (but not by Kirk and de Wit [20]), drinking more alcohol [15, 21], and wanting more alcohol [20]. Altogether, we expect a positive relationship between craving ratings for alcohol and the amount of alcohol consumed.

The scarce results on AB suggest a different response pattern to various prime doses than the desire for alcohol typically shows. In the only study reporting prime effects after multiple alcohol doses, AB was higher after a low dose (0.3 g/kg) than after a moderate dose (0.6 g/kg) and placebo [7]. A study that compared a placebo to a low alcohol dose replicated these results for the low dose [12]. By monitoring eye movements, the latter study also found a concurrent increase in gaze dwell time and in the percentage of first eye movements towards alcohol related stimuli. A third study found that social drinkers who were primed with half an English unit of alcohol (approximately 4 g of alcohol, a low dose) had higher AB scores for positive alcohol related words than without a sip prime [22]. Based on this evidence we expect a positive relationship between AB scores and amount of alcohol consumed in people that have been drinking low-to-moderate doses, and a negative relationship for higher doses.

It might be questioned to what extent the results from these controlled laboratory experiments can be generalized to real-world drinking settings in which many more uncontrolled factors might influence drinking motivation. Firstly, the interior of common drinking environments differs from the interior of labs. In a meta-analysis, McKay and Schare [23] found that, compared to normal labs, alcohol effects on expectancies and pharmacological reactions were larger in natural environment labs. This was explained by the presence of environmental cues that are also encountered during normal alcohol consumption, and a greater relaxation in participants. Secondly, the amount of alcohol consumed in a real-world drinking setting often exceeds the amount of alcohol in the experimental priming studies. Consequently, knowledge about alcohol prime effects thus far is limited to effects of relatively modest alcohol doses.

The present study investigated alcohol prime effects in a natural drinking environment. Our participants did not ingest standardized amounts of alcohol as in laboratory studies, but had already been drinking various amounts during a normal night out when they were invited to participate. To prevent disrupting participants’ natural drinking behavior, we designed a very brief study procedure and each participant was tested once. Aim of the study was to test the generalizability of prime effects to uncontrolled, real-world drinking settings. This could validate the alcohol prime research thus far, and extend it to higher alcohol doses than have been administered in the lab. We hypothesized that craving ratings would show a positive relationship with reported amounts of consumption. Further, we hypothesized that AB scores would show a positive relationship with amount of consumption up to moderate doses, and a negative relationship from moderate to higher doses.

Methods

Participants

We recruited an opportunistic sample of visitors (58 male, 22 female) of two pubs in the Netherlands. Two participants who indicated to never drink and six participants who had not been drinking in the last hour were excluded from analyses. Ninety percent of participants had taken their last sip from an alcoholic drink less than 20 min ago. Normal alcohol use was on average 15.9 Dutch standard drinking units of 10 g of alcohol per week for males and 9.18 units for females, indicating most participants were social drinkers. Three male participants and one female participant had an outlying high normal drinking pattern, i.e. over 35 units per week. See table 1 for further descriptives. The study received approval from the Ethics Committee of Psychology from Maastricht University.
Stimuli for our AB measure were full-color photographs (fig. 1). For the critical trials, the alcohol-related objects were positioned left from the center of the photographs, and the neutral objects (stationery) right from the center. This composition was reversed for half of the participants. In the practice photograph, there were no alcohol-related objects, nor neutral objects related to the neutral category in the critical trials. The mask consisted of a screen full of Xs. The task was programmed in Inquisit 2.0 (Millisecond Software) and presented on a laptop computer with a 22 × 29 cm screen size. The stimuli, sized 13.5 × 17 cm, were presented centralized on the screen. Viewing distance was approximately 40 cm.

Procedure
Participants were tested on a Thursday, Friday or Saturday between 7 p.m. and midnight. Testing took place in the back of two pubs, where it was relatively quiet. Visitors of the pubs were asked whether they were interested in participating in a brief study on attentional processes and alcohol use. When participants agreed to participate, they gave informed consent and agreed not to drink during the remainder of the procedure. Participants did not receive any compensation for participating. All participants were tested separately, without immediate presence of other participants.

