

# Experimental manipulation of attentional biases in heavy drinkers: do the effects generalise?

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## Abstract

**Rationale** In heavy drinkers, training attention towards alcohol cues increases alcohol craving, but it is not clear if effects of ‘attentional training’ generalise to novel stimuli and measurement procedures.

**Objectives** We investigated possible generalisation of attentional training to novel alcohol cues and other methods of measuring cognitive bias.

**Materials and methods** A modified visual probe task was used to train participants to direct their attention either towards (‘attend alcohol’ group) or away from (‘avoid alcohol’ group) alcohol cues; attentional bias was not manipulated in a control group (total  $N=60$ ). After attentional training, we measured cognitive bias (using visual probe, modified Stroop, flicker-induced change blindness and stimulus–response compatibility tasks), alcohol craving and alcohol consumption.

**Results** Attentional bias for alcohol cues increased in the ‘attend alcohol’ group, and this effect generalised to novel stimuli, but not to other cognitive bias tasks. In the ‘avoid alcohol’ group, attentional bias was reduced for the stimuli that were used during attentional training, but these effects did not generalise to different stimuli or cognitive bias tasks. Alcohol craving increased among participants in the ‘attend alcohol’ group, but only among participants who

were aware of the experimental contingencies during attentional training. There were no group differences in alcohol consumption.

**Conclusions** The effects of attentional training show limited generalisation to different alcohol cues and methods of measuring cognitive bias. Experimentally increased attentional bias seems to increase subjective craving, but only among participants who are aware of the experimental contingencies that were in place during attentional training.

**Keywords** Attentional bias · Craving · Incentive motivation · Attentional training

## Introduction

Alcohol abuse is associated with biased cognitive processing of alcohol-related stimuli. As predicted by incentive-motivational models of addiction (e.g. Robinson and Berridge 1993; Franken 2003), alcohol-related cues tend to ‘grab the attention’ and elicit approach responses in heavy drinkers compared to light drinkers. For example, studies with the ‘alcohol Stroop’ generally demonstrate that heavy drinkers, but not light drinkers, are slow to name the colour in which alcohol-related words are printed (e.g. Field et al. 2007; Stormark et al. 2000; Sharma et al. 2001; see Cox et al. 2006 for a review). Other paradigms generally yield consistent findings. For example, studies that use the visual probe task demonstrate that compared to light drinkers, heavy drinkers respond to visual probe stimuli more rapidly when the stimuli replace alcohol-related rather than alcohol-unrelated pictures, which suggests that they preferentially direct their attention towards alcohol-related pictures (Townshend and Duka 2001; Field et al. 2004). This task appears sensitive to pharmacological

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manipulations of the motivation to drink; for example, administration of a moderate (0.3 g/kg) ‘priming’ dose of alcohol increases the magnitude of attentional biases for alcohol cues when assessed using the visual probe task (Duka and Townshend 2004). Studies that use the flicker-induced change blindness (flicker ICB) task have found that participants who detect an alcohol-related change in a ‘flickering’ visual display tend to consume more alcohol than participants who detect an alcohol-unrelated change in the display (e.g. Jones et al. 2002). Finally, with regard to approach tendencies, recent research using the stimulus-response compatibility (SRC) task suggests that alcohol consumers tend to categorise pictures more quickly when the appropriate response is to make a symbolic movement towards, rather than away from, alcohol-related pictures, and this bias appears to be associated with subjective alcohol craving (Field et al. 2005).

Incentive-sensitization theory (Robinson and Berridge 1993) posits that these cognitive biases occur as a *consequence* of chronic alcohol consumption. According to the theory, repeated alcohol use leads to dopaminergic sensitization in the nucleus accumbens, which causes alcohol to acquire incentive-motivational properties. Through a classical conditioning process, alcohol-related cues also become imbued with incentive-motivational properties, so they grab the attention and elicit approach. Animal and human evidence is consistent with this view, as animals tend to direct approach responses to environments or discrete cues that have previously been paired with the administration of alcohol (Bardo and Bevins 2000; Tomie 1996), and humans direct their attention to discrete environmental cues that were previously paired with the effects of a moderate dose of alcohol (Field and Duka 2002).

However, recent models of cognitive biases and drug craving (Franken 2003; Kavanagh et al. 2005; Ryan 2002) suggest that their relationship may actually be reciprocal. That is, persistent allocation of attention to alcohol-related cues may serve to increase craving and alcohol-related cognitions, which would increase the likelihood of drinking (or relapse to drinking in those attempting abstinence). Therefore, it is possible that attentional biases could play a crucial role in the maintenance of addictive disorders: Whilst they may initially occur as a consequence of neuroadaptations caused by alcohol use, once established, they may prime craving and increase drinking behaviour. Findings from a recent study are consistent with this view. Field and Eastwood (2005) used a modified visual probe task to ‘train’ social drinkers to direct their attention either towards (‘attend alcohol’ group) or away from (‘avoid alcohol’ group) alcohol-related cues. This was achieved by modifying the visual probe task so that the visual probes replaced the alcohol-

related pictures on either 100% (‘attend alcohol’ group) or 0% (‘avoid alcohol’ group) of trials. Findings indicated that compared to a pre-manipulation baseline, attentional bias was elevated in the ‘attend alcohol’ group and reduced in the ‘avoid alcohol’ group after participants had been exposed to this attentional training manipulation. Furthermore, subjective alcohol craving was significantly elevated in the ‘attend alcohol’ group after attentional training, although there was no change in craving in the ‘avoid alcohol’ group. Finally, when participants were given the opportunity to sample alcoholic and non-alcoholic drinks during a post-experimental taste test, the ‘attend alcohol’ group consumed more alcohol than the ‘avoid alcohol’ group.

These results suggest that direct manipulation of attentional bias for alcohol-related cues can influence subjective craving and behavioural measures of the motivation to drink alcohol. They provide evidence in support of predictions made by numerous recent models (Franken 2003; Ryan 2002; Kavanagh et al. 2005) that attentional biases for alcohol-related cues might play a causal role in the generation or potentiation of subjective craving and drinking behaviour. However, the failure to observe a decrease in subjective craving in the ‘avoid alcohol’ group suggests that the clinical utility of these attentional training manipulations might be limited. However, Wiers et al. (2004, 2006) have suggested that more intensive ‘cognitive training’ programmes might produce beneficial effects in heavy drinkers who are attempting to reduce their alcohol consumption.

The present study aimed to extend the earlier study (Field and Eastwood 2005) in several important ways. Firstly, a control group was included in the present study. This group received equal exposure to alcohol-related stimuli as the other two groups (‘attend alcohol’ and ‘avoid alcohol’), but their attentional bias was not manipulated. Secondly, we examined whether any effects of attentional training would generalise to novel alcohol-related stimuli and to other ways of measuring biased cognitive processing of alcohol-related cues. Although research on attentional training in addiction is in its infancy, there is a parallel literature in anxiety disorders. Several authors have explored the utility of attentional training as a possible treatment for the reduction of the symptoms of anxiety disorders. For example, MacLeod et al. (2002) used a modified visual probe task to train participants to direct their attention either towards, or away from, threat-related words. Results indicated a significant reduction in attentional bias in the ‘avoid threat’ group, which was coupled with a decrease in emotional vulnerability during a subsequent stressful task. Importantly, this reduction in attentional bias for threat-related words generalised to novel threat stimuli that were not used during the attentional

training. A recent report by Schoenmakers et al. (2007) used a similar attentional training manipulation to that used in the Field and Eastwood (2005) study and reported no evidence of generalisation of experimentally manipulated attentional biases to novel alcohol-related stimuli. However, those authors only attempted to reduce attentional biases, so they could not examine generalisation to novel stimuli in participants trained to attend towards alcohol-related stimuli. In the present study, we investigated possible generalisation of attentional biases in groups trained to attend either towards ('attend alcohol' group) or away from ('avoid alcohol' group) alcohol-related stimuli.

