Alcohol and the wandering mind: A new direction in the study of alcohol on attentional lapses

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Abstract: This study examined the influence of acute alcohol on attentional lapses whilst performing a sustained attention task (SART). The sample consisted of 17 male and seven females. A dose of alcohol achieving 80mg/100ml was administered to subjects before completion of the task. Alcohol led participants to make more errors as the session progressed and report a greater incidence of mind wandering. Importantly, alcohol reduced individuals' ability to recover from a lapse in attention. Although the sample size is small, the study did enable us to gain insight into the detrimental effects of acute alcohol ingestion on mind wandering. The authors anticipate that through the use of thought probes in the context of the SART and a larger sample size, we hope to shed further light on this phenomenon.

Key words: Alcohol consumption, attentional lapses, mind wandering, sustained attention

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INTRODUCTION

In many of today's societies, the law prohibits individuals from engaging in tasks such as operating heavy machinery or driving a car when under the acute influence of alcohol. These tasks share a common skill: they require participants to monitor the environment and their own performance continuously to detect, as early as possible, the sequence of events that can lead to accidents. In tasks requiring continuous attentional supervision, it has recently emerged that thoughts that are unconstrained by the task can have serious consequences for task performance (1). In this paper, we consider the possibility that the effects of alcohol consumption on a continuous performance are, in part, due to such brief failures to maintain continuous attentional supervision on the necessary features of the larger task environment.

In the literature, shifts in attention away from the task environment have been variously described as stimulus independent thought (SI) (2), task unrelated thought (TUT) (3-7) zone outs (8,9) or more recently, as mind wandering (1,10). Despite the variations in terminology, these labels emphasize that, periodically, attention leaves the constraints of the task, often focusing instead on information derived from one's own internal world. Recent neuro-imaging work suggests that the so-called *default network* (11,12)—a network of cortical and subcortical areas—provides the neural substrates for such experiences (11). The present study aimed to determine whether mind wandering during a sustained vigilance task is influenced by acute alcohol ingestion. Such a finding would be an important step in understanding the consequences of alcohol on safety conscious industries.

INFLUENCE OF ALCOHOL ON PERFORMANCE

Although it is well known that elevated blood alcohol level (BAL) impairs both behavioral and psychomotor performance on a range of tasks (13-19), it is often the case that these effects are subtle and that even small amounts of alcohol impair performance on many common tasks, even when blood alcohol levels are at or below the legal limit for driving (20). Such acute alcohol induced impairment may be seen on inhibitory control of attention (21) and cognitive executive function (22). Moreover, performance impairment can persist for at least two hours after drinking (23-26) and perhaps much longer (27). Despite alcohol impairing performance on a range of tasks, there is a lack of consistent evidence that the acute administration of alcohol can impair sustained attention (28). For example, although both a Digit Symbol Task and word recall were impaired following the acute administration of alcohol, no difference was observed in a vigilance task (28). Moreover, wide individual differences have been seen in the effects of alcohol on reaction time, with some individuals showing faster and some individuals showing reaction times that did not vary from baseline (29). This lack of consistent findings of the effects of alcohol on a simple reaction time task, particularly given the notion that alcohol is often described as the most likely cause of impaired driving, suggests that perhaps alcohol has subtle effects that traditional tasks fail to detect (30,31).

PREDICTING ALCOHOL IMPAIRMENT

It has also been shown that performance at a given time is very poorly correlated with blood alcohol when both performance and BAL were recorded over time. Studies that have charted performance across the ascending and descending limbs of the blood-alcohol curve tend to show characteristic patterns, whereby following the ingestion of alcohol, the blood-alcohol level increases to a peak that is generally associated with maximal impairment of performance. Although the BAL then declines, this decrease does not show a parallel reduction in the degree of performance impairment. For example, it has been shown (23) that reaction time was slowed to about 112% of baseline after a dose of about 40 mg% BAL, but this impairment did not improve as BAL decreased over time. By 120 minutes after drinking, performance was still at 115% baseline, whereas BAL had decreased to below 10% mg% from peak. Furthermore, performance could be better predicted from the initial alcohol dose than from the current BAL. These issues make it difficult to determine the extent to which BAL can be indicative of current levels of impairments.

What is perhaps the greatest concern for our ability to prevent the detrimental effects of alcohol, however, is the dissociation between subjective ratings of alcohol intoxication and objective measures of both BAL and performance deficits. In general, subjects rate themselves most drunk within the first 15 minutes of drinking and progressively rate themselves less intoxicated despite their rising blood alcohol concentrations (29). Despite this reduction in subjective impairment, the detrimental effects of alcohol on the rate of processing have been shown to be independent of practice or cognitive judgments (32,33). Similar to BAL, therefore, subjective intoxication does not provide a reliable index of acute alcohol impairment.

Clearly, to date, little evidence has supported impairment due to alcohol on simple tests of sustained attention. Moreover, research to date does not indicate a simple correlation between dose, current BAL, and impairment in both subjective and objective performance. Such null results are surprising, given the emphasis that society places on drunkenness during routine tasks such as driving, and that BAL is the preferred measure of intoxication.