First, participants were asked how many minutes ago they had taken their last sip of alcohol, and how many drinks they had consumed in total (‘drinks today’). Then, they indicated their normal alcohol use in units per week (‘normal use’). Before measuring their breath alcohol concentration (BrAC), participants had to rinse their mouth thoroughly with water to remove any remaining alcohol. BrAC was measured with a Lion Alcometer SD-400. After the BrAC measurement participants rated their urge to ‘drink alcohol right now’ (craving) on a 100-mm visual analogue scale [24], ranging from ‘no urge at all’ to ‘an almost irresistible urge’. Lastly, AB was measured with a Flicker Paradigm. After the Flicker task, participants were debriefed and thanked.

Attentional Bias Measure
AB was measured with a modified Flicker Paradigm to induce change blindness [25–29]. An advantage of this task is that it takes very little time to administer and stimuli are naturalistic. The
Flicker paradigm is an AB task that measures spatial attention, just as the visual probe task. Alcohol prime effects have been found in visual probe task, both on maintenance of attention as well as on early detection [7–12], measured with reaction times and eye movements [12]. Although early detection and maintenance of attention cannot be differentiated in results of the Flicker paradigm, findings are likely caused by one of these processes or both. Therefore, we assumed that any prime effects that occur would be detected with this task.

In our version of the Flicker task, participants were instructed to detect a changing object within a picture as fast as possible. A trial of the task started with an originating stimulus picture for 250 ms, then a mask for 80 ms, followed by a changed stimulus picture for 250 ms, than the mask for 80 ms again. This loop was repeated until the participant pressed a response button to indicate that he or she had detected the difference between the two pictures. Participants then indicated the position on the screen where they had spotted the change and described the object that they had seen changing. Participants performed three Flicker trials. The first was a practice trial, with a change in the center of the picture to avoid creating expectancies about the change location in the later trials. In the subsequent alcohol trial, an alcohol related object was turned in the changed stimulus picture. In the neutral trial, a neutral object was turned in the changed stimulus picture. For each individual participant, the originating stimulus picture was identical in the alcohol and neutral trial. Participants were randomly assigned to the version of the task with either alcohol left or right from the centre.

AB was calculated by subtracting the response latency in the alcohol trial from the response latency in the neutral trial. We expected that, through practice, participants would be faster in the second than the first critical trial. Therefore, the order of trials was not counterbalanced between subjects. Every participant first performed the alcohol change trial and then the neutral change trial. As a consequence, the absolute value for the AB score might be an underestimation of the ‘real’ AB score. In this study, however, the absolute value was irrelevant, and the neutral trial has been used purely to control for interindividual differences in change detection ability.

### Data Analyses
Prime effects were calculated in hierarchical regression analyses, separately for craving and AB. As predictors in these analyses, we included gender and usual drinking behavior (‘normal use’) as a control factor in the first step, and added the number of drinks that participants had drunk at the testing day (‘drinks today’), the elapsed time (in minutes) since the last sip, and BrAC in the second step. Cook’s distance was calculated to identify and subsequently remove observations with disproportional large residuals or a disproportional large influence on the outcome of fitting the regression models. For all regression analyses, factors with p values over 0.30 were excluded and not reported.

### Results

#### Craving
One influential case was removed based on its Cook’s distance. ‘Drinks today’ significantly predicted urge, confirming our hypothesis that craving increases dose-dependently up to considerably high alcohol doses. The positive effect of ‘normal use’ on craving indicates that heavier drinkers experience more craving than lighter drinkers. The results are shown in table 2.

#### Attentional Bias

**Preparation of Data.** We expected a different pattern in AB for participants who had been drinking low doses of alcohol than for those who had been drinking moderate-to-high doses. Therefore, the hierarchical regression analysis was done separately for participants who had binged and participants who had not binged at the time of testing. A binge was defined as having drunk more than four units (more than three for females) [1]. For each participant, AB was calculated by subtracting the response latency in the alcohol trial from the response latency in the neutral trial. Therefore, only participants who reported the correct position and object of change in both critical trials of the Flicker task were included in the analyses, leaving 24 bingers and 24 nonbingers for the analyses. To check whether these participants differed from the excluded participants on any of the predictors and age, we performed nonparametric Mann-Whitney tests separately for the binge and non binge groups. None of these comparisons was significant (all p > 0.35).