As well as examining whether the effects of attentional training would generalise to new stimuli, we also investigated if the effects would generalise to different measures of cognitive bias. As described previously, there are numerous tasks available to assess preferential selective processing of alcohol-related cues, including the modified Stroop, the visual probe task and the flicker ICB task. These different tasks may be measuring different components of attention—for example, the visual probe task measures the allocation of visuo-spatial attention to alcohol-related cues when those cues compete for attention with perceptually similar cues with no alcohol-related content, whereas the modified Stroop task measures the ability to suppress involuntary processing of alcohol-related semantic cues, and the flicker ICB task measures the ability of alcohol-related cues to facilitate the detection of a subtle change in a flickering visual scene. Therefore, it is interesting to examine if manipulation of attentional bias for alcohol-related cues using one procedure (in the present study, a modified visual probe task) can influence disparate measures of attentional bias. Furthermore, according to Franken (2003), when alcohol-related cues become the focus of attention, this should increase the likelihood that the individual will direct approach responses towards those cues. Therefore, in the present study, we examined effects of attentional training on performance on the SRC task; as described earlier, the task measures the relative speed with which participants can direct approach versus avoidance responses towards alcohol-related pictures. Our primary hypothesis was that the attentional training manipulation would influence performance on all of these measures. That is, after attentional training, the 'attend alcohol' group should show potentiated attentional biases for alcohol-related cues, and biases to rapidly approach those cues, relative to the 'avoid alcohol' group, with the control group showing an intermediate level of responding. These group differences should be evident for each of the different tasks that we used.

Finally, as in the previous study (Field and Eastwood 2005), we measured participants' awareness of the experimental contingencies that were applied during attentional

training (i.e. the location of probes relative to the location of alcohol-related pictures). In the earlier study, approximately half of the participants were aware of the experimental contingencies, and contingency awareness did not appear to be important in mediating the effects of attentional training. However, results from a conditioning study with human participants demonstrated that when participants were trained to associate the interoceptive effects of alcohol with arbitrary environmental cues, those cues were able to evoke some components of subjective craving only in participants who were aware of the experimental contingencies (Field and Duka 2002). Furthermore, similar findings have been reported when conditioning paradigms were used with human smokers—participants only learned to attend to a smoking-predictive cue, and only reported elevated craving in response to that cue, once they became aware of the experimental contingencies (see Hogarth and Duka 2006 for a review). Although these results are not directly applicable to the present study—which is not a classical conditioning study in the sense that no unconditioned stimulus, (i.e. alcohol) is administered—they do suggest that participant awareness of the experimental contingencies may be important when using cognitive techniques to alter attention, craving and drug-seeking behaviour. Our supplementary exploratory hypotheses were that individual differences in awareness of the experimental contingencies used during attentional training would mediate the effects of attentional training on attentional bias, subjective craving and alcohol consumption.

To summarise our primary hypotheses, we predicted that: (1) a between-subjects 'attentional training' manipulation would produce significant group differences in measures of attentional bias for alcohol-related cues as assessed using a visual probe task, with a group trained to direct their attention towards alcohol cues ('attend alcohol') showing increased attentional bias, a group trained to direct their attention away from alcohol cues ('avoid alcohol') showing reduced attentional bias, with no change in attentional bias in a control group in whom attentional bias was not manipulated; (2) these effects of attentional training would generalise to novel alcohol-related stimuli that were not used during attentional training and to different measures of attentional bias (alcohol Stroop and flicker ICB tasks) and a measure of the bias to approach alcohol-related cues (SRC task); (3) the attentional training manipulation would also influence subjective craving and beer consumption during an experimental 'taste test' procedure; specifically, subjective craving and beer consumption should be elevated in the 'attend alcohol' group compared to the 'avoid alcohol' group, with the control group showing an intermediate level of craving and amount of beer consumed.

## Materials and methods

### Participants

Sixty (40 women, 20 men) heavy social drinkers were recruited from the staff and students at the University of Liverpool via online and poster advertising. The sample size ( $N=20$  per experimental group) was identical to that used in our previous study (Field and Eastwood 2005) in which the experimental manipulation of attentional bias produced effect sizes (Cohen's  $d$ ) of 1.27, 0.42 and 0.62 on the dependent measures of attentional bias, urge to drink alcohol ratings and beer consumption, respectively ('very large', 'medium' and 'medium' effects, respectively; Thalheimer and Cook 2002). Inclusion criteria included average weekly alcohol consumption at levels above those deemed 'safe' by the UK Department of Health (for females, this meant consuming more than 14 units per week and for males, over 21 units per week; see Edwards 1996). Participants were also required to speak English fluently, have normal or corrected to normal vision, with a minimum age of 18 years. The study was approved by the Research Ethics Committee in the School of Psychology at the University of Liverpool.

### Overview of experiment design

A mixed experimental design was employed. Between-subjects variables were attentional training group ('attend alcohol', 'avoid alcohol' and control) and the stimulus subset that was used during attentional training (subset 1 or subset 2). All dependent measures, apart from beer consumption, were measured twice: once before the attentional training and once afterwards. Therefore, 'time' was the primary within-subjects variable. Furthermore, all of the cognitive bias measures apart from the flicker ICB task contain within-subject measurements, as participants' responses are typically compared in response to alcohol-related and control stimuli.

### Materials

Thirty pairs of alcohol-related pictures and matched control pictures were incorporated from previous studies (Field et al. 2004, 2005; Field and Eastwood 2005; Townshend and Duka 2001; Duka and Townshend 2004) and were used in the visual probe and SRC tasks. For the purposes of attentional training (see below), these were split into picture subsets 1 and 2, which each contained 15 picture pairs. Each alcohol-related picture depicted alcohol-related stimuli or scenes, for example bottles of spirits or a bar scene, and each was matched for perceptual characteristics (e.g. complexity, brightness) with a control picture that lacked

any alcohol-related content, for example bottles of water or café scenes. Additionally, a set of eight neutral picture pairs (with no alcohol-related content) were used during practice and buffer trials in the visual probe task.

The picture pairs used in the flicker ICB task were developed for this experiment. Stimulus pictures depicted an array of objects; half of the items were alcohol-related, and half of them were not related to alcohol. Stimulus picture pairs consisted of an original stimulus (OS) and a changed stimulus (CS). The CS was almost identical to the OS, although two of the stimuli in the array—one alcohol-related and one unrelated to alcohol—were rotated by 90°. Two stimulus picture pairs were used in this task—in stimulus picture pair 1, the array of objects was arranged so that all alcohol-related items were on the left of the frame, and all of the alcohol-unrelated items were on the right of the frame. Stimulus picture pair 2 was arranged in the opposite way, that is, all alcohol-related items on the right of the frame and all alcohol-unrelated items on the left of the frame.

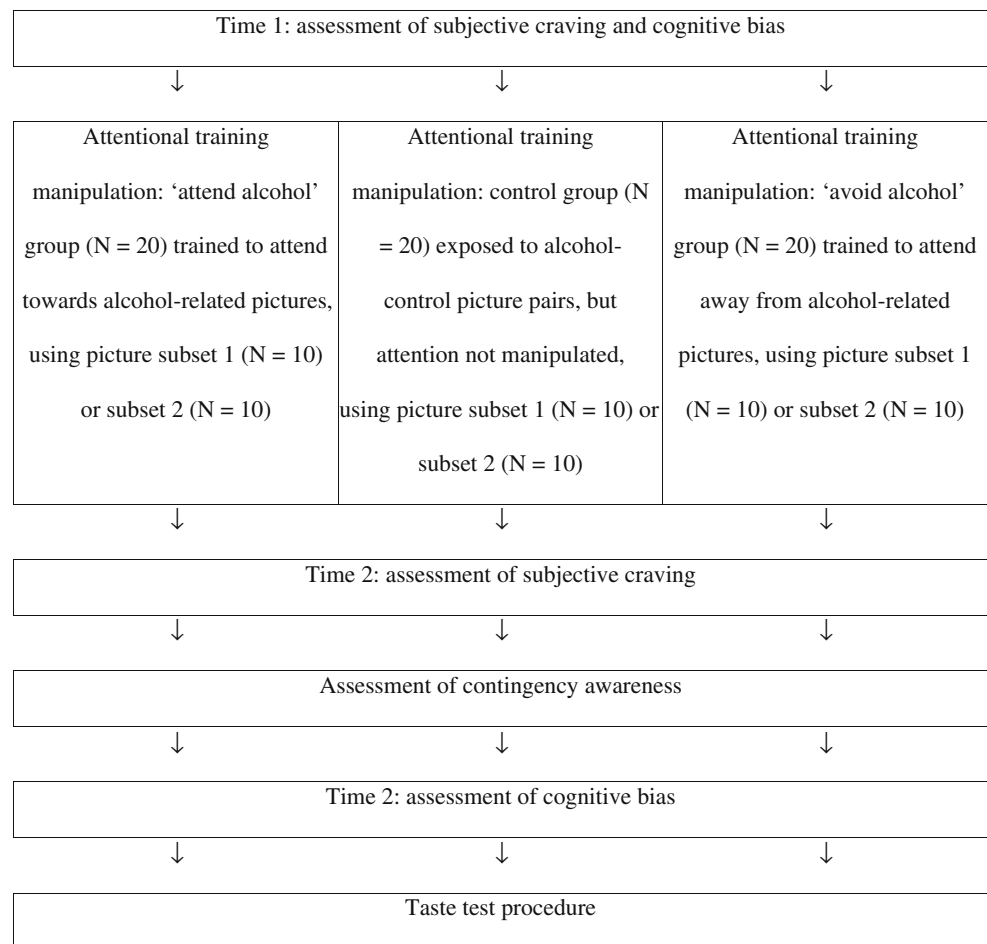
All computer tasks were presented on a Pentium PC with a 15" monitor using Inquisit version 1.33 software (Inquisit 1.33 [computer software] 2002; Millisecond Software, Seattle, WA) attached to a standard keyboard and a two-button response box.

