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Conflicting rewards: effects of task goals on attention for alcohol cues

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ABSTRACT

Research has shown that temporary task goals capture more attention than negative, threatening cues, even in anxious individuals. In the current study, we investigated whether temporary task goals would also capture more attention than alcohol-related cues. In Experiment 1, 59 hazardous drinkers performed both a modified dot-probe and a flanker task in which temporary goal- and alcohol-relevant stimuli were presented together. Results of the dot-probe task confirmed an attentional bias towards goal-relevant stimuli in the presence of alcohol cues. This effect was absent in a modified flanker task, although there was a general slowing when the targets appeared on top of goal-relevant stimuli, suggesting that goal-related backgrounds captured more attention than alcohol backgrounds. In Experiment 2, we replicated the dot-probe procedure in 29 hazardous drinkers who had been exposed to a prime dose of alcohol prior to performing the task. Our findings indicate that temporary goal stimuli are more salient than alcohol cues, which might lead the way to novel clinical applications.

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Attentional bias; goals; alcohol

All stimuli present in the environment of an individual attract attention and compete for priority in the attentional system. A selective attention mechanism helps us to attend to and process the most relevant stimuli, depending upon the context in which these stimuli are encountered (Desimone & Duncan, 1995). From this perspective, goals are considered to be an important moderator of attention, and information irrelevant to these goals is filtered from the attention span (Corbetta & Shulman, 2002; Munakata et al., 2011). For example, Vogt, De Houwer, Moors, Van Damme, and Crombez (2010) found the goal to react to a specific stimulus in order to win points in a secondary task led to a shift of attention towards goal-related cues in an attention task (see also Vogt, De Houwer, & Moors, 2011).

In a follow-up study, Vogt, De Houwer, Crombez, and Van Damme (2013) examined how attention is prioritised when temporary goal-related stimuli are presented in comparison with emotionally salient, threatening stimuli. They employed a standard dot-probe paradigm, in which participants are required to respond to an emotionally neutral target appearing on one of two previously cued locations. They used combinations of threat-neutral, goal-threat, and goal-neutral picture pairs as cues. Attentional bias for each category of stimuli versus the comparison category was inferred from differences in reaction times between trials where the target appeared on the location of cues belonging to that category versus reaction times on trials where the target appeared on the location of comparison category cues. Embedded within their dot probe task, they presented trials of a goal-inducer task. On these trials, a single picture appeared in the centre of the screen and participants were required to press a button whenever a goal picture (e.g. an emotionally neutral picture of a type of transport) appeared, leading participants to accrue points. They found a large attentional bias (AB) for goal-relevant stimuli versus threat stimuli (Experiment 1), even in an anxious sample (Experiment 2), and even with cues signalling imminent

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threat (Experiment 3). These results indicate that temporary task-goals draw attention towards goal-relevant stimuli as they seem to exert greater motivational influence than threatening stimuli.

One remaining question concerns the generalizability of these findings. Vogt et al. (2013) compared positively reinforced goal pictures with negative (threatening) pictures. As such, there was a valence discrepancy between these two categories of pictures. It is thus unclear whether goal-relevant pictures would also attract more attention than comparison pictures that also signal a reward. In the present study, we investigated whether temporary goals induce a similar preferential deployment of attention when competing for attention with other reward-related cues. In a sample of hazardously drinking students, we induced a goal using the intermixed dot probe/goal task of Vogt et al. (2013), and assessed attention for alcohol, soda, and goal cues. In line with the results of Vogt et al. (2013), we expected that goal-relevant pictures would attract more attention than both alcohol and soda pictures, resulting in an AB for goal-relevant stimuli. As such, we expected larger, positive AB scores on the goal-alcohol and goal-soda comparisons.

As another extension to the study of Vogt et al. (2013), we induced the goal either actively (as in Vogt et al., 2013) or passively (participants simply registered goal-related pictures in the goal task and were awarded points). The passive goal induction allowed us to control for the influence of active responses to the goal pictures. We anticipated larger AB scores for goal pictures when goals were formed and maintained by active responses as opposed to passive responses. Finally, we embedded the same goal task in another task assessing AB, a modified flanker task (Nikolaou, Field, Critchley, & Duka, 2013). In this paradigm, participants are required to respond to the direction of the middle arrow in a row of five congruent or incongruent arrows (classic Flanker), superimposed on task-irrelevant alcohol or soda pictures. Previous research found stronger distraction by alcohol background pictures (Nikolaou, Field, Critchley, et al., 2013; Nikolaou, Field, & Duka, 2013). In our adaptation of this task, we presented the arrows superimposed on a goal-, alcohol-, or soda-related background. We hypothesised that the congruency effect (difference in reaction time between congruent and incongruent arrow configurations) would be largest for goal-related backgrounds compared to the other backgrounds, with more pronounced effects in the active compared to the passive goal condition.

Experiment 1

Method

Participants

Sixty participants (41 females, $M_{age} = 22.5$ years, $SD = 3.03$) participated in the study. Participants were recruited through a screening procedure using the Alcohol Use Disorder Identification Test (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). Participants were invited only if they scored 8 or higher on the questionnaire ($M_{AUDIT} = 12.25$, $SD = 3.89$, 8–25), a score which has been suggested as a cut-off for hazardous drinking (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). Further, participants were accepted for the study only if they were 18 years or older, had no history of health problems or psychiatric disorders, were not pregnant, and had not consumed any alcohol or drugs within 6 hours of performing the study. All participants provided informed consent before the study, and were awarded either course credits or monetary compensation for their time. The sample size for the study was estimated using G-Power (Faul, Erdfelder, Lang, & Buchner, 2007), prior to data collection, based on a power of .80, an alpha of .05, an expected medium sized ($f = 0.25$) within-between interaction, and the unknown correlation among repeated measures set at 0.

Materials

The experiment was programmed using Inquisit 5.0 (Millisecond Software), and was implemented on a Dell Optiplex 9010 desktop computer. All stimuli were presented on a black background.

All alcohol[1] and soda[2] pictures were taken from the Amsterdam Beverage Picture Set (Pronk, Van Deursen, Beraha, Larsen, & Wiers, 2015). Alcohol pictures were selected based upon high scores for valence ($M = 1.56$, $SD = 0.16$), and urge to drink ($M = 1.75$, $SD = .14$). Soda pictures were also selected based upon high scores for valence ($M = 2.54$, $SD = 0.50$), and urge to drink ($M = 2.31$, $SD = 0.62$). A neutral category, consisting of office supplies/stationery (e.g. pen, pencil, stapler), was used as the temporary goal category; pictures for this category were selected from the internet with each picture depicting a single object on a white background. Two sets of 15

different pictures (500 × 500pixels) were used; containing five pictures each of alcohol, soda, and temporary goals. Both the dot probe/goal and flanker/goal tasks used distinct picture sets. An additional five neutral filler images depicting random objects (e.g. coffee mug, ipod) were selected from the internet and used solely in goal trials. During the practice trials, random filler pictures obtained from the internet were used, and no pictures related to main experimental trials were presented.

Alcohol use disorder identification test

The AUDIT was used to identify and select only hazardous drinkers (Saunders et al., 1993). The AUDIT has a test-retest reliability ranging between .80 and .88, and an internal consistency of .94 (De Meneses-Gaya, Zuardi, Loureiro, & Crippa, 2009). Cronbach's alpha in our sample was .51.

Dot probe/goal task

Each trial in the dot probe/goal task began with a white fixation cross in the centre of the black screen, along with two white squares (10.5 × 10.5 cm) to the left and right of the fixation point (see Figure 1). After 500 ms, the white squares were replaced by two pictures (goal + alcohol, goal + soda, alcohol + soda) for 350 ms. Then, the pictures were masked by the white squares for 20 ms, followed by a probe (black square; 0.5 × 0.5 cm) in either one of the white squares. Participants were required to press the A-key if the probe appeared in the left square and the L-key if the probe appeared in the right square, and they were asked to do so as fast and as accurately as possible. Trials ended if a response was registered or after a 1500 ms timeout. Depending on the combination of cue pictures (goal + alcohol, alcohol + soda, goal + soda) and the probe location, there were a total of six trial types. Participants performed a total of 240 trials of dot probe, and the six trial types were presented 40 times each in a random order.[3]

Each dot probe trial was followed by a goal trial. These trials began with a white fixation cross (5 mm high) in the centre of the black screen. After 500 ms, a single goal or non-goal (alcohol, soda, filler) picture appeared in the centre of the screen for 250 ms. The picture was replaced by a black screen for 10 ms, immediately followed by a red question mark (8 mm high) which remained on screen until response or time out (2000 ms). Participants had to respond to the goal-relevant stimulus by pressing spacebar (active group) or registering the picture (passive group), i.e. wait for trial to time out. Ten points were awarded for pressing the spacebar for goal pictures within the response window (active group), and whenever the goal picture appeared on the screen during the goal task (passive group). No points were awarded when a non-goal picture appeared on the screen, and incorrect responses were followed by error feedback. To keep motivation high, participants were encouraged to accrue a total of 1400 points by the end of the task. Participants performed a total of

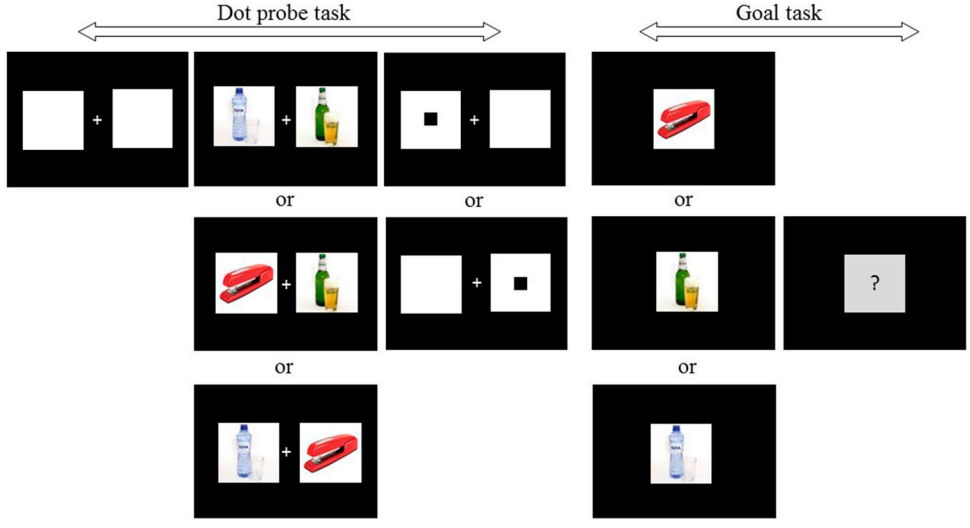

Figure 1. Depiction of the trial course of dot probe and goal tasks in the dot probe/goal task.