A recently developed task, the Sustained Attention to Response Task [SART], requires participants to respond to a sequence of stimuli presented on a computer screen, responding to frequent non-target stimuli and withholding a response to an infrequent target. The SART requires participants to perform a simple task while paying close attention not just to the task but also to the manner in which they are performing it (34,35). This combination of a routine task environment with a need to attend to ones behavior, therefore mimics in an important manner the nature of many of the task environments from which alcohol is forbidden.

Failing to attend to the SART in a continuous manner leads to error. The SART has been shown to be sensitive to the individual differences in the frequency of attentional lapses (34) as measured by the Cognitive Failures Questionnaire (CFQ) (36). The task has also been shown to be sensitive to the experience of task disengagement as measured by a thought sampling methodology (37, Experiments 1 and 2) and retrospective self report (37, Experiment 3). Recent research using thought sampling techniques has confirmed that periods in which transcribed verbal reports indicate attention has left the task are associated with errors on the SART (37) and co-vary with physiological indices implicated in task disengagement, such as GSR (38).

One advantage of the SART as a measure of sustained attention is that, because participants are required to respond continuously to the infrequent target, it is possible to derive a number of additional parameters regarding the nature or character of attentional lapses. For example, generally the response time is rapid before a lapse in attention (34,37,39) a phenomenon that is usually interpreted as a lack of careful or controlled processing of the task behavior. Likewise, following a lapse, the response time lengthens as participants re-establish controlled processing of the task environment, the so called ‘oops’ phenomenon. Consistent with the notion that deceleration in response time indexes awareness and so recovery from an attentional lapse, participants with traumatic brain injury neither lengthen their response times after an error (34) nor show subjective or physiological awareness that their performance lapsed (38).

In the present study, participants performed the SART after consuming either alcohol or placebo. We recorded both behavioral (e.g. response inhibition errors) and subjective indicators of the frequency of mind wandering. In addition, we examined the consequences of acute alcohol consumption on three measures of response time during task performance: (i) response time prior to an error, (ii) response time after an error, and (iii) the deceleration following an error.

METHOD

The study was approved by the Glasgow University's Psychology Department Ethical Committee. Seventeen male and seven female volunteers (see table 1 for demographic details) were recruited by local advertising in and around the university. Females were specifically included in this study because data on alcohol and ingestion are seriously lacking in this area. Females were given a pregnancy test (Predictor Pregnancy, Predictor Frameset) to ensure that they were not unknowingly pregnant. All volunteers gave informed consent to participate. Inclusion depended upon satisfactory completion of a health-check questionnaire, a history of moderate social drinking (a score of less than 3 on Short Michigan Alcoholism Screening Questionnaire (SMAST) (40), and absence of current medication. Participants received a £15 disturbance allowance, £5:00 taxi fare and £5:00 food voucher (redeemable by the university refectory) on completion of the study. Participants were free to terminate the study without reason at any time.

Design

A between-group design was employed to avoid the asymmetrical transfer of treatment effects that often afflict within-subjects designs (41,42). Subjects were allocated at random to either to the alcohol (n=12) or control (n=12) condition.

Alcohol

Alcohol was administered as vodka (37% v/v/ ethanol). Doses were calculated per liter of body water computed from height, weight, and age, which as been advocated as a more accurate method than body weight alone (43). The dose was chosen to achieve peak BAL of 80mg/ 100 ml. The alcohol was mixed with an equal volume of water and diabetic orange juice (Robinsons Orange No Added Sugar). For placebo and alcohol mixtures, 4 ml of vodka was floated on the surface of the drink and the rim of the glass was swabbed with alcohol. To mask any taste of alcohol (44), all participants first sucked a 5 mg benzocaine 'Tyroset' lozenge and a menthol flavored cough sweet 'Halls Mentholyptus extra strong' before ingesting the mixture. BALs were assessed using a Lion Alcometer,SD 400 series (Lion Laboratories, Cardiff, Wales, UK) which was calibrated at weekly intervals.

Tasks

Participants performed the standard SART (34), which consisted of single digit alpha numeric stimuli (X or Y) presented in the centre of a VDU against a black background. The target stimulus was the digit Y. All stimuli were non-masked and presented on the screen for 1000 ms. The inter-stimulus interval (ISI) was 1000 ms, during which time the screen was blank. The rate of stimuli presentation was comparable with that employed on standard SART tasks (34). In the present study, the duration of each test session on the task was ten minutes. A short practice session was carried out before the first task.

Questionnaires

Participants also completed the Thinking Content component of the Dundee Stress State Questionnaire (DSSQ) (45), which is a sixteen-item questionnaire considering the content of thinking during a recently completed task. The instrument assesses (i) Task Appraisal (e.g. 'I thought about how I should work more carefully' or 'I thought about by level of ability' and (ii) Task Disengagement (e.g. 'I thought about my personal worries' or 'I thought about something than happened earlier today'). Each item contains eight factors that are measured on a five-point Likert scale ranging from 'Never' to 'Very Often'. Participants also completed a seven-day retrospective drinking diary and a drinking-history questionnaire and subjective mood as assessed by an 11-item Subjective Feelