

Testing Alcohol Myopia Theory: Examining the effects of alcohol intoxication on simultaneous central and peripheral attention

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## **Abstract**

The effect of alcohol intoxication on central and peripheral attention was examined as a test of Alcohol Myopia Theory (AMT). Previous research has supported AMT in the context of visual attention, but few studies have examined the effects of alcohol intoxication on central and peripheral attention. The study followed a 2(alcohol treatment) x 2(array size) x 2(task type) mixed design. Forty-one participants (placebo or intoxicated) viewed an array of 4 or 6 coloured circles, while simultaneously counting the flashes of a centrally presented fixation cross. Participants were instructed to prioritise flash counting accuracy. The subsequently presented coloured probe matched the cued peripheral stimulus on 50% of trials. Flash counting and probe identification accuracy were recorded. There was a significant main effect of alcohol treatment on accuracy scores, as well as an alcohol treatment by task type interaction. Accuracy scores for the central flash counting task did not differ between treatment groups, but scores for peripheral probe identification were lower in the alcohol group. As predicted by AMT, alcohol impairment was greater for peripheral probe detection than for the central and prioritised flash counting task. The findings support the notion that alcohol intoxication narrows attentional focus to the central aspects of a task.

**Keywords:** Attentional Processes, Dual Task, Induced States

## Introduction

The detrimental effect of alcohol intoxication on attentional control has been well documented, for example, in the context of driving performance (Ogden & Moscovitch, 2004; Voas et al. 2000). However, not all sub-types of attention are equally affected by the drug. Previous studies have demonstrated a negative impact of alcohol intoxication on divided attention (Canto-Pereira et al., 2007; Schulte et al., 2001) and selective attention, while sustained attention on one specific task seems less sensitive to the drug (Miles et al 1986; Schulte et al., 2001). One theoretical account that has been applied to explain this selective effect of alcohol intoxication on attention is *alcohol myopia theory* (AMT, Josephs and Steele 1990, Steele and Josephs, 1990). The theory was originally devised to explain extreme social behaviours under the influence of alcohol, suggesting that intoxicated individuals are more likely to focus on immediate, central or salient social cues, rather than considering more distal or peripheral cues. For example, this theory explains the greater likelihood for an intoxicated individual engaging in a bar brawl, or unprotected sex, as they tend to focus on the immediate social cues, whilst disregarding the longer term consequences of their actions. More recently, AMT has been used to explain aspects of cognitive performance under the influence of alcohol. For instance, Schreiber Compo et al. (2011) reported that intoxicated participants recalled less peripheral information in an interactive social event than their sober counterparts. A similar effect has been proposed for attentional control, whereby alcohol narrows the focus of attention such that central rather than peripheral cues are prioritised (e.g. Canto-Pereira et al., 2007; Clifasefi et al., 2006; Harvey, 2015).

Evidence from visual scene processing has indicated a narrowing of foveal attention such that fewer eye movements are made to peripheral regions of a scene (Harvey et al.,

2013). While this is consistent with AMT for central (foveal) attention, it is not clear whether the scope of peripheral (i.e., parafoveal) attention is also narrowed. Attending to information whilst looking elsewhere is referred to as covert attention, and suggests enhanced visual processing at a peripheral location when eye gaze is not fixated at that location (e.g. Findlay, 2005). There are two possible explanations. Firstly, according to the attentional spotlight metaphor (Posner, 1980), the focus of attention need not coincide with gaze, so it is possible that, despite a reduction of eye fixations to peripheral scene regions, the spotlight of attention may still be flexibly directed to these areas if necessitated by task demands. However, a second possible explanation is peripheral load theory. Peripheral processing also depends on perceptual attentional load on central vision, such that in situations of high central perceptual load there is a concomitant reduction in peripheral processing (Lavie, 2006). Evidence from the literature investigating the effect of alcohol intoxication on visual attention seems to be consistent with perceptual load theory rather than a flexible spotlight metaphor, in that limitations to processing capacity result in a reduction of processing at peripheral locations (Hoyer et al., 2007; Moskowitz & Sharma, 1974). For example, when intoxicated participants are required to categorise the middle letter of successive nouns (as being within a particular alphabetic range) they are significantly slower than sober controls at responding to surprise probes presented to the left or right of the central letter fixation point, suggesting that alcohol acts to reduce the capacity of focal visual attention (Harvey, 2015). Furthermore, in their study of visual scene processing, Harvey et al. (2013) not only reported fewer eye-movements to peripheral scene regions, but also lower recall of central and peripheral information contained in the stimulus images, again suggesting that peripheral attention can be impaired by alcohol intoxication. Similarly, Clifasefi et al. (2006) demonstrated increased inattention blindness in intoxicated viewers, relative to sober controls, to a surprise novel event (a gorilla walking through the middle of a ball game) that occurred during a continuous