240 trials of the goal task, and 60 pictures of each category were presented randomly.

Prior to the actual task, participants completed a short practice phase, consisting of three blocks. A first practice block consisted of 10 dot probe trials only, the second practice block consisted of 10 goal trials only, and the third practice block consisted of 10 dot probe trials interspersed with 10 goal trials.

Flanker/goal task

Each trial in the flanker/goal task began with a white square (10.5 × 10.5 cm) in the centre of the screen. After 100 ms, a black fixation cross (5 mm high) would appear in the centre of the square. Both the white square and fixation cross were replaced after 500 ms with a picture (goal, alcohol, or soda) in the centre of the screen. Another 10 ms later, a row of five arrows was superimposed on the centre of the screen (each arrow 5 mm high), with the picture in the background still visible. The row of arrows consisted of a central target arrow flanked by two arrows on either side, pointing in either the same direction as target arrow (congruent; >>>) or in the opposite direction (incongruent; <>>) (see Figure 2). Participants responded to the direction of the target arrow by pressing the A-key if the arrow pointed left or the L-key if the arrow pointed right. A trial ended when a response was registered or when a response deadline of 1500 ms had passed. Participants performed 240 trials of the flanker task. Each flanker trial was followed by a goal trial, and the flanker trials were presented in random order.

A goal trial began with the words, "GOAL TASK!", announcing the task in order to differentiate it from flanker trials, since both had a single image on the screen. After 500 ms, a picture (goal, alcohol, soda, or filler) appeared on the screen for 250 ms. The picture was replaced by a black screen for 10 ms, followed by a red question mark (8 mm high) which remained on screen until a response was registered or until the trial timed out (2000 ms). The response and feedback procedure remained the same as goal trials in the dot probe/goal task, including the distinction between active and passive groups. Participants performed 240 trials of the goal task, and 60 pictures of each category were presented in a random order.[4]

The actual flanker/goal task was also preceded by a practice phase consisting of 2 blocks; with the first practice block consisting of 10 flanker trials only, and the second practice block consisting of 10 flanker trials combined with 10 goal trials.

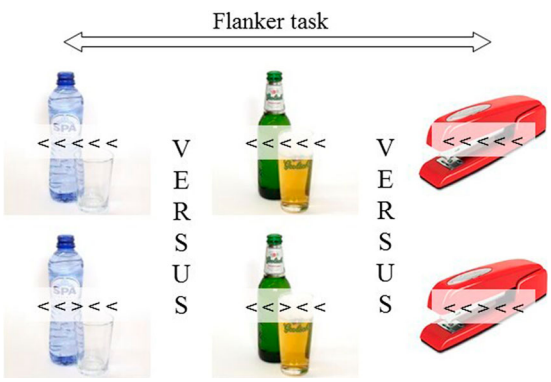

Figure 2. Depiction of different trial types of the flanker task in the flanker/goal task.

Procedure

The study was approved by the Ethics Review Board at the University of Amsterdam (ref. number 2016-DP-6469). Upon arrival in the lab, participants completed the AUDIT questionnaire, based upon which they were invited to take part in the study. Then, participants were randomly allocated to the active or the passive response group, and they were informed about the nature of the goal stimuli (i.e. office supplies) and the tasks at hand. For the main experiment, participants performed two tasks: the dot probe/goal task and the flanker/goal task in this fixed order. The participants were seated at a viewing distance of about 60 cm from the screen. Upon completion of both the tasks, participants were debriefed and rewarded for their participation.

Results

Dot probe task

Performance on the goal task yielded few errors (98% mean accuracy in active goal group). Trials exceeding the response deadline (0.67%) were removed. One participant scored poorly on the dot probe task (participant's score = 62.90%, overall *M* accuracy = 97.55%, *SD* = 4.89), and we set all dot probe data of this participant to missing. Next, we removed incorrect trials on the dot probe (1.87%), and trials with RTs deviating more than 3 *SDs* from the group mean (*M* = 368.09, *SD* = 127.48, cut-off = 750.53, 2.11% removed) as well as trials with RTs deviating more than 3 *SDs* from each individual's mean (1.94% removed). Based on the remaining data, we calculated