### Procedure

See Fig. 1 for a schematic overview of the experimental procedure. Participants were tested between the hours of 12 P.M. and 7 P.M. in a quiet laboratory in the School of Psychology. After providing informed consent, participants were weighed and breathalysed with a Lion Alcolmeter (Lion Laboratories, Barry, UK) before being seated at a desk approximately 1 m away from the computer monitor. All participants had a breath alcohol level of zero at the start of the session. Participants then provided general demographic information before providing an estimate of their average weekly alcohol consumption and completing a battery of questionnaires: the alcohol use disorders identification test (Babor et al. 2001), the 14-item obsessive compulsive drinking scale (Anton et al. 1995) and the 14-item desires for alcohol questionnaire (DAQ; Love et al. 1998). Finally, participants rated the strength of their urge to drink alcohol 'right now' on an anchored scale which ranged from 0 (not at all) to 10 (extremely).

Participants then completed four different tasks assessing attentional and approach biases for alcohol-related cues (time 1, before attentional training). These tasks were the visual probe task, the alcohol Stroop task, the flicker ICB task and the SRC task. The order of these four tasks was counterbalanced across participants, and the lights in the laboratory were dimmed before participants started the tasks.

**Fig. 1** Schematic overview of experimental procedure. See “Materials and methods” section for details



**Visual probe task** As in the previous study (Field and Eastwood 2005), each trial began with a fixation cross which was presented in the centre of the computer screen for 500 ms. This was then replaced by a picture pair, presented side by side, for a further 500 ms. After picture offset, a small probe (an arrow pointing either up or down) appeared in the spatial location that had been occupied by one of the pictures. Participants were required to respond to the orientation of the probe by pressing the upper or lower button on the response box. To familiarise participants with the task, it began with ten practice trials in which neutral picture pairs were presented. The instructions were then reiterated by the experimenter and clarified if necessary before the main task began. There were, firstly, two buffer trials (in which neutral picture pairs were presented) followed immediately by 120 critical trials in which each of the 30 alcohol-control picture pairs (from picture subsets 1 and 2) were presented four times. Within each picture pair, each alcohol-related picture appeared twice on the left hand side of the screen and twice on the right hand side. Probes replaced each picture with equal frequency, and there was an equal number of probes of each type. Trials were presented in a new random order for each participant, and participants' response latencies and accuracy were recorded.

**Alcohol Stroop task** Following recent recommendations (Cox et al. 2006), the alcohol Stroop task was administered in a blocked format. After receiving verbal instructions from the experimenter, participants named the colour in which words were printed in three different word lists: one list containing neutral words (for practice), one containing alcohol-related words and one containing music-related words (control stimuli). The word lists were taken from those used in an earlier study (Cox et al. 1999). Each list was presented on a separate laminated card containing 100 words consisting of 20 different words, each repeated five times. Words were presented in a random order in blue, green, red and yellow ink, and there were an equal number of words of each colour on each card. All participants completed the practice card first, followed by the alcohol and control cards; the order of presentation of alcohol and control cards was counterbalanced across participants. Cards were individually presented to the participant by the experimenter who recorded the time taken to colour name all of the words on each card as well as the number of errors made for each card (error data are not reported).

**Flicker ICB task** Participants were informed that two photographs would be repeatedly presented, and they

were instructed to ‘spot the difference’ between the two and to press the spacebar on the keyboard once they had detected the difference. We followed the procedures used by Jones et al. (2002) for stimulus presentation: The OS was presented for 250 ms, followed by a blank screen for 80 ms, followed by the CS for 250 ms, followed by the blank screen again for a further 80 ms. These four stimuli were repeatedly presented in this sequence until the participants made a response by pressing the spacebar on the keyboard. Participants then informed the experimenter what change they had detected, and the experimenter recorded their response as either (1) alcohol change correctly detected, (2) neutral change correctly detected, (3) incorrect alcohol change reported, (4) incorrect neutral change reported. Participants did not receive any practice trials for this task. The use of stimulus sets (OS1 and CS1 versus OS2 and CS2) was counterbalanced across participants.

**SRC task** This task was also based on procedures described previously (see Mogg et al. 2003; Field et al. 2005). The task consisted of two blocks, with 120 trials in each block. On each trial, an alcohol-related or control picture was presented in the centre of the screen, and a small manikin (a cartoon matchstick man) was also presented either directly above or below the picture. Participants were instructed to use the upper and lower keys on the response box to move the manikin either towards or away from the picture. Correct responses caused the manikin to move towards or away from the picture before the screen was cleared. Incorrect responses led to the presentation of a large red ‘X’ in the centre of the screen before the screen was cleared. The latency and accuracy of participants’ responses were recorded on each trial.

In the ‘approach alcohol’ block, participants were instructed to move the manikin towards alcohol-related pictures and away from pictures that were unrelated to alcohol. So, for example, if the manikin was presented below an alcohol-related picture, an ‘up’ response was required (to move the manikin towards the picture), but if the manikin was presented below a control picture, a ‘down’ response was required (to move the manikin away from the picture). In the ‘avoid alcohol’ block, these instructions were reversed: Participants were instructed to move the manikin away from alcohol-related pictures and towards pictures that were unrelated to alcohol. The order of completion of ‘approach alcohol’ and ‘avoid alcohol’ blocks was counterbalanced across participants. In each block of the task, there were eight practice trials in which four alcohol-related and four control pictures were presented before 120 critical trials. During critical trials, each of the 30 alcohol-related and 30 control pictures were presented twice each: once with the manikin above each

picture and once with the manikin below. Trials were presented in a new random order for each participant.

After participants had completed these four tasks, they completed a further DAQ and single-item urge to drink scale (time 1, before attentional retraining) before the attentional training phase of the experiment began. Participants were randomly allocated to complete one of six attentional training programs, which were modified versions of the visual probe task described above. This task was a lengthier version of the visual probe task, incorporating four blocks of 240 critical trials (960 trials in total). Within each block, each of 15 picture pairs (utilising either subset 1 or subset 2 of the picture pairs, see below) was presented 16 times each, with alcohol-related pictures appearing on the left hand side of the screen on half of trials and on the right hand side of the screen on the remaining half of trials. As before, participants were instructed to press the upper and lower buttons on the response box to indicate the orientation of the probes.

Attentional training programs differed in the location of probes and in the stimulus set that was employed. One third of participants were allocated to the ‘attend alcohol’ group, one third were allocated to the ‘avoid alcohol’ group, and one third were allocated to the control group; within these groups, half of the participants were trained with subset 1 of the stimulus pairs only, and the remaining participants were trained with subset 2 of the stimulus pairs only. Groups differed in the location of the visual probes. As in our previous study (Field and Eastwood 2005), for the ‘attend alcohol’ and ‘avoid alcohol’ groups, probes replaced the alcohol-related pictures on 100 or 0% of trials respectively, which was intended to train participants’ attention towards or away from the location of the alcohol-related pictures, respectively. For the control group, probes replaced alcohol-related pictures on 50% of trials and the control pictures on the remaining 50% of trials. Therefore, this group received equal exposure to the stimuli as the ‘attend alcohol’ and ‘avoid alcohol’ groups, but our intention was that this manipulation would not influence the orienting of attention to alcohol-related cues in this group. The attentional training programs were presented double blind: Participants were not informed about the location of the probes before training began, and the experimenter was not aware of the participants’ group allocation.

Upon completion of the attentional training phase, participants completed a further DAQ and single-item urge to drink scale (time 2, after attentional retraining). We then assessed participants’ awareness of the relationships between the location of the alcohol pictures and the location of the probes. Initially, participants were asked to describe the relationship between the different types of pictures and the location of probes. Subsequently, recognition of the

experimental contingencies was assessed by asking participants to choose the accurate statement from five different statements which described possible relationships between picture type and probe position, one of which was correct (e.g. ‘arrows always appeared on the same side of the screen as alcohol-related pictures’) and four of which were incorrect (e.g. ‘arrows always pointed up if there was an alcohol-related picture on the left’).

Participants then repeated the four different tasks assessing cognitive biases for alcohol-related cues (time 2: after attentional training). Task order was again counter-balanced across participants. The visual probe, SRC and alcohol Stroop tasks were identical to those completed during time 1. The instructions and stimulus presentation conditions for the flicker ICB task were identical to those described for time 1, although the stimuli differed. Those participants who were tested with OS1 and CS1 at time 1 were tested with OS2 and CS2 at time 2 and vice versa.

Upon completion of these tasks, participants completed a ‘taste test’ procedure which was identical to that used in our earlier study (Field and Eastwood 2005). Participants were simultaneously presented with a 250-ml glass of chilled lager (Stella Artois, 5.0% alcohol by volume) and a 250-ml glass of chilled orange juice (‘Safeway’ fresh orange juice). Participants were instructed to consume as much or as little of each drink as they wished to make value judgements for each drink along four different rating continuums (unpleasant–pleasant; tasteless–strong tasting; bitter–sweet; flat–gassy). For each drink and each rating, participants marked a line on a 100-mm visual analogue scale (rating data were not analysed, as the amount of beer consumed was the primary variable of interest). Participants indicated to the experimenter when they had finished rating both drinks, at which point the drinks were removed and the amount of each that had been consumed was measured, outside of the laboratory. Participants then completed a further DAQ and single-item urge to drink scale (these data are not shown, although we note here that there were no between-group differences in either measure at this time point,  $p > 0.1$ ). At this point, participants completed a brief questionnaire measure which assessed their beliefs about the experimental hypotheses (data are not shown, although there were no significant group differences in beliefs about the experimental hypotheses, and participant beliefs did not influence any of the dependent measures).

Before participants left the laboratory, the experimenter discussed the risks to health of excessive alcohol consumption using information which is provided elsewhere (Babor and Higgins-Biddle 2001). Participants were also provided with contact details for sources of information and help for those who were worried about their drinking before

receiving a full debriefing. Undergraduate psychology students received course credit for taking part; all other participants were compensated for their time with cash (£10 Sterling).

#### Data analysis

Data from the visual probe, alcohol Stroop and SRC tasks and subjective urge to drink ratings and mean scores on the DAQ were analysed using mixed-design analyses of variance (ANOVAs). Where significant interactions emerged, further ANOVAs and  $t$  tests were used to clarify the interaction (see below for details). For the flicker ICB task, the type of change detected (alcohol-related vs non-alcohol related) was treated as a categorical variable, and the association between this variable and group assignment was investigated using Cramer’s  $V$  (a test of the association between these two categorical variables) performed separately at time 1 (before attentional training) and time 2 (after attentional training). Data from the taste test were analysed as in our previous study (Field and Eastwood 2005). The amount of beer consumed was expressed as a percentage of total fluid consumption (total volume of beer + orange juice consumed), and this was analysed using a one-way ANOVA, with group as the between-subjects variable. Finally, supplementary analyses were conducted to investigate the role of awareness of the experimental contingencies by including this as an additional between-subject factor in the ANOVAs (see below for details).

## Results

### Group characteristics

Table 1 shows summary data for the questionnaire measures obtained at the beginning of the experiment shown separately for participants allocated to ‘attend alcohol’, ‘avoid alcohol’ and control groups. Data were analysed using a series of one-way ANOVA, with group as the between-subjects factor. Weekly alcohol consumption and participant age and weight were skewed, so were normalised using log transformation before analysis. As can be seen in Table 1, there were significant group differences in age. Post hoc Bonferroni comparisons indicated that the control group were significantly older than the ‘attend alcohol’ group ( $p < 0.01$ ), but there were no other significant differences ( $p > 0.1$ ). There were no other significant group differences for the other variables, and groups did not differ in gender ratio ( $\chi^2 = 0.60$ ,  $p > 0.1$ ).

**Table 1** Characteristics of participants allocated to ‘attend alcohol’, ‘avoid alcohol’ and control groups

	Attend alcohol	Avoid alcohol	Control	<i>F</i> (2,57)	<i>p</i>
Age (years)	21.73±7.65	22.05±5.19	25.63±13.14	5.20	<0.01
Gender ratio (M/F)	6:14	6:14	8:12		0.74
Weight (kg)	71.15±13.76	72.30±18.28	75.25±15.85	0.39	0.68
Weekly alcohol consumption	21.73±7.65	22.05±5.19	25.63±13.14	0.72	0.49
AUDIT	13.70±5.13	14.60±3.93	14.95±5.11	0.37	0.69
OCDS	8.85±3.62	8.35±3.47	8.05±2.87	0.29	0.75
DAQ	2.52±0.87	2.55±0.86	2.53±0.50	0.01	0.99
Urge to drink	2.75±2.29	2.70±2.49	2.25±1.62	0.32	0.73

Values are mean±SEM.

*Weekly alcohol consumption* self-reported average weekly alcohol consumption, in UK units.

*AUDIT* score on the alcohol use disorders identification test, possible range of scores 0 to 40; *OCDS* total score on the obsessive compulsive drinking scale, possible range of scores 0 to 40; *DAQ* mean score on the desires for alcohol questionnaire, possible range of scores 0 to 7; *Urge to drink* self-reported urge to drink, possible range of scores 0 to 10.

### Correlations between cognitive bias and subjective craving measurements at time 1

To examine whether the different cognitive bias measures were intercorrelated with each other and with subjective craving measures, we performed Pearson correlations on the craving measures and ‘bias scores’ from the cognitive bias tasks at time 1 (before attentional training). For the visual probe, SRC and modified Stroop tasks, ‘bias scores’ were calculated as the differences between stimulus / trial types such that positive scores indicate a bias to attend to alcohol-related pictures (visual probe task), colour-naming interference from alcohol-related words (modified Stroop task) or a bias to rapidly approach alcohol-related pictures (SRC task). Bias scores were averaged across picture subsets 1 and 2. We could not include responses in the flicker task in these correlations, as the data are categorical (type of change detected: alcohol-related vs non-alcohol-related). Craving measurements were urge to drink ratings and mean scores on the DAQ at time 1. These correlations were performed on all participants ( $N=60$ ).

The correlation matrix can be seen in Table 2. There was a small but significant correlation between the two

measures of attentional bias (modified Stroop and visual probe tasks), but neither measure was correlated with the SRC task. One of the subjective craving measures (DAQ) was correlated with the SRC task, but not with the attentional bias measures.

### Effects of the experimental manipulation of attentional bias on cognitive bias tasks

#### *Visual probe task*

Reaction time data from trials with errors (3%) were removed. To eliminate outliers, reaction times were removed if they were greater than 2,000 ms and then if they were more than three standard deviations (SDs) above the individual mean (1% of data). To examine whether participants showed a significant attentional bias for alcohol cues at time 1 (before attentional training), we calculated mean reaction times to probes that replaced alcohol pictures and compared these with mean reaction times to probes that replaced control pictures (averaged across picture subsets 1 and 2) using a mixed design 3×2 ANOVA, with a between-subjects factor of group (three levels: ‘attend

**Table 2** Pearson correlations between visual probe task, alcohol Stroop, SRC task, urge to drink alcohol ratings and scores on the DAQ at time 1 (before attentional training)

	Modified Stroop task	SRC task	Urge to drink alcohol	DAQ
Visual probe task	0.22*	0.15	0.15	0.15
Modified Stroop task		0.10	0.11	0.03
SRC task			0.18	0.32*
Urge to drink alcohol				0.77*

Correlations were performed on data from the entire sample ( $N=60$ ).

\* $p<0.05$



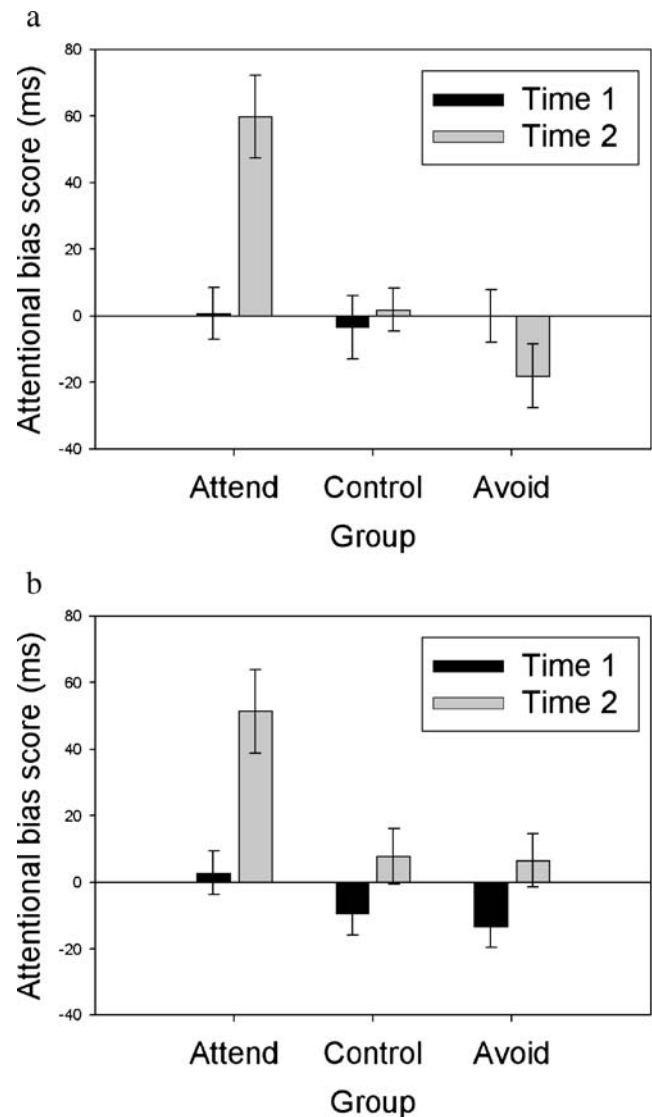
alcohol', 'avoid alcohol' and control) and a within-subject factor of probe position. There were no significant main effects or interactions ( $F < 0.99$ ,  $p > 0.1$ ), indicating the absence of any significant attentional bias at time 1 in any of the experimental groups.

To examine the effects of attentional training, attentional bias scores were then calculated by subtracting reaction times to probes that replaced alcohol pictures from reaction times to probes that replaced control pictures such that positive scores indicate an attentional bias for alcohol-related cues. These attentional bias scores were then analysed using a mixed design  $3 \times 2 \times 2$  ANOVA, with a between-subjects factor of group (three levels: 'attend alcohol', 'avoid alcohol' and control) and within-subject factors of time (two levels: time 1, before attentional training and time 2, after attentional training) and picture set (two levels: 'old' stimuli that were used in attentional training and 'new' stimuli that were not used in attentional training). There were numerous significant main effects and interactions, but these were all subsumed under a significant three way interaction group  $\times$  time  $\times$  picture set [ $F(2,57) = 6.59$ ,  $p < 0.01$ ].

We investigated the source of this interaction by conducting  $2 \times 2$  within-subject ANOVAs separately on each of the three groups. In the control group, there were no significant main effects or interactions ( $F < 1.83$ ,  $p > 0.1$ ). In the 'attend alcohol' group, there was a significant main effect of time [ $F(1,19) = 19.82$ ,  $p < 0.01$ ], but there were no other significant main effects or interactions ( $F < 1.23$ ,  $p > 0.1$ ). As can be seen in Fig. 2a and b, attentional bias increased in the 'attend alcohol' group from time 1 to time 2 (i.e. after attentional training), and this effect was evident for both 'old' and 'new' stimuli. In the 'avoid alcohol' group, the time  $\times$  picture set interaction was statistically significant [ $F(1,19) = 14.09$ ,  $p < 0.01$ ]. For 'old' stimuli, attentional bias scores decreased from time 1 to time 2, and this difference approached statistical significance [ $t(19) = 1.90$ ,  $p = 0.07$ ; see Fig. 2a]. However, for 'new' stimuli, attentional bias scores actually increased from time 1 to time 2, and this difference was statistically significant [ $t(19) = 2.37$ ,  $p < 0.05$ ; see Fig. 2b].

#### Alcohol stroop task

Colour-naming times were analysed using a  $3 \times 2 \times 2$  mixed design ANOVA, with group (three levels: 'attend alcohol'/'avoid alcohol'/control) as the between-subjects factor, and time (two levels: time 1, before attentional training and time 2, after attentional training) and word type (two levels: alcohol-related words/control words) as the within-subject factors. There was a significant main effect of word type [ $F(1,57) = 4.54$ ,  $p < 0.05$ ], as colour-naming times were slower for alcohol-related words than for control words. The main



**Fig. 2** Attentional bias scores (in ms) from the visual probe task at time 1 (before attentional training) and time 2 (after attentional training) Data are shown separately for participants in the 'attend alcohol', 'avoid alcohol' and control groups and for 'old' stimuli (used during attentional training, panel a) and 'new' stimuli (not used during attentional training, panel b) Values are mean  $\pm$  SEM

effect of time was also significant [ $F(1,57) = 28.29$ ,  $p < 0.05$ ], as colour-naming times were faster during time 2 compared to time 1, which probably reflects participants' improvement on the task due to repeated practice. There were no significant effects or interactions involving group ( $F < 2.49$ ,  $p > 0.09$ ), which suggests that the attentional training had no influence on colour-naming performance. See Table 3 for summary data.

#### Flicker ICB task

All data from the flicker ICB task was missing from one participant (in the 'avoid alcohol' group) due to an

**Table 3** Summary data for SRC and alcohol Stroop cognitive bias tasks shown separately for ‘attend alcohol’, ‘avoid alcohol’ and control groups at time 1 (before attentional training) and time 2 (after attentional training)

	Attend alcohol		Avoid alcohol		Control	
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
<b>Alcohol Stroop</b>						
Colour naming time for alcohol words (s)	70.62±19.90	68.61±21.54	74.78±16.20	69.49±17.17	72.53±15.22	67.37±11.82
Colour naming time for control words (s)	67.02±14.29	64.32±12.66	70.14±14.48	66.10±14.81	73.68±18.44	68.42±14.35
<b>SRC task</b>						
RT during ‘approach alcohol’ block—‘old’ stimuli (ms)	708.75±127.64	673.20±110.48	715.20±120.84	704.73±118.04	774.29±157.99	756.32±167.47
RT during ‘approach alcohol’ block—‘new’ stimuli (ms)	705.94±124.82	677.45±109.28	719.65±121.75	702.04±119.29	776.40±161.37	752.23±161.45
RT during ‘avoid alcohol’ block—‘old’ stimuli (ms)	736.90±110.10	735.82±114.67	787.12±156.14	767.07±124.04	838.72±200.68	826.91±196.53
RT during ‘avoid alcohol’ block—‘new’ stimuli (ms)	739.15±114.63	722.68±99.99	773.85±126.51	754.46±109.09	838.88±196.84	821.53±179.39

Values are mean±SEM.

experimenter error. At time 1 (before attentional training), 56 participants (93%) correctly identified either the alcohol-related or the alcohol-unrelated change, with only three participants (one from each group, 5%) reporting the change inaccurately. Eleven participants in each group (55%) correctly identified the alcohol-related change, with the remaining participants identifying the alcohol-unrelated change. There was no significant association between group membership and the type of change detected at time 1 ( $V=0.03$ ,  $p>0.1$ ). At time 2 (after attentional training), 59 participants (98%) correctly identified the alcohol-related or the alcohol-unrelated change (i.e. no participants reported the change inaccurately at time 2). Fourteen participants in both the ‘attend alcohol’ and control groups (70%), and 13 participants in the ‘avoid alcohol’ group (65%) correctly identified the alcohol-related change, with the remaining participants identifying the alcohol-unrelated change. Again, there was no significant association between group membership and the type of change detected at time 2 ( $V=0.02$ ,  $p>0.1$ ). In summary, there were no group differences in the type of change detected (alcohol-related vs alcohol-unrelated) during the flicker ICB task, and this was the case both before and after attentional training.

#### SRC task

Data from the SRC task at time 2 was missing from one participant (in the control group) due to a computer error, so all data from this participant were excluded from the analyses. Reaction time data from trials with errors (3%) were removed. To eliminate outliers, reaction times were removed if they were greater than 2,000 ms and then if they were 3 SDs above the individual mean (3% of data).

Reaction time data were then analysed using a mixed design  $3 \times 2 \times 2 \times 2$  ANOVA, with group (three levels: ‘attend alcohol’/‘avoid alcohol’/control) as the between-subjects factor and time (two levels: time 1, before attentional training and time 2, after attentional training) block type (two levels: ‘approach alcohol’ block/‘avoid alcohol’ block) and picture set (two levels: ‘old’ stimuli that were used in attentional training versus ‘new’ stimuli that were not used in attentional training) as the within-subject factors. This revealed main effects of time [ $F(1,56)=5.26$ ,  $p<0.05$ ] and block type [ $F(1,56)=30.57$ ,  $p<0.01$ ], but there were no other significant main effects or interactions ( $F<2.42$ ,  $p>0.1$ ).

The main effect of time reflects the observation that on average, participants were faster to respond at time 2 compared to time 1, which probably reflects a simple practice effect. The main effect of block type indicates that participants were faster to respond during the ‘approach alcohol’ compared to the ‘avoid alcohol’ blocks of the task. See Table 3 for summary data.

Effects of the experimental manipulation of attentional bias on subjective craving/urge to drink

#### Urge to drink alcohol

Data were missing from one participant (in the ‘attend alcohol’ group) at time 2, so all data from this participant were excluded from the analysis. Data were analysed using a mixed design  $3 \times 2$  ANOVA, with group (three levels: ‘attend alcohol’/‘avoid alcohol’/control) as the between-subjects factor and time (two levels: time 1, before attentional training/time 2, after attentional training) as the

within-subjects factor. The main effect of time was significant [ $F(1,56)=5.27$ ,  $p<0.01$ ], reflecting a general increase in urge to drink over time. However, there were no other significant main effects or interactions ( $F<0.37$ ,  $p>0.1$ ). Data are not shown.

#### *Desires for alcohol questionnaire*

Mean scores on the DAQ-brief were analysed using a mixed design  $3 \times 2$  ANOVA as described above for the urge to drink alcohol data. There were no significant main effects or interactions ( $F<1.29$ ,  $p>0.1$ ). Data are not shown.

Effects of the experimental manipulation of attentional bias on the taste test (beer and orange juice consumption)

Due to an experimenter error, data were missing from one participant (in the control group). There was no significant difference between groups in the percentage of beer consumed [ $F(2,56)=0.02$ ,  $p>0.1$ ]. Mean beer consumption was 42.98% ( $\pm 18.50$ ), 42.41% ( $\pm 18.12$ ) and 43.66% ( $\pm 16.45$ ) in the ‘attend alcohol’, ‘avoid alcohol’ and control groups, respectively.

The role of awareness of experimental contingencies

Forty-seven participants (78%) were able to either correctly recall or correctly recognise the experimental contingencies (i.e. the relationship, or lack of relationship, between the location of alcohol pictures and the location of visual probes during the attentional training phase), whereas the remaining 13 participants (22%) were not aware of the experimental contingencies. These percentages were similar in all three experimental groups (16, 15 and 16 participants were contingency aware in the attend alcohol, avoid alcohol and control groups respectively, no significant association between the categorical variables group membership and contingency awareness,  $V=0.06$ ,  $p>0.1$ ).

The ANOVAs described above were repeated with the addition of contingency awareness (aware/unaware) as a further between-subjects factor. In this section, we report only interactions that involved time, contingency awareness and experimental group. For the visual probe task, the three-way interaction time  $\times$  group  $\times$  contingency awareness was statistically significant [ $F(2,54)=5.04$ ,  $p=0.01$ ], but there were no other significant interactions involving time, group and contingency awareness ( $p>0.1$ ). The main effect of time was significant only in participants in the ‘attend alcohol’ group who were contingency aware [ $F(1,15)=23.71$ ,  $p<0.01$ ], but not in any of the other groups ( $p>0.1$ ). These results demonstrate that the effects of attentional training on the visual probe task, described in the preceding section, were restricted to participants who were aware of the

experimental contingencies. For the sake of brevity, data are not shown separately for participants who were aware vs unaware of the contingencies.

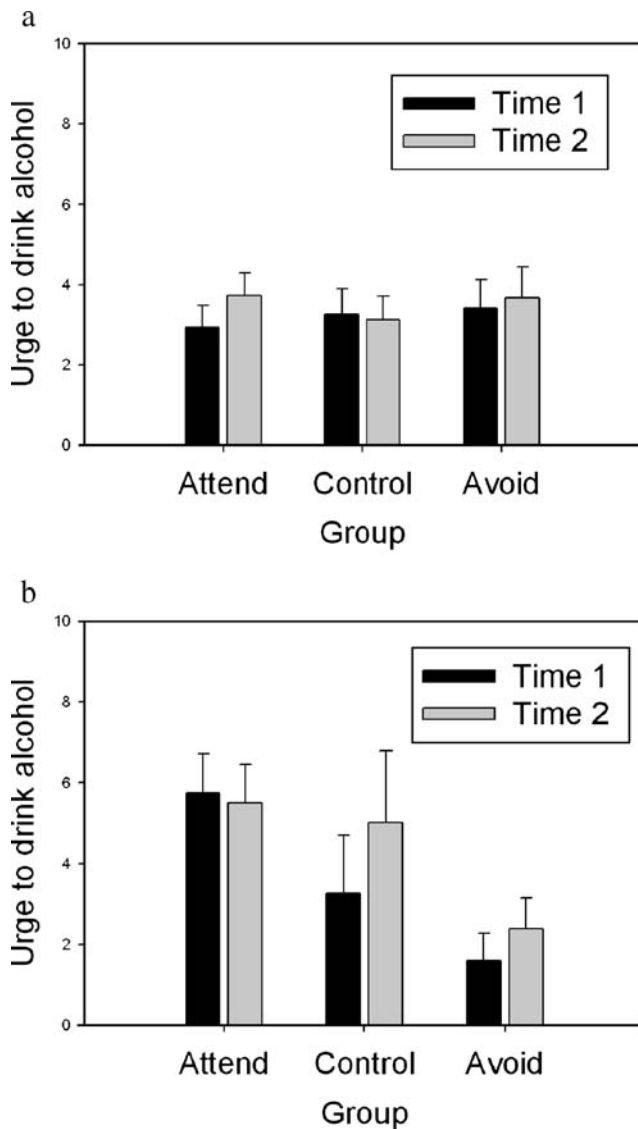
For the alcohol Stroop, flicker ICB and SRC tasks, there were no significant interactions involving group, time and contingency awareness ( $p>0.1$ ). However, for the urge to drink alcohol ratings, the three-way interaction time  $\times$  group  $\times$  contingency awareness was significant [ $F(2,53)=4.04$ ,  $p<0.05$ ]. Further ANOVAs investigating the effects of time separately for participants in the ‘attend alcohol’, ‘avoid alcohol’ and control groups who were contingency aware vs unaware revealed that the main effect of time was significant only in participants in the ‘attend alcohol’ group who were aware of the experimental contingencies [ $F(1,14)=9.33$ ,  $p<0.01$ ]. However, the main effect of time was not significant in any of the other groups ( $p>0.1$ ). As can be seen in Fig. 3, the urge to drink alcohol significantly increased from time 1 to time 2 (i.e. after attentional training) in participants in the ‘attend alcohol’ group who were aware of the experimental contingencies [ $t(14)=3.06$ ,  $p<0.01$ ]. Among the other experimental groups, there were no significant changes in craving from time 1 to time 2 regardless of whether participants were aware or unaware of the experimental contingencies ( $p>0.1$ ).

Data from the DAQ showed a similar pattern. There was a significant three-way interaction time  $\times$  group  $\times$  contingency awareness [ $F(2,54)=3.30$ ,  $p<0.05$ ]. The main effect of time was statistically significant only in participants in the ‘attend alcohol’ group who were aware of the experimental contingencies [ $F(1,15)=9.73$ ,  $p<0.01$ ]. It was non-significant for the other groups ( $p>.1$ ). As can be seen in Fig. 4, DAQ scores increased from time 1 to time 2 (i.e. after attentional training) only among participants in the ‘attend alcohol’ group who were aware of the experimental contingencies [ $t(15)=3.12$ ,  $p<0.01$ ], but there were no significant changes in craving among the other experimental groups ( $p>.1$ ).

Finally, regarding the taste test, the group  $\times$  contingency awareness interaction was not statistically significant ( $p>0.1$ ).

## Discussion

The results from the present study constitute a partial replication of those from a previous study (Field and Eastwood 2005). In brief, the attentional training manipulation produced an increase in attentional bias for alcohol-related stimuli in the group trained to attend to alcohol-related stimuli (‘attend alcohol’ group); these effects were seen for the stimuli that were used during attentional training, and they also generalised to novel alcohol-related stimuli. In the group trained to direct their attention away from alcohol-related stimuli, the attentional training manipulation produced a reduction in

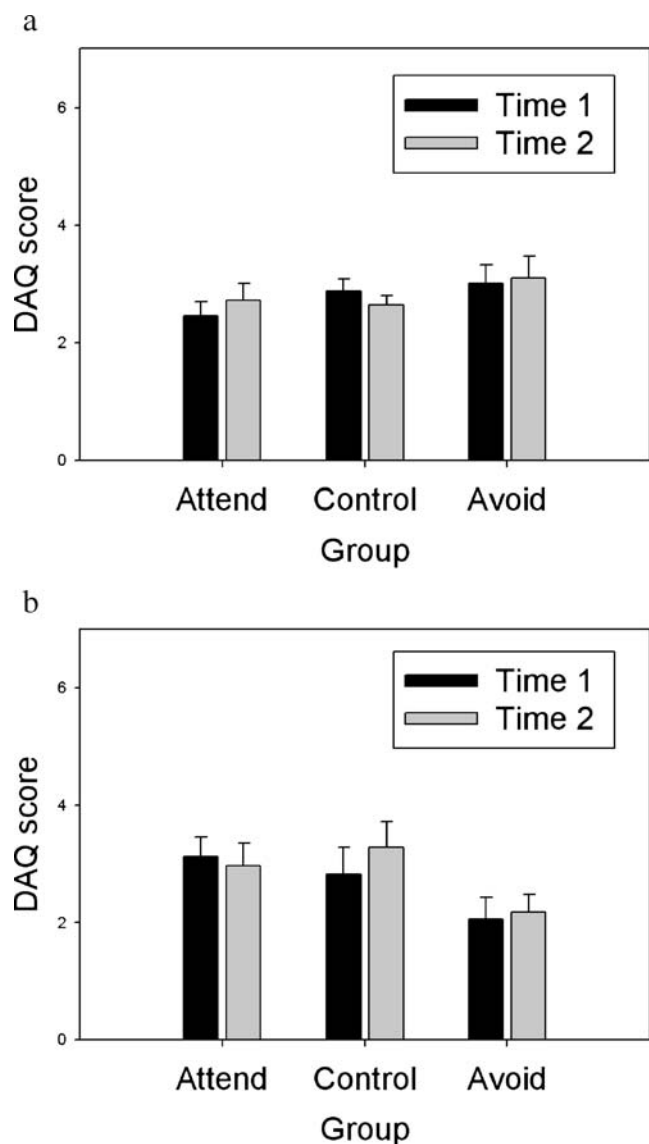


**Fig. 3** Urge to drink alcohol ratings at time 1 (before attentional training) and time 2 (after attentional training). Data are shown separately for participants in the 'attend alcohol', 'avoid alcohol' and control groups who were aware (a) or unaware (b) of the experimental contingencies. Values are mean±SEM

attention towards the alcohol-related stimuli used during training, but an unexpected increase in attentional bias for novel alcohol-related stimuli. As predicted, in a control group in which attentional bias was not manipulated, there were no changes in attentional bias for any of the alcohol-related stimuli. In all groups, there was no evidence that the effects of attentional training generalised to different tasks measuring attentional bias and the bias to approach alcohol-related cues; however, results from two of these three tasks (the alcohol Stroop and the SRC task) did reveal the predicted biases for alcohol-related stimuli in our sample of heavy drinkers. As in the previous study, the group who were trained to direct their attention towards alcohol-related stimuli reported an increase

in subjective alcohol craving after the attentional training; however, unlike in the earlier study, these effects were limited to a subgroup of participants who were aware of the experimental contingencies during attentional training. Finally, we failed to replicate the effects of attentional training on beer consumption that were reported in the earlier study.

Results from the visual probe task suggest that the attentional training manipulation had the desired effects on attentional bias for alcohol-related cues. That is, the magnitude of attentional bias for the stimuli that were used during training increased in the 'attend alcohol' group, decreased in the 'avoid alcohol' group and did not change



**Fig. 4** Mean scores on the Desires for Alcohol Questionnaire (DAQ), at Time 1 (before attentional training), and Time 2 (after attentional training). Data are shown separately for participants in the 'attend alcohol', 'avoid alcohol' and control groups, who were aware (a) or unaware (b) of the experimental contingencies. Values are Mean±SEM

in the control group (in whom attentional bias was not manipulated). The data from the control group are important, as they suggest that attentional bias for alcohol cues is unaffected by simple exposure to the alcohol-related stimuli; instead, the observed changes in attentional bias in the ‘attend alcohol’ and ‘avoid alcohol’ groups must be due to the attentional training manipulation. Therefore, these results replicate and extend the findings from the earlier study (Field and Eastwood 2005). These results suggest that heavy drinkers’ attentional processing of alcohol-related cues can be reduced using an attentional retraining manipulation. However, in the present study, there was no evidence for statistically significant attentional bias for alcohol-related cues at the start of the study (before attentional training) in any of the experimental groups. This finding was unexpected, as the stimuli used were drawn from two previous studies (Townshend and Duka 2001; Field et al. 2004), both of which demonstrated significant attentional biases for these stimuli in heavy social drinkers, relative to light social drinkers. One possible explanation is that as the recruitment advertising for the present study specifically requested heavy drinkers only, participants may have been concerned about their drinking at the time of testing, which could have resulted in strategic attempts to avoid attentional processing of alcohol-related cues (see Noel et al. 2006). However, the absence of a light drinker control group in the present study makes it difficult to make direct comparisons with those earlier studies.

The effects of attentional training showed limited generalisation to novel stimuli and cognitive bias tasks. In the visual probe task, participants in the ‘attend alcohol’ group showed an increase in attentional bias that appeared to generalise to a novel set of alcohol-related stimuli that were not used during attentional training. However, in the ‘avoid alcohol’ group, there was no evidence that the experimentally induced avoidance of alcohol-related stimuli generalised to novel alcohol stimuli, which is a replication of the results reported in an earlier study (Schoenmakers et al. 2007). Unlike in that study, we did observe an unexpected finding in that attentional bias for the novel alcohol stimuli actually *increased* after attentional training in this group. This may be related to the relative novelty of the stimuli after attentional training, although this interpretation is speculative and requires further investigation.

We also noted that there were no effects of the attentional training manipulation on two additional measures of attentional bias for alcohol-related cues: the alcohol Stroop and the flicker ICB task and on one measure of the tendency to direct symbolic approach responses towards alcohol cues (the SRC task). However, results from the alcohol Stroop and SRC tasks did reveal a significant attentional bias for alcohol-related words and a significant

bias to rapidly approach, rather than avoid alcohol-related pictures, respectively, among our sample of heavy drinkers. These results were not affected by time, that is, they appeared to be present both before and after attentional training. The lack of a light drinker control group in the present study does not enable us to draw any firm conclusions about the specificity of these cognitive biases to heavy drinkers. Also, one limitation of the findings from the Stroop task is that we used a card presentation format for this task rather than a computer presentation format. A recent meta-analysis (Cox et al. 2006) recommends using a computer presentation format for the alcohol Stroop task, as this enables more accurate recording of colour-naming times and also permits recording of response times to individual stimuli (rather than taking an average across blocks of different stimulus types).