visual task (counting the number of passes made by some of the ball players). These authors therefore conclude that inebriated viewers attending to a central task are less likely than sober controls to detect even novel peripheral events occurring within their visual field. This may be because of a narrowed field of central attention or related to reduced perceptual load capacity, both being the result of alcohol intoxication.

Clifasefi et al.'s (2006) findings are consistent with AMT, which proposes that the extent to which alcohol impairs attentional performance depends on the extent of other ongoing cognitive activity (Josephs & Steele, 1990). This view is supported by one of the earliest reports of the effect of alcohol intoxication on attention (Moskowitz and Sharma, 1974). Moskowitz and Sharma measured reaction times to peripherally presented targets and found an alcohol related performance decrement when participants were simultaneously required to count the blinks of a central light. In the absence of this central task, no reaction time slowing was recorded for the intoxicated group. More recently, Schulte et al. (2001) reported only a limited compromise of peripheral attention under alcohol in Posner's (1980) classic attentional cueing task, when no secondary task was performed. The standard Posner task simply requires participants to make a key-press response to a target that appears to the right or left of central fixation, following a congruent or incongruent directional cue. Despite foveal gaze being directed to the central fixation cross, parafoveal attention is also engaged to locate peripheral targets. Schulte and colleagues found that alcohol did not reduce the size of the so-called congruency effect (faster responses to targets on the same side as the cued location, and slower to targets on opposite side of the cued location). According to attention allocation theories such as AMT, the congruency effect should be reduced under alcohol when there is competition for attention, either in terms of additional locations to be attended or a dual task requirement, as intoxicated participants in Posner style tasks should be slower to shift their attention from centrally fixated objects or locations.

In the present study we aimed to test this hypothesis by presenting participants with two simultaneous tasks, one requiring foveal attention to count flashes in the centre of the display, accuracy on which was prioritised, and the other requiring parafoveal attention to detect the colour and location of stimuli presented around the periphery of the display. If the voluntary allocation of the attentional spotlight to peripheral locations is compromised by alcohol, then we would expect intoxicated participants to perform at a lower accuracy for the peripheral task compared to sober counterparts. However, if alcohol intoxication does not affect the allocation of peripheral attention we would not expect this difference. Specifically, three hypotheses were proposed. Firstly, that alcohol intoxication results in a decrease of overall (regardless of task) accuracy scores due to its sedative effect on general cognitive performance. Secondly, that overall accuracy scores will be lower in a 6-item array task compared to a 4-item array task due to the burden of an increased cognitive load. And, finally, that there will be an interaction between alcohol treatment condition, and task type, such that the alcohol group will perform significantly worse than the sober group on the peripheral probe identification task but not on the central flash counting task.

## **Method**

### *Participants*

The study protocol adhered to the ethics guidelines set out by the British Psychological Society and ethical approval was granted by the University of Winchester's ethics committee. A total of 41 participants completed the study (26 female; mean age = 20.90 years,  $SD = 2.29$ ). Participants were undergraduate Psychology students who were invited to participate in this study either for course credit or a £10 payment. Individuals who expressed an interest in the study were sent an information sheet and screening form to determine eligibility. Individuals who were younger than 18 years of age or who reported any

medical contraindication to alcohol consumptions were excluded. All participants reported to have normal, or corrected to normal vision.

### *Stimuli and Design*

The task required participants to count the number of flashes of a centrally presented cross-hair, whilst simultaneously monitoring a cued location in a peripherally presented array of stimuli. The array size was either 4 or 6 items. Responses were required for the flash count, and to identify whether a subsequently presented probe matched the stimulus in the cued target location. The task was presented using E-Prime stimulus presentation software on a desktop PC, and a Belinea 1745S1 17" LCD monitor with screen resolution of 1280 x 1024 pixels. Responses were made using the computer keyboard ("A" and "S" for probe responses, "H, J, K, L" for flash count responses). Participants were seated on an adjustable chair, such that the centre of the display was at eye-level and at a viewing distance of 30cm to ensure desired visual angles, and participant head position was stabilised using a chin rest.