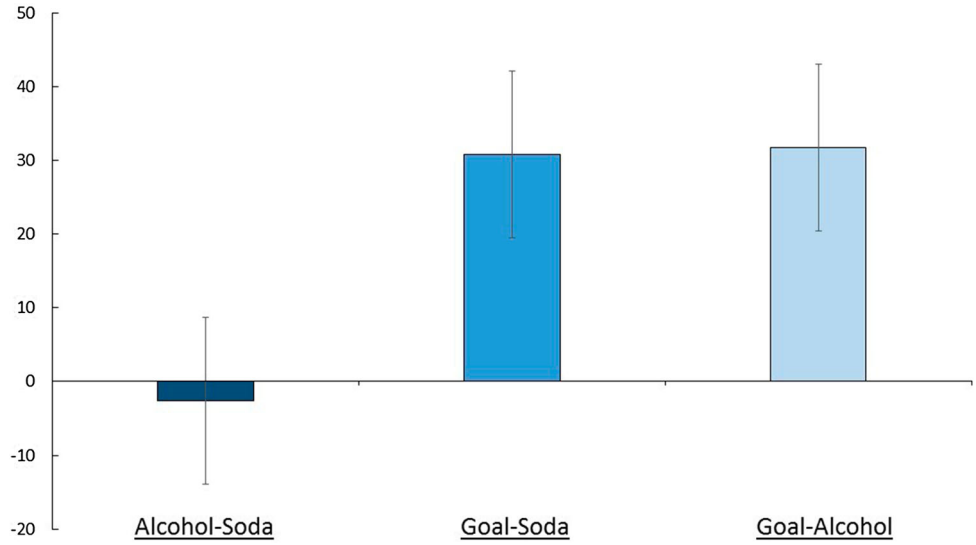

Figure 4. Mean AB scores in Experiment 2 according to trial type. AB scores were calculated using the same procedure described in Figure 3.

AB scores by subtracting the mean RT of congruent trials from the mean RT of incongruent trials (Vogt et al., 2013), separately for each picture combination. For goal-soda and goal-alcohol trials, we calculated AB scores with positive scores indicating an AB towards goals, while for the alcohol-soda trials, we calculated AB scores with positive scores indicating an AB for alcohol cues. Using different outlier detection and removal criteria, such as the absolute deviation from the median (Leys, Ley, Klein, Bernard, & Licata, 2013), did not affect the pattern of results. We also calculated split-half reliability scores for each of the three attentional bias scores: Goal-alcohol $r = .52$, $p < .001$, goal-soda $r = .50$, $p < .001$, and alcohol-soda $r = .08$, $p = .55$.

To test for differences in the dot probe AB scores, a 2 (Goal Group: active vs. passive) × 3 (Trial Type: goal + alcohol, goal + soda, alcohol + soda) mixed measures ANOVA was performed with Goal Group as

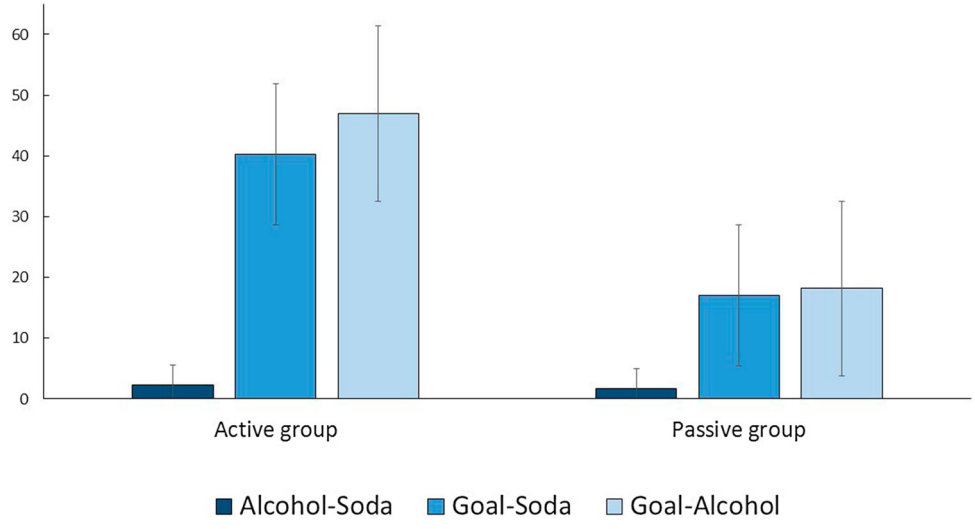

Figure 3. Mean AB scores in Experiment 1 for the two goal group conditions of dot probe task according to trial type. For the Alcohol-Soda comparison, mean RTs on trials where the target appeared on the alcohol location were subtracted from mean RTs on trials where the target appeared on the soda location. For the Goal-Alcohol and Goal-Soda trials, mean RTs on trials where the target appeared on the goal location were subtracted from mean RTs on trials where the target appeared on the alcohol or soda location.

a between-subjects factor and Trial Type as a within-subjects factor. We found significant main effects of Trial Type, $F(2, 56) = 29.39$, $p < .001$, and Goal Group, $F(1, 57) = 20.27$, $p < .001$. Most importantly, these main effects were qualified by the significant interaction, $F(2, 56) = 5.85$, $p < .01$, $f = 0.46$ (see Figure 3).

Within-group comparisons revealed similar effects in both groups, with AB for goals in both goal-alcohol and goal-soda trials larger than AB for alcohol in alcohol-soda trials, all Fs > 7.15, all ps < .05. The difference in AB for goals between goal-alcohol and goal-soda trials was not significant in either group, both Fs < 2.95, both ps > .09. In sum, both groups showed a similar overall pattern of attentional preference for goal-relevant stimuli over both alcohol and soda stimuli, although the effects were more pronounced in the active compared to the passive goal group.

We also conducted a 2 (Goal Group) × 3 (Trial Type) Bayesian mixed measures ANOVA. We used BF_{10}, which is the probability of the alternative hypothesis relative to the null hypothesis.[5] We found very strong to decisive evidence in favour of all the main effect models as well as the interaction model relative to the null model (all BFs > 98).[6] Comparing the interaction model with the main effects model, we found substantial evidence in favour of the interaction model (BF = 98.042). Following up on the interaction model, we ran Bayesian ANOVAs on the attentional bias scores of each of the three trial types separately, with Goal Group as a fixed factor. These analyses provided substantial evidence against group differences on the alcohol-soda bias scores (BF = 0.266), and decisive evidence for group differences on the goal-soda and goal-alcohol bias scores (both BFs > 100). Finally comparing the three attentional bias scores in each group against zero (= no bias), we found substantial evidence against attentional bias on the alcohol-soda trials (BFs in both groups < 0.23), while in both groups, there was decisive evidence for an attentional bias for goals in both the goal-alcohol and goal-soda trials (all BFs > 100).

Flanker task

Performance on the goal task yielded few errors (98% mean accuracy in active goal group). One participant performed at chance level on the flanker task (participant score = 50% correct, overall M accuracy = 92.90% correct, $SD = 7.44$), so we set all flanker data of this participant to missing. As in the dot probe data, we removed incorrect trials (6.38%), RTs deviating more than 3SDs from the group mean ($M = 545.85$, $SD = 176.41$, cut-off = 1075.08, 1.99%), and trials deviating more than 3SDs from each individual's mean (1.13%). Based on the remaining data, we calculated congruency effects by subtracting the mean RT of congruent trials from incongruent trials (Nikolaou, Field, & Duka, 2013), separately for each of the background pictures. The larger these scores, the more attention was captured by the background stimuli. Additionally, we calculated interference effect scores by averaging RTs for each of the backgrounds, irrespective of arrow congruency (e.g. see Van Bockstaele, Koster, Verschuere, Crombez, & De Houwer, 2012). Like the flanker effect, larger interference effects are thought to reflect more attention for the background stimuli. Using different outlier detection and removal criteria, such as the absolute deviation from the median (Leys et al., 2013), did not affect the pattern of results.

To assess differences in the flanker AB scores, a 2 (Goal Group) × 3 (Background: soda, alcohol, goal) mixed measures ANOVA was performed with Goal Group as a between-subjects factor, and Background as a within-subjects factor. No effects reached statistical significance, all Fs < 1. As such, analysing the scores in a similar vein as Nikolaou, Field, and Duka (2013), the results of the flanker task failed to replicate our findings from the dot probe task. However, based on the interference scores (Van Bockstaele et al., 2012), we found no significant interaction nor a main effect of Goal Group, both Fs < 1, but, importantly, a significant main effect of Background, $F(2, 56) = 8.49$, $p < .005$, $f = 0.55$. Follow-up comparisons showed that the interference effect was larger with goal backgrounds compared to both alcohol and soda backgrounds, $F(1, 58) = 13.60$, $p < .001$, and $F(1, 58) = 16.54$, $p < .001$, respectively, and there was no difference between alcohol and soda backgrounds, $F < 1$. These interference results thus dovetail with the results of the dot probe task, suggesting that goal-relevant backgrounds captured more attention and interfered more with the task execution than both alcohol- and soda-backgrounds.

Similar to the dot probe task analysis, we conducted Bayesian mixed measures ANOVAs to reaffirm the above results. For the congruency effects, we found anecdotal to decisive evidence favouring the null model over all the main effects models as well as the interaction model, all BFs between 0.003 and 0.414. For the interference effects, we found decisive evidence in favour of the

model with the main effect of Background (BF = 907.558) relative to the null model, but the interaction model was not favoured over this main effect model (BF = 0.122). Comparing the interference scores of the different backgrounds, irrespective of groups, we found very strong to decisive evidence for differences between goal backgrounds and both alcohol and soda backgrounds (BFs = 50.414 and 154.928, respectively), and substantial evidence against a difference between alcohol and soda backgrounds (BF = 0.144).

Discussion

In this first experiment, we investigated whether positively reinforced temporary goal stimuli attracted more attention than alcohol and soda cues in hazardous drinkers. The results from the dot probe task confirmed our hypothesis, showing that hazardous drinkers attend more to goal-related cues than to alcohol and soda cues. This effect was present in both the active and the passive group, but it was stronger in the active group, suggesting that goal-pursuit that requires action makes the associated stimulus more salient. These results were not replicated in a conventional analysis of the flanker data, yet a supplementary analysis of the interference effect indicated more interference by goal-relevant backgrounds. As the interference effect reflects the inability to disengage attention from task-irrelevant stimuli (Fox, Russo, Bowles, & Dutton, 2001), these results were in line with our findings in the dot probe task.

Despite the indication of stronger attentional preference for goal-related stimuli in our study, we tested attention for alcohol by merely presenting alcohol pictures. It is possible that the mere visual presentation of alcohol cues was not as motivationally salient and rewarding as the physical presence of alcohol would be. Previous research has shown that participants who were given a prime dose of alcohol attended more to alcohol-related cues (Duka & Townshend, 2004; Schoenmakers, Wiers, & Field, 2008). Therefore, in Experiment 2, we also gave participants a low dose of alcohol, prior to completing the dot probe task. As such, we attempted to further increase the motivational salience and reward value of alcohol cues. If temporary goals still attract more attention than alcohol cues in a context where alcohol is readily available, it would further attest to the superior motivational valence of goals in the attentional system. We asked hazardously drinking participants to consume a small amount of alcoholic beverages and then presented them with the same dot probe task as in Experiment 1. We expected to replicate our results of Experiment 1 in goal-alcohol and goal-soda trials, demonstrating that goals attract more attention than both other categories of stimuli. Given the results of Experiment 1, we decided to shorten Experiment 2 and we retained only the dot probe task and the active goal induction.