The present results are important because they suggest that effects of attentional training on subsequent cognitive processing are extremely limited, as they do not generalise to different tasks. A likely explanation is that the four tasks are all measuring different components of the same phenomena (the incentive-motivational properties of alcohol-related cues), which may not be strongly correlated (see “Introduction”). In the present study, before the attentional training manipulation, the visual probe and alcohol Stroop measures were moderately positively correlated with each other, but neither measure was correlated with the bias to approach alcohol-related pictures during the SRC task. Previous work with smokers suggests that while smokers show an attentional bias for smoking-related cues on both modified Stroop and visual probe tasks, these two indices of attentional bias are not inter-correlated (Mogg and Bradley 2002). Similarly, in smokers, the visual probe measure of attentional bias has been found to correlate with the bias to approach smoking-related pictures during the SRC task (Mogg et al. 2003, 2005), but in studies with social drinkers and cannabis users, the two measures were not correlated (Field et al. 2005, 2006a). These results suggest that there are, at best, weak correlations between different measures of attentional bias and between measures of attentional bias and approach bias, although these associations appear inconsistent across different studies. The attentional system is not unitary, with clear distinctions made between the processes that subservise the shifting of attention versus the maintenance or disengagement of attention (LaBerge 1995). It has been suggested (Field et al. 2006b) that these different measures of attentional bias may be measuring different aspects of selective attention, for example the visual probe task with relatively brief stimulus presentations (as used in the present study) may measure the initial shifting of attention, whereas the modified Stroop task may be sensitive to impairments in the disengagement of attention. In addition to this distinction, it is not

clear if the bias to direct approach behaviours towards alcohol-related cues should be associated with the bias to orient attention to those cues, to show impaired disengagement of attention from those cues, or if this aspect of cognitive bias measures another aspect of the incentive-motivational properties of alcohol-related cues entirely. The important point is that the present study suggests that simply manipulating one aspect of attentional bias or (more broadly) the incentive-motivational properties of alcohol cues, is not sufficient to influence different measures of what is theoretically the same underlying process.

An alternative interpretation of the present results is that the attentional training manipulation described here is *not* sufficient to change the fundamental underlying process (i.e. the incentive-motivational properties of alcohol cues). That is, the observed effects of attentional training on the visual probe task may simply represent an effect of practice, with no real change in the underlying ‘incentive salience’ of alcohol cues. However, this interpretation seems unlikely. The visual probe task operates on the basis that probe stimuli are more rapidly detected if they appear in an attended, rather than an unattended, region of a visual display (Posner et al. 1980). Therefore, it is possible to infer the deployment of visuo-spatial attention to alcohol and control pictures from reaction times to probes, with faster responses to probes that replace alcohol-related pictures indicative of an attentional bias for alcohol pictures, but faster responses to probes that replace control pictures indicative of an increase in attentional allocation towards those pictures. The observed pattern of results on the visual probe task, after attentional training, clearly indicate a relative increase/decrease in attention for alcohol pictures in the ‘attend alcohol’ and ‘avoid alcohol’ groups, respectively. Furthermore, the observed effects of the experimental manipulation on subjective craving (discussed below) suggest that the attentional training manipulation produced subjective motivational effects, in addition to the clear effects produced on reaction times during the visual probe task.

At present, although there is evidence to suggest that attentional bias may be clinically significant (Cox et al. 2002; Waters et al. 2003; Marissen et al. 2006) and associated with subjective craving for alcohol and other drugs (Field 2006; Field et al. 2005, 2006b; Franken 2003), we are far from reaching a consensus on which aspects of attentional bias, if any, are most important. In keeping with this concern, recent studies suggest that some aspects of attentional bias may mediate the performance of drug seeking behaviour in response to drug-related cues (Hogarth et al. 2005). Therefore, if attentional training is to have any clinical utility, it is essential to first identify which component(s) of attentional bias are most important

for craving and inducing relapse to drug taking and then ensuring that any manipulation of attentional bias is sufficient to reduce those specific components of attention. Furthermore, other attempts to treat addiction by modifying responses to drug-related cues, such as cue exposure therapy, have met with limited success possibly because the beneficial effects of these treatments do not generalise well from the treatment setting to different contexts (see Conklin and Tiffany 2002). One target for future research into the potential clinical utility of attentional training paradigms is to examine if the effects generalise beyond the treatment setting.

The attentional training manipulation appeared to influence subjective alcohol craving in a manner broadly consistent with that reported in our earlier study (Field and Eastwood 2005). As in the previous study, participants in the ‘attend alcohol’ group reported an increase in alcohol craving after attentional training, whereas there was no change in alcohol craving among participants in the ‘avoid alcohol’ and control groups. This effect was seen for both a single item rating of ‘urge to drink alcohol’ and also, unlike in the first study, for scores on the DAQ. These results are therefore consistent with theories of craving which suggest that when drug-related cues become the focus of attention or are ruminated on, subjective drug craving increases (Franken 2003; Kavanagh et al. 2005; Ryan 2002).

Unlike in the previous study, these effects were limited to those who were aware of the experimental contingencies, and we noted that the effects of attentional training on attentional bias (during the visual probe task) were also limited to those participants who were aware of the experimental contingencies. This discrepancy with the previous study (in which effects of attentional training on attentional bias were not mediated by contingency awareness) may have occurred due to a change in the position of the awareness check within the experimental procedure; in the previous study, we assessed awareness *after* we conducted the post-training assessment of attentional bias, whereas in the present study, we measured awareness *before* we conducted the post-training assessments of attentional bias. One consequence of this change in procedure may have been to highlight the experimental contingencies during training to participants, which may have increased participants’ confidence in their judgments of the experimental contingencies and, therefore, exaggerate their responses during the post-training measurement of attentional bias. The implication is that attentional training only has effects on subjective craving and attentional bias in participants who notice the ‘rule’ predicting probe location during the attentional training phase—once participants become aware of this rule, they direct more attention to the alcohol-related cues, which then provokes an increase in craving.

This is broadly consistent with findings from the drug conditioning literature in humans, which generally demonstrate that when participants are learning associations between an arbitrary environmental stimulus (conditioned stimulus, CS) and the effects of or availability of a given drug (unconditioned stimulus, US), then, the CS becomes the focus of attention and evokes subjective craving only after participants become aware of the CS–US contingencies (Field and Duka 2001, 2002; Hogarth and Duka 2006). The present results are therefore broadly consistent with a more general model of conditioning processes in addiction, which posits that cognitive and emotional responses to drug-related cues are consciously mediated (Hogarth and Duka 2006). However, the present results may extend this model, as they suggest that direct manipulation of attentional biases produces effects on subsequent craving and attentional allocation which are also mediated by conscious cognitive processes. However, in the present study, only a minority of participants (22%) did not become aware of the experimental contingencies during attentional training. In future research of this type, larger sample sizes should be employed to more closely examine the effects of attentional training on subsequent attentional bias and craving in participants who do not become aware of the contingencies. This would permit a more statistically powerful test of the hypothesis advanced here, i.e. that effects of attentional training are specific to those participants who are aware of the experimental contingencies, but absent in those who are not aware. Increased statistical power would also permit investigation of the effects of attentional training on different measures of cognitive bias such as those used in the present study. However, low statistical power does not appear to be a likely explanation for the failure to observe effects of attentional training on the alcohol Stroop, flicker ICB and SRC tasks in the present study, as the sample sizes were identical to those used in a previous study (Field and Eastwood 2005) in which an *N* of 20 participants per experimental group produced effect sizes which ranged from medium to very large.

There were no between-group differences in the volume of beer consumed. The present results suggest that the effects of attentional training on alcohol consumption (observed in the previous study; Field and Eastwood 2005) are not particularly robust. Furthermore, one previous study failed to find any association between attentional bias and operant responding for beer reinforcement (Field et al. 2005). One interpretation of these findings is that attentional biases may be most closely associated with subjective craving rather than with actual drug-seeking behaviour. This would be inconsistent with several incentive-motivational models of addiction (Franken 2003; Robinson and Berridge 1993), but it would be consistent with suggestions that craving and drug-

seeking behaviour can be decoupled in certain circumstances (Tiffany 1990).

In summary, the present results indicate that the effects of attentional training only partially generalise to novel alcohol-related stimuli (in the ‘attend alcohol’ group only), and there was no evidence of generalisation of these effects to alternative measures of attentional bias for alcohol cues or the bias to approach those cues. Furthermore, training participants, to attend to alcohol-related cues, can increase their subjective alcohol craving, but only if they are aware of the experimental contingencies that were in place during attentional training.

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