Alcohol intoxication was measured using a Dräger Alcotest 6510 Fuel Cell Breathalyzer, which recorded breath alcohol concentration (BrAC) in participants' deep lung air. The unit of alcohol was grams per 210 litres of breath (g/210L). This device is a professional screening tool, which is Type Approved by the UK Home Office and used by UK police forces.

The experiment followed a 2(Alcohol Treatment) x 2(Array Size) x 2(Task) mixed-design, with alcohol treatment (intoxicated, placebo) as the between-subjects variable, and array size (4-item, 6-item) and task (central counting, peripheral probe identification) as within-subjects variables. Participants were randomly assigned to one of the alcohol treatment groups, and presentation of the array size trial blocks was counterbalanced such

that half the participants completed the 4-item task first, and half completed the 6-item task first. The central flash counting and peripheral probe detection tasks were performed simultaneously with response accuracy for both flash counting and probe detection serving as the only dependent variables.

### *Procedure*

On the day of the experimental study participants again completed the screening form and gave informed written consent. The study only commenced if they had consumed at least 6 units of alcohol in one sitting during the past three months, had no medical contraindication to alcohol (including pregnancy and taking medications other than contraception), and no adverse reactions to drinking tonic water and alcohol. Following informed consent, participants were weighed, and a baseline breath alcohol concentration (BrAC) reading was taken (BrAC 1). Participants were allocated randomly to the alcohol or single blind placebo condition. Some previous studies have used a balanced placebo design (BPD) which incorporates both a known sober and a placebo alcohol condition to test for the effects of alcohol expectancy (Marlatt & Rohsenow, 1980). However, the evidence suggests that alcohol expectancy effects are observed in social behaviours, rather than cognitive performance (Assefi & Garry, 2003). Furthermore in a recent study testing the effect of alcohol intoxication on visual attention, there was no difference between the known sober and placebo groups. On the basis of this evidence and for pragmatic reasons, in the present study were not told whether or not their drink contained alcohol. In the alcohol condition, participants received a 500ml beverage containing 1ml of ethyl alcohol per 1kg of body weight mixed with sugar free tonic water. In the placebo condition, participants received 500ml of tonic water, with traces of alcohol dropped on the surface and mist sprayed around the glass. Participants were asked to consume the drink within 15 minutes, after which they relaxed in the experimental room for a further 15 minutes to allow for absorption of the



alcohol. Physiological studies of alcohol metabolism have demonstrated a faster absorption rate for more concentrated alcoholic beverages (such as spirits), such that peak blood alcohol concentration is reached typically within 40 minutes of initiation of alcohol consumption in a fasting participant (Mitchell et al., 2014). The alcohol consumption schedule used in this study is consistent with recent studies using a comparable alcohol administration procedure, and which achieve the desired BrAC levels at the time of beginning the experimental tasks (Clifasefi et al., 2006; Harvey et al., 2015; Schreiber Compo et al., 2011). Thirty minutes after beginning the consumption of their beverage, participants were asked to rinse their mouth with water, to remove any alcohol traces, before a second BrAC reading was taken (BrAC 2). They then rated their subjective level of intoxication on a numeric rating scale of 0 (“not at all drunk”) to 100 (“extremely drunk”). Actual BrAC levels were not disclosed to participants until the end of the experiment.

Participants were comfortably seated at the computer with their chin positioned in the chin rest and the chair adjusted such that their eyes were level with the centre of the display. The task instructions were explained verbally and repeated as on-screen instructions. Participants were told that the task consisted of monitoring the colour of briefly presented stimuli whilst simultaneously counting the flashes of a centrally presented cross. It was stressed to participants that they should keep their gaze fixated on the central crosshair, and to keep count of the flashes as accurately as possible. Figure 1 shows a graphical representation of the stimuli and trial sequence.