**Results of Attentional Bias.** Three influential cases (Cook’s distance) were removed from analysis in the nonbinge group. Contrary to expectations, table 3 shows that ‘drinks today’ did not predict AB in the group of nonbingers. As hypothesized, in the group of bingers, AB was negatively predicted by ‘drinks today’, indicating that AB decreased with increased consumption levels (table 4). In

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**Table 2. Summary of hierarchical regression analysis predicting the urge to drink alcohol**

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>β</th>
<th>SE β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>‘Normal use’</td>
<td>0.48</td>
<td>0.11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2</td>
<td>‘Normal use’</td>
<td>0.41</td>
<td>0.10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>‘Drinks today’</td>
<td>0.24</td>
<td>0.10</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>Time elapsed since last sip</td>
<td>-0.19</td>
<td>0.10</td>
<td>0.064</td>
</tr>
</tbody>
</table>

Initially, normal use, gender, drinks today, time elapsed since last sip and BrAC were included as predictors. However, predictors with p values >0.30 were excluded and are not reported here.

n = 71; R² = 0.21 for step 1, R² change = 0.14 for step 2; final model: R² = 0.35, p < 0.001.
both groups, AB was positively predicted by ‘normal use’, indicating that AB was higher for participants with heavy normal use than for those with light normal use. A possible confounder in the assessment of AB in the binge group is a slowdown in reaction time caused by alcohol [30]. However, since AB is a difference score, the effect of variable reaction times between participants is controlled. Moreover, there was no correlation between ‘drinks today’ and reaction time in the practice trial (as an indication for reaction time performance), $\rho = 0.07$, $p = 0.73$.

**Correlations**

Urge and AB were not significantly correlated in the group of nonbingers ($r = 0.29$, $p = 0.19$) nor in the group of bingers ($r = 0.03$, $p = 0.91$). ‘Drinks today’, ‘normal use’ and BrAC were positively skewed, thus we calculated non-parametric Spearman correlation coefficients. ‘Drinks today’ and ‘normal use’ showed a positive correlation ($\rho = 0.32$, $p < 0.01$), as well as ‘drinks today’ and BrAC ($\rho = 0.64$, $p < 0.001$). Consistent with the correlation between ‘drinks today’ and urge, BrAC and urge were positively correlated ($\rho = 0.30$, $p = 0.01$). However, BrAC and AB were correlated neither in the nonbingers ($\rho = 0.07$, $p = 0.75$) nor in the bingers ($\rho = -0.13$, $p = 0.55$).

**Discussion**

In the present study, we have extended the empirical evidence on alcohol prime effects to real-life settings, thereby validating results from earlier laboratory studies. Furthermore, alcohol prime effects could be investigated up to much higher alcohol dose levels than in earlier laboratory studies, where the percentage of alcohol in a prime dose is limited by ethical standards. The amount of alcohol in our study ranged up to 16 units. To compare, 0.8 g/kg has been the maximum amount in laboratory studies, approximating 6 units for a person weighing 75 kg. As expected, craving ratings increased in relation to the dose of alcohol consumed. In addition, AB for alcohol related cues decreased in relation to the amount of alcohol consumed within the subgroup of people who had been drinking in excess of a binge. Contrary to expectations however, we did not find a dose-dependent association with AB scores in the subgroup of participants who had not binged at the time of testing.

The positive association between craving ratings and the amount of alcohol consumed is consistent with a large number of laboratory studies on prime effects (see introduction). The questionnaire that was used to measure craving was a single item visual analogue scale asking for the urge to drink. There are, however, more dimensions to craving [31]. To find out which craving dimensions are affected by alcohol priming, future studies should include multiple item questionnaires such as the Alcohol Urge Questionnaire [32], Desires for Alcohol Questionnaire [33], or Approach and Avoidance of Alcohol Questionnaire [34].

We did not find a significant relation between dose and AB scores in the subgroup of nonbingers, i.e. participants who had been drinking less than a binge at the time of testing. This is inconsistent with findings in earlier studies [7, 12]. A difference is that in those studies an increase in AB was found for a 0.3 g/kg dose of alcohol. In the present study, we investigated a relation between AB and con-
sumption up to a higher alcohol dose, i.e. four units for females, five units for males. Thus, we cannot rule out the possibility that there was an increase in AB in the first few drinks, but soon after a decrease in this group of non-bingers. However, since there were only a few participants who had been drinking one or two drinks, we could not test the increase from one to two drinks.

The decrease in AB scores after a binge is consistent with Duka and Townshend [7], who found lower AB after a moderate (0.6 g/kg) dose than after a low dose (0.3 g/kg) of alcohol. They explained the decrease in AB following a moderate dose of alcohol by a satiation effect. Thus, the motivation to drink would decline after a few drinks. This explanation, however, seems to contradict the available evidence of increased desire for alcohol in all other studies mentioned before, including the present one. Social drinkers do not seem to feel satiated after a high alcohol dose (0.8 g/kg) [20, 35]. We propose two possible explanations for the difference in prime effects between AB and craving, which are not mutually exclusive.

Our first explanation is that subjective, conscious feelings of craving (as measured by questionnaires) might be affected by different factors than relatively automatic reactions, such as AB. Research has shown that stimulant and sedative effects can occur simultaneously after increased ingestion of alcohol [36]. Possibly, AB is affected by a basic affective reaction to which sedation contributes increasingly more after more alcohol, leading to a decrease in the incentive value of alcohol cues. Craving, in contrast, might be affected by more conscious processes that are biased by the positive, social context in the pub and even by asking for the motivation to drink, not for the motivation not to drink. As a result, positive arousing effects might be more prominent than negative sedative effects, resulting in increased desire for alcohol. To test this idea, future studies should include measures of the motivation not to drink [34] and measures of subjective intoxication effects [36, 37].

A second possible explanation concerns the difference between responses to alcohol cues on the one hand, and the internal stimulus properties of alcohol and the act of drinking on the other. An increased salience of drug-related cues (as reflected by AB) is functional in drug seeking [38], since it increases the chance of detecting the drug. When one desires an unavailable drug, drug-related cues may become sensitized [39] and attract more attention [40, 41], which facilitates drug seeking. After some drinks, subjective intoxication effects increase and it becomes evident that alcohol is easily available. Then, the saliency of alcohol cues loses its function and decreases. Concurrently, the incentive value of alcohol and reinforcing effects of drinking may still increase. Thus, alcohol cues become less determining in further alcohol use while consuming alcohol still determines the motivation to drink. In terms of the explanations listed by de Wit [2]: the classical conditioned effects decline while instrumental learning effects and unlearned incentive motivation increase.

Compared to experimental studies, this study did not randomly assign participants to different conditions. As a consequence, various trait and state variables might have been of influence on the relationships found in this study. To control for trait variables that predispose to heavier drinking we included normal drinking behavior in the regression analyses. Nonspecific state variables were not controlled for. However, as all nonexperimental studies, this study did not aim to demonstrate a causal relationship between cognitive variables and drinking. It merely showed a relationship between drinking behavior and AB, and between drinking behavior and craving. There are several limitations as a consequence of not using an experimental design. However, a unique advantage of our method was that we could measure much higher alcohol doses than in experiments.

Another limitation of this study was the high number of participants that needed to be excluded from AB analyses because of errors they made in the Flicker task. These participants did not differ on any of the independent variables, including drinking behavior at the day of testing, but it did reduce statistical power. Intoxication might account for these errors. In a next study, stimuli could be simplified to prevent errors.

Naturalistic drinking differs from that in lab studies in that BrAC might fluctuate during one occasion, depending on the pace of drinking and various percentages of alcohol that different types of beverages contain. Subjective intoxication effects have been found to differ between rising and falling BrAC [36]. However, we do not know the additional effect of previous BrAC fluctuation to momentary rising or falling. Future studies should address the effect of BrAC fluctuation on appetitive motivation for alcohol. Notwithstanding, we believe that our participants had a rising BrAC at the time of testing as indicated by two observations: 90% of our sample had taken their last sip less than 20 min before testing. And BrAC correlated significantly positive with the number of drinks that had been drunk at the time of testing.

With this study, we have extended knowledge from laboratory studies on alcohol priming by measuring effects up to considerably higher alcohol ingestion levels.
and in a real-life setting. Further, we were able to test the relationship between a wide range of alcohol ingestion levels and prime effects, instead of measuring differences on a few standardized amounts of alcohol as in laboratory studies. We showed that different aspects of appetitive motivation show a different response pattern to increased alcohol consumption. While the incentive saliency of alcohol cues decreases after a few drinks, the desire to drink keeps on increasing up to considerably high levels of intoxication. This validates earlier experimental laboratory studies and offers insights into the motivation to drink alcohol in real-life settings.

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