Experiment 2

Method

Participants

Thirty participants (22 females, M_{age} = 23.4 years, SD = 3.2, 18–30), meeting the same inclusion criteria as in Experiment 1 (M_{AUDIT} = 11.77, SD = 4.75, 8–25), were included in the study. All participants provided informed consent before the study, and were awarded either course credit or monetary compensation for their time. The sample size was estimated using the same general procedure as for Experiment 1, but based on the results of Experiment 1, we expected a large rather than a medium sized within-subjects effect.

Materials

The materials presented in Experiment 2 were the same as the materials presented for the dot probe task in Experiment 1, with the exception of pictures used and the sip-prime procedure. Cronbach's alpha for the AUDIT in our sample was .71.

Pictures

We used the same goal and filler pictures as in Experiment 1. For alcohol and soda pictures, we used one of the subsets that we used in Experiment 1.

Alcohol priming

An alcohol prime was administered in the form of an alcohol taste test. Participants had to take a sip of four different types of alcohol: White wine, red wine, normal beer, and wheat beer. The participants had to rank the four types of alcohol from 1 to 4 in order of preference.

Dot probe/goal task

The dot probe task was identical to the task that we used in Experiment 1, but we only retained the active goal condition.

Procedure

The study was approved by the Ethics Review Board at the University of Amsterdam (ref. number 2016-DP-7163). Participants first completed the AUDIT, based upon which they were allowed to take part in the study. All participants first completed the taste test, and then completed the dot probe task. Upon completion of this task, they were debriefed and compensated.

Results

Performance on the goal task yielded few errors (*M* accuracy = 98%). Dot probe trials exceeding the response deadline (0.75%) were not further analysed. One participant's accuracy on dot probe trials was more than 3*SD*s below the group mean (participant's score = 91.78% correct, group $M = 97.67\%$, $SD = 1.96\%$), and we set all dot probe data of this participant to missing. Next, we removed incorrect trials (2.12%). Reaction times deviating more than 3*SD*s from the group mean ($M = 405.08$, $SD = 130.91$, cut-offs = 12.35 and 797.81) were considered outliers and were removed from further analysis (2.06%). Next, we removed trials deviating more than 3*SD*s from each individual's mean reaction time (1.75%). AB scores were calculated as in Experiment 1. Using different outlier detection and removal criteria, such as the absolute deviation from the median (Leys et al., 2013), did not affect the pattern of results. Split-half reliability scores for each of the three attentional bias scores were as follows: Goal-alcohol $r = .60$, $p = .001$, goal-soda $r = .56$, $p = .002$, and alcohol-soda $r = .12$, $p = .53$.

To test for differences in AB scores, a repeated measures ANOVA was performed with Trial Type (goal-alcohol, goal-soda, alcohol-soda) as a within-subjects factor. We found a significant main effect of Trial Type, $F(2, 27) = 25.07$, $p < .001$, $f = 1.36$ (Figure 4). Significant one sample *t*-tests for goal-soda trials, $t(28) = 7.13$, $p < .001$, and goal-alcohol trials, $t(28) = 6.96$, $p < .001$, confirmed that goal stimuli attracted more attention than both alcohol (Mean AB score for goals = 38.13, $SD = 29.49$) and soda (Mean AB score for goals = 36.29, $SD = 27.41$) stimuli. The one sample *t*-test for alcohol-soda trials, $t(28) = 1.41$, $p = .17$, indicated that there was no significant difference in attention for alcohol and soda pictures (Mean AB score for alcohol = −4.04, $SD = 15.41$). Finally, in order to reaffirm the sensitivity of our results, we conducted a Bayesian repeated measures ANOVA with Trial Type as a within-subjects factor. As expected, the model with the main effect of Trial Type was favoured over the null model (BF = 1.994e + 8). Bayesian one-sample *t*-tests (comparing the attentional bias scores on each trial type against zero) showed decisive evidence for attentional bias for goals in both goal-alcohol and goal-soda trials (both BFs > 100), and no bias in either direction in the alcohol-soda trials (BF = 0.483).

Discussion

The goal of Experiment 2 was to replicate the findings from Experiment 1 that temporary task goals prioritise attention in hazardous drinkers over goal-irrelevant alcohol and soda stimuli. We included an alcohol sip prime to increase the salience of alcohol cues to test whether goals receive more attention even in the physical presence of alcohol. The results of Experiment 2 are a near perfect replication of Experiment 1, demonstrating that goal cues capture and/or hold attention more strongly than alcohol and soda cues, even after a prime-dose of alcohol, confirming the robustness of our effects.

General discussion

The main aim of the current study was to investigate whether temporary goal-related stimuli would capture attention more strongly than other rewarding stimuli. The results of both experiments indicate that goal-related stimuli attract attention more strongly than both alcohol and soda cues in samples of hazardous drinkers. In Experiment 1, these effects were more pronounced when participants were required to actively pursue the goal compared to when they only passively registered their progress in achieving the goal. In Experiment 2, we found that the general pattern of results was maintained, even in a context where alcohol cues were made more salient by a prime-dose of alcohol.

These results are in line with the findings of Vogt and colleagues, who found that goal-related stimuli attracted more attention than neutral stimuli (Vogt

et al., 2010, 2011, 2013) and negative or threatening stimuli (Vogt et al., 2013). We further add to these previous findings by demonstrating that they unlikely result from a discrepancy in valence between the positively reinforced goal-related stimuli and the neutral or negative control stimuli. Given that, with increased alcohol use, alcohol pictures are seen as more rewarding and induce a stronger urge to drink than soda pictures (Pronk et al., 2015), we show that goal-related stimuli still attract more attention than other rewarding stimuli. As such, we add to the extensive literature demonstrating that an individual's goals steer attention towards goal-related events and stimuli (Folk, Remington, & Johnston, 1992; Moskowitz, 2002), regardless of the nature of the competing stimuli. In addition, these effects were not dependent on the active goal-eliciting condition in previous research, but were still found (albeit smaller) in a passive condition.

The prevailing theories of AB in the context of addiction argue that drug-related cues automatically capture the attention of frequent drug users (e.g. Stormark, Laberg, Nordby, & Hugdahl, 2000; Tiffany, 1990), and in line with this idea, there is evidence showing that hazardous drinkers attend more to alcohol cues compared to soda cues (Field, Mogg, Zetteler, & Bradley, 2004; for a review see Field & Cox, 2008). However, in our study we found that hazardous drinkers attended more strongly to task goal-related cues than alcohol-related cues, indicating that the AB for alcohol cues may be context dependent, where a specific context such as a bar may trigger a drinking goal (see also Cox, Brown, & Rowlands, 2003; Cox, Yeates, & Regan, 1999; Groefsema, Engels, Kuntsche, Smit, & Luijten, 2016). More importantly, by showing that hazardous drinkers attend more to task goal-relevant stimuli than to alcohol-related stimuli, even after being physically exposed to alcohol, our results convey that attentional bias for drug-related cues may have a more goal-dependent component and it may thus not be fully automatic (Moors & De Houwer, 2006). This is especially striking given the relatively weak goal inductions that we used in our experiments: The goals were induced in a secondary task and were task-irrelevant in the crucial attention tasks, and the rewards for pursuing the goal were minimal (i.e. participants received relatively meaningless "points").

Our results are in line with the current concerns theory proposed by Klinger and Cox (2004). Current concerns are defined as the "motivational states between the point of becoming committed to pursuing a particular goal and the point of either attaining the goal or giving up its pursuit" (Field & Cox, 2008, p. 3). Current concerns bias information processing, encouraging the preferential processing of goal-related cues. Substance users are assumed to have drug-related goals and associated drug-related current concerns, leading them to selectively attend to substance-related cues. Crucially, people can have multiple goals at the same time, leading to competition between different current concerns. Therefore, the strength of the attentional bias for substance-related cues depends on a number of variables, including the presence and importance of other current concerns (Cox, Fadardi, & Pothos, 2006; cf. Stroebe, van Koningsbruggen, Papies, & Aarts, 2013). In line with this idea, two recent studies found that alcohol and smoking cues received attentional priority only when they were aligned with participants' current search goals (Brown, Duka, & Forster, 2018; Brown, Forster, & Duka, 2018). In these studies, task-irrelevant drug-related distractors only drew attention away from the main task if participants were instructed to detect drug cues in the main task, as opposed to when participants' main task was to detect neutral stimuli. Our results are in line with this goal-driven account of attention, showing that currently activated goals of the individual draw attention even in the presence of other reward-related stimuli. Our study also expands on the works of Brown et al. by showing that active goal pursuit creates a stronger bias towards goal-related stimuli than passive goal pursuit does. Further, the direct comparison of goal and alcohol cues allows us to evaluate the hierarchy of attention allocation towards goal and alcohol cues. Lastly, our sample consisted exclusively of hazardous drinkers, demonstrating that goal-related stimuli are more salient even in people for whom alcohol-cues are more likely to signal reward. Using the sip prime in Experiment 2 further strengthens this finding, showing that goal-related stimuli remained more salient, even in a context where alcohol was readily available. It should be noted that these results do not necessarily generalise to alcohol-dependent patients, where a stimulus-driven effect may still exist (as also indicated by a small effect in some of the participants with the highest AUDIT scores in Brown, Duka, & Forster, 2018). Overall, in line with the current concerns theory, our present results indicate that even the relatively simple goal to press the space bar when seeing office supplies in a secondary

task is strong enough to prioritise attention towards office supplies and not towards alcohol pictures in hazardous drinkers.

Our results form an important future direction for clinical applications. First, they support the rationale of motivational interventions, which focus on replacing drug-related goals with meaningful alternative goals (Cox & Klinger, 2004). Second, they provide a novel future direction for attentional bias modification interventions. In these studies (e.g. Schoenmakers et al., 2010), the standard dot probe task with alcohol and soda cues is modified to present only trials in which targets appear on the location of the soda cues. Consequently, people are trained to direct their attention away from alcohol stimuli and towards soda stimuli, and this shift in attentional bias has been shown to lead to reductions in substance craving and substance use (Schoenmakers et al., 2010; Rinck, Wiers, Becker, & Lindenmeyer, 2018). Future studies aiming to improve current attentional bias modification procedures could replace the standard, neutral, soda-category by a category of goal-relevant stimuli, which could maximise attentional disengagement from alcohol-cues and may thus also lead to stronger reductions in craving or substance use. A study by Cox, Fadardi, Hosier, and Pothos (2015) used the temporary task goal of colour naming in an attentional control training to reduce attention for alcohol distractors. They found that the attentional control training reduced excessive drinking in the short term but not in the long term. Further, Cox et al. (2015) found that a motivation training which assisted participants in identifying key long-term life goals reduced excessive drinking both at post-training measurement and 6-month follow-up. As such, intervention studies could benefit from tailoring the category of goal stimuli to each individual's motivation to reduce their drinking: Some people may want to reduce their drinking because it threatens their career opportunities, while others may want to do so to save money, to reduce stress on their families, to have a healthier life, etc. (see Köpetz, MacPherson, Mitchell, Houston-Ludlam, & Wiers, 2017 for a proof-of-principle study with smokers).

Our study also has limitations. First, in absence of an AB towards alcohol in the alcohol-soda trials, we cannot argue that the AB for goal-related cues "overrides" the AB for alcohol cues. Although we did not anticipate this limitation, it is inherent to the data and therefore something that we can only try to explain post-hoc. One possibility is that the alcohol AB scores were not reliable enough to differ significantly from zero. Alternatively, the absence of alcohol AB could be due to the high cognitive load imposed by the task. In addition to responding to the dot probe, participants had to keep their goal constantly active. In line with this idea, previous studies have shown that high cognitive load can lead to inhibition of cognitive preferences for alcohol-related stimuli (Nikolaou, Field, & Duka, 2013; Sharbanee, Stritzke, Jamalludin, & Wiers, 2014; Van Dillen, Papies, & Hofmann, 2013). Second, there are some indications that AB for alcohol primarily occurs in more heavily drinking males, with similar differences in the animal literature (stronger sign-tracking in males and goal-tracking in females, Barker & Taylor, 2017), and in human cue-reactivity (e.g. Kaag, Wiers, de Vries, Pattij, & Goudriaan, 2018). As our sample consisted primarily of hazardously drinking females, results may have been different for heavier drinking males. Another limitation concerns our operationalisation of the goals. We created goals solely by rewarding participants with points. This excluded the opportunity to investigate the goal to avoid negative events or stimuli. Some individuals might value avoiding negative outcomes more than gaining positive outcomes, which might lead to stronger avoidance goals for such people. Future studies could address this by incorporating a separate goal condition, wherein participants have to focus on not losing points. This would allow to test whether high reward-sensitive individuals attend more to cues related to reward-gain goals, and whether high loss-sensitive individuals attend more to cues related to loss-avoidance goals. A related limitation concerns the nature of the goal stimuli used. In both experiments, we used "office supplies" as the goal-relevant category because we considered them an inherently neutral category of stimuli. However, in the active goal groups, this coherent category of office supplies was more task-relevant than alcohol and soda pictures. Adding an extra subset of different, task-irrelevant office supplies as an additional control category may control for this issue in future work. Related, in the active conditions, participants could have strategically attended to goal-relevant stimuli (office-supplies) to improve their performance in the goal-task. One possible option to assess whether the attentional bias for goals in our paradigm is more or less automatic could be to present more goal-incongruent (e.g. 75%) than goal-congruent (25%) dot probe trials. In such a design, it would be detrimental to

strategically attend to goals in dot probe trials as the target would more likely be presented at the opposite location. As such, if an attentional bias for goals is also present in such a design, this would suggest that the attentional bias for goals is unlikely a result of strategic attention allocation alone.

In conclusion, the current study provides evidence for the idea that temporary goals attract more attention than other rewarding stimuli, like alcohol cues. As such, we show that attentional bias for alcohol cues is context dependent and influenced by one's goals. Our findings thus support theories in which different goals compete for attention, and they counter the idea that hazardous substance users automatically preferentially process substance-related information.

Notes

1. SDC10889, SDC10903, SDC11635, SDC11488, SDC11574, SDC10705, SDC11184, SDC11349, SDC11485 and SDC11584.
2. SDC10758, SDC10759, SDC11444, SDC11373, SDC11591, SDC10744, SDC10734, SDC11445, SDC11370 and SDC 11594.
3. Due to a programming error, for 7 participants, 10 congruent and 10 incongruent alcohol + goal trials were presented without waiting for a response. As such, these participants completed 30 instead of 40 congruent and incongruent alcohol + goal trials. Exclusion of these participants affected neither the pattern nor the significance of the results.
4. Due to a programming error, 2 participants only completed 120 flanker and 120 goal trials. Exclusion of these participants affected neither the pattern nor the significance of the results.
5. We used default priors for our Bayesian analyses.
6. We interpreted the Bayes factors as follows: BF10 < 1/100 = Decisive evidence for H0; BF10 = 1/100–1/30 = Very strong evidence for H0; BF10 = 1/30–1/10 = Strong evidence for H0; BF10 = 1/10–1/3 = Substantial evidence for H0; BF10 = 1/3–1 = Anecdotal evidence for H0; BF10 = 1 = no evidence for either hypothesis; BF10 = 1–3 = Anecdotal evidence for H1; BF10 = 3–10 = Substantial evidence for H1; BF10 = 10–30 = Strong evidence for H1; BF10 = 30–100 = Very strong evidence for H1; BF10 > 100 = Decisive evidence for H1.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Data availability statement

The data are available on the following OSF-page: osf.io/rmqdk.

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