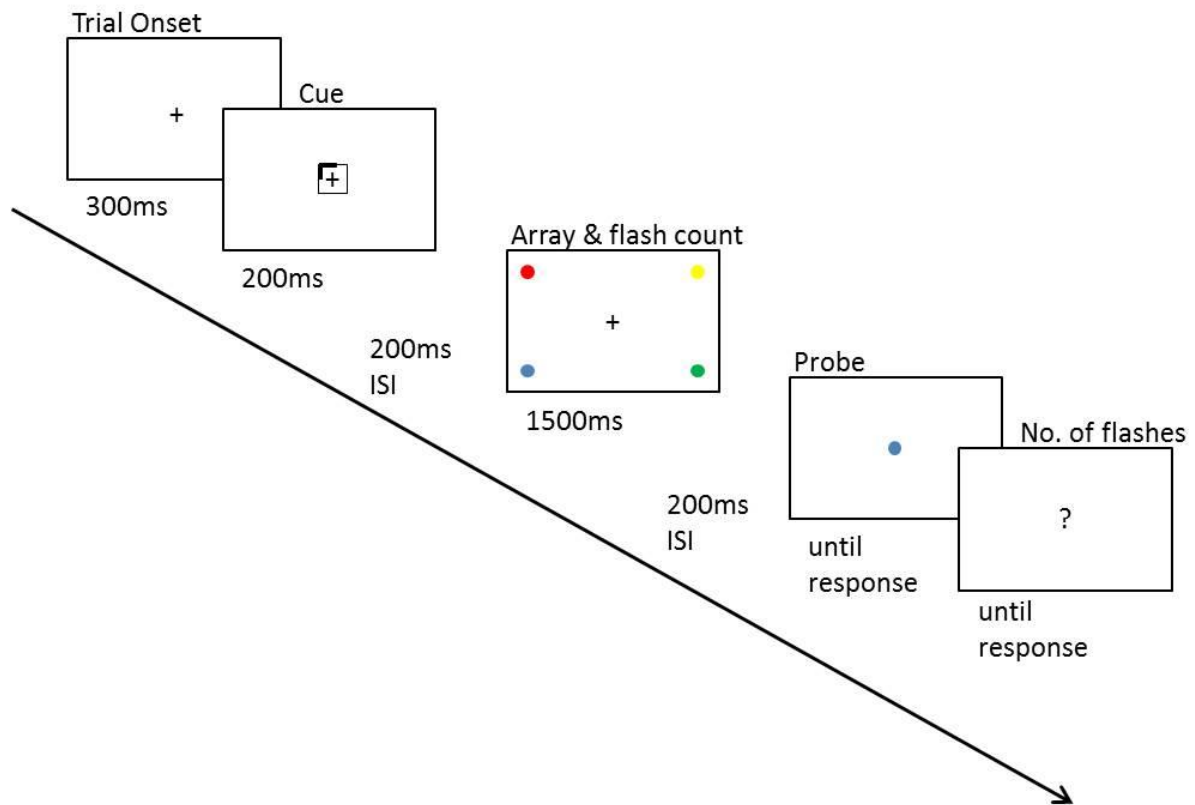


Figure 1: Outline of a trial sequence, showing an example of a four-item array (red, yellow, blue, green) and a probe (blue) requiring a “no” response. The six-item array was analogous, except that the cue stimulus consisted of a hexagon on which one of the six vertices was highlighted, and the array contained six coloured circles arranged in a rectangle formation (as per the four-item, with an additional circles in the top and bottom centre).

The stimulus array subtended a visual angle of 48.5°, and the colour stimuli, directional cue, probe and central fixation subtended a visual angle of 1.9°. A trial consisted of a 300ms fixation cross, followed by the centrally presented cue (200ms), a 200ms inter-stimulus interval (ISI), the stimulus array and central flashing stimulus (1500ms), a 300ms ISI, and concluded with 300ms fixation cross. The central flashing stimulus count ranged between 1 and 4 per trial. After the end of each trial, participants responded to the probe, which had a 50% likelihood of matching the colour of the stimulus at the cued location using the keyboard. Following this, they were prompted to key in the number of flashes they had counted. After a short interval (2000ms) the next trial began. The experiment consisted of two blocks of 120 trials (4- and 6-item stimulus arrays), which were presented in randomised order and took around 20 minutes to complete.

Following the attention task a third BrAC reading was taken (BrAC 3). Intoxicated participants were invited to remain in the lab until their alcohol intoxication had dropped below the UK legal driving limit (BrAC 0.08g/210L) and they felt comfortable to leave.

## Results

Breath alcohol concentration (BrAC) for the intoxicated group immediately prior to task onset was 0.068g/210L (SD = 0.020, range 0.029-0.103), and at the end of the experiment the mean intoxication measured was 0.074g/210L (SD = 0.023, range 0.038-0.140). As expected the placebo group had BrAC values of 0. An independent samples t-test demonstrated the expected group differences post alcohol administration (BrAC 2:  $t(15.72) = 9.77$ ,  $p < 0.001$ ; BrAC 3:  $t(15.96) = 12.12$ ,  $p < 0.001$ ). Subjective intoxication ratings taken immediately prior to task onset ranged from 0 – 85 overall ( $M = 34.24$ ,  $SD = 27.93$ ). An independent samples t-test showed a significant difference in subjective intoxication ratings,  $t(31) = -6.02$ ,  $p < 0.001$ , with the mean score for the placebo group ( $M = 14.65$ ,  $SD = 4.25$ )

being significantly lower than that of the intoxicated group ( $M = 55.06$ ,  $SD = 21.00$ ). Pearson correlation coefficients demonstrated the expected association between actual intoxication level and subjective intoxication (for BrAC 2:  $r = 0.73$ ,  $p < 0.001$ ; for BrAC 3:  $r = 0.74$ ,  $p < 0.001$ ).

We expected the data to follow three predictions: firstly that the alcohol group would have lower accuracy scores overall compared with the placebo group, secondly that accuracy scores would be lower for the 6 item task compared to the 4 item task due to an increase in cognitive burden, and finally, that there would be an interaction between alcohol condition and task, such that the alcohol group perform worse on the peripheral task, but equally well on the central task compared to placebo group. Accuracy scores were calculated separately for the flash counting and probe identification tasks. For flash counting, the number of correct counts was divided by the total number of trials (120 per array size) to obtain a score between 0-1. Similarly, for probe identification, the number of correct responses was divided by the total number of trials. Participants with accuracy scores that fell below 3 interquartile ranges were excluded from the analysis (3 in each treatment group for flash counting accuracy) as they were likely not attending sufficiently to the central flash counting task, and data from one participant was lost due to a technical error. The analyses were carried out with 33 participants (17 sober, 16 intoxicated).

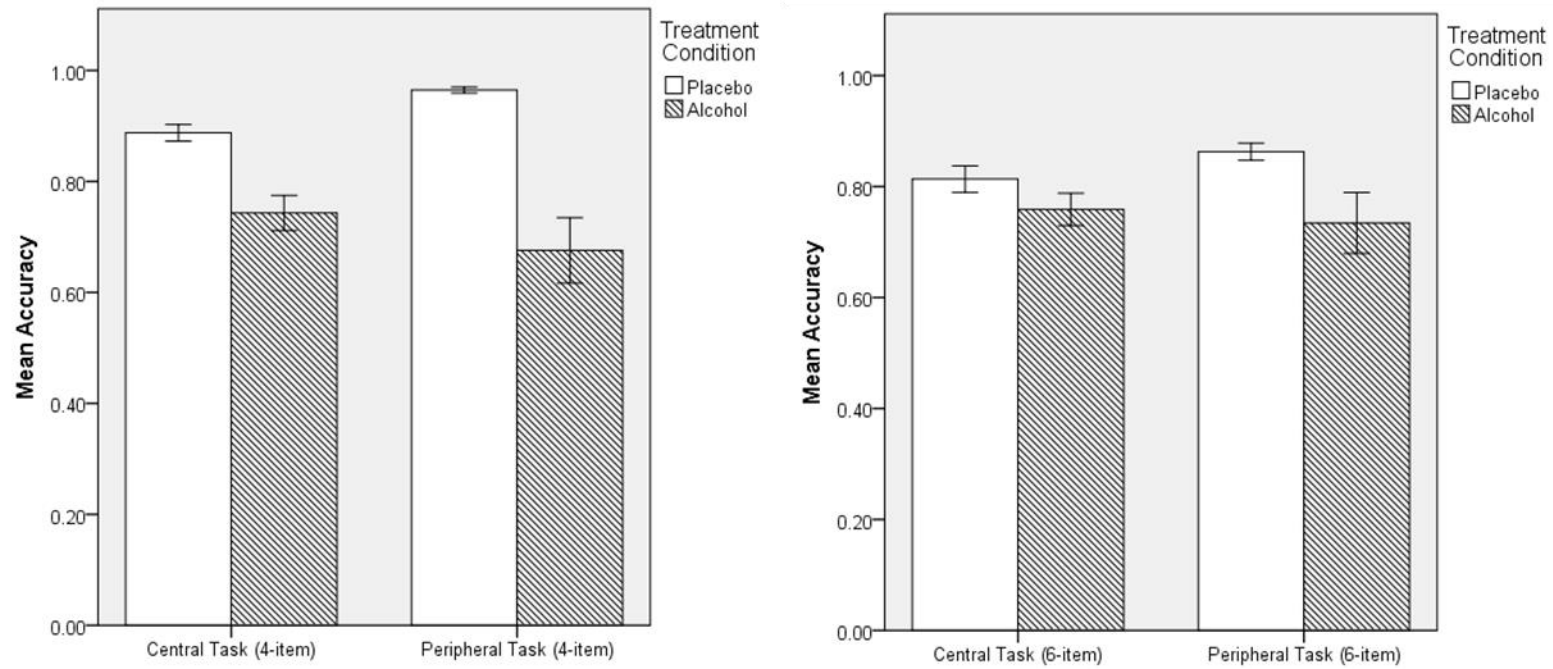


Figure 2. Mean accuracy scores for central task (flash counting) and peripheral task (probe identification) on the 4-item and 6-item tasks as a function of alcohol intoxication. Error bars represent 1 standard error of the mean.

The analysis of accuracy scores (see Figure 2) revealed no significant effect of task,  $F(1,31) = 0.14$ ,  $MSE = 0.017$ ,  $p = 0.71$ ,  $n_p^2 = 0.01$ , but a significant main effect of alcohol treatment,  $F(1,31) = 16.03$ ,  $MSE = 0.049$ ,  $p < 0.01$ ,  $n_p^2 = 0.34$ , and array size,  $F(1,31) = 5.03$ ,  $MSE = 0.04$ ,  $p < 0.05$ ,  $n_p^2 = 0.14$ . As expected, the main effects reflect that overall task accuracy was worse in the alcohol group ( $M = 0.73$ ) compared with the placebo group ( $M = 0.88$ ),  $p < 0.01$ ; and worse for the 6-item array ( $M = 0.79$ ) condition compared to the 4-item array conditions ( $M = 0.82$ ),  $p < 0.05$ . These main effects confirm hypotheses 1 and 2 respectively. There was no overall difference in accuracy between the two tasks (central flash counting  $M = 0.80$ ; peripheral probe identification  $M = 0.81$ ;  $p = 0.71$ ). These effects were modulated by significant interactions between array size and alcohol treatment,  $F(1,31) = 30.57$ ,  $MSE = 0.049$ ,  $p < 0.01$ ,  $n_p^2 = 0.50$ , and between task and alcohol treatment,  $F(1,31) = 5.64$ ,  $MSE = 0.049$ ,  $p < 0.05$ ,  $n_p^2 = 0.15$ . There were no significant interactions between array size and task,  $F(1,31) = 0.15$ ,  $MSE = 0.003$ ,  $p = 0.70$ ,  $n_p^2 = 0.01$ , or between array size, task and alcohol condition,  $F(1,31) = 3.12$ ,  $MSE = 0.049$ ,  $p = 0.09$ ,  $n_p^2 = 0.09$ . Figure 2 shows the critical predicted interaction between task and alcohol treatment, with the alcohol group showing inferior peripheral probe identification performance relative to placebo controls, confirming hypothesis 3. Follow-up independent t-tests supported this finding for the 4-item flash counting task ( $t(21.53) = 4.13$ ,  $p < 0.01$ ); the 4-item probe accuracy task ( $t(15.25) = 4.88$ ,  $p < 0.01$ ) and the six-item probe accuracy task ( $t(17.33) = 2.26$ ,  $p < 0.05$ ). However, there was no between group difference for the 6-item flash counting task ( $t(31) = 1.46$ ,  $p = 0.15$ ). Mean probe monitoring accuracy and flash counting scores suggest that the alcohol group performed worse on the peripheral task than the central task, but these differences are not significant. The adverse effect of alcohol treatment is visibly smaller for the central flash counting task.

## Discussion

In this experiment we examined the effect of alcohol intoxication on a task requiring simultaneous central (foveal) flash counting and peripheral probe monitoring. Array size was manipulated to include 4- or 6-items which were to be monitored using peripheral attention, while foveal attention was required to count central flashes of the fixation cross. Alcohol intoxication resulted in lower accuracy rates overall, as expected. Also, as hypothesised, interaction effects between alcohol treatment and task indicated a differential effect of alcohol on peripheral probe identification compared to central flash counting.

Our findings are consistent with the predictions of AMT for cognitive performance, which predicts a narrowing of attentional scope such that alcohol selectively impairs peripheral attention more than central (or salient) attention. Our study is amongst the few which have directly tested the effect of alcohol intoxication on peripheral (covert) and central (overt) attention simultaneously. While one previous study found no overall effect of alcohol treatment in a classic Posner paradigm (Schulte et al., 2001), we suggest this is due to the study imposing only a single task demand. It seems that peripheral attention is more likely to be impaired by alcohol intoxication in situations of dual task demands, either in the form of central/peripheral task (Moskowitz and Sharma, 1974; Harvey, 2015) or a dual peripheral task location (Canto-Pereira et al., 2007). The results of the present study are in keeping with several other recent reports that provide evidence for AMT as a mechanism to explain the cognitive compromise that can accompany alcohol intoxication (Clifasefi et al., 2007; Harvey et al., 2013; Harvey, 2015; Schreiber Compo et al., 2011).

One unexpected finding was that the differential effect of alcohol intoxication was greater for the easier 4-item task compared to the more demanding 6-item task. It was predicted that any narrowing of attentional scope would be pronounced for the more

demanding task. The pattern of results suggests, however, that both sober and intoxicated groups prioritised the peripheral identification task at some cost to central flash counting accuracy in the more demanding 6-item version, despite the task instructions emphasising the importance of the counting task. A further possibility that cannot be ruled out is that participants made some gaze shifts to the peripheral stimuli, especially in the more demanding version of the task, which may in turn have reduced central flash counting accuracy. However, in the absence of eye-movement data this interpretation remains speculative. Future work will incorporate eye-movement recordings as a means to ensure that participants maintain fixation at the centre of the display, and to track any saccades which may be indicative of shifts to overt and covert attention (Findlay, 2010).

It is necessary to concede two limitations<sup>1</sup> of this study. The first is the individual variation in the response to alcohol intoxication. As reported in the results, there was a significant variation in BrAC levels in our sample, such that some participants were only mildly intoxicated at the time of the task, while others were considerably more affected. This is fairly typical in alcohol research and relates to individual differences in alcohol metabolism (e.g., Gentry, 2000; Kalant, 2000). As a result, the relatively large variance in accuracy scores may be due to the different degrees of intoxication experienced by our participants. Additional analyses showed no significant effect of BrAC on accuracy scores, possibly on account of the small sample size. Nevertheless, future studies will incorporate an alternative calculation for alcohol administration, involving body mass index rather than body mass, as this may take into account alcohol metabolism more accurately (Jones, 2007). The second

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<sup>1</sup> Two additional points should be noted. Firstly, that the sample size was relatively small, and this was determined by the project budget. However, the number of participants per treatment condition was consistent with other recent studies (e.g. Canto-Pereira et al., 2007; Clifasefi et al., 2006; Harvey, 2014). Secondly, as pointed out by a reviewer, despite counterbalancing presentation order of the 4- and 6-item tasks the possibility of order effects must be acknowledged. Presentation order was counterbalanced mainly to avoid fatigue and practice effects. Unfortunately the information about presentation order was not recorded for each participant and cannot be extracted retrospectively in order to investigate this possibility.



limitation relates to the use of a simple chin rest, rather than a chin and headrest combination. It is feasible that participants may have tilted their heads whilst resting in the chin rest, which would lead to small variations in viewing distance and visual angle. Although this is unlikely to have had significant impact on the results, a greater accuracy of viewing distance will be achieved in future work that will incorporate the use of eye-tracking methods. These require a more careful immobilisation of the head using both a chin and forehead rest as part of the eye-tracking camera's tower mount.

The results of the present study support the notion of AMT by demonstrating a differential effect of alcohol intoxication on simultaneous central and peripheral task performance. Alcohol selectively impairs peripheral attention more than central attention, a mechanism which may explain observations of compromised driving performance under the influence of alcohol (Ogden & Moscovitch, 2004; Voas et al., 2000). Furthermore, this selective effect on attention has been linked to reduced recall of peripheral details of an event (Schreiber Compo, 2011) or visual scene (Harvey et al., 2013). Such findings have important implications in forensic settings, for instance in interpreting the accuracy of statements made by intoxicated witnesses. The details provided by these witnesses are likely to be accurate in relation to salient events and information, and more lacking with respect to more peripheral details (see Compo Schreiber et al. 2012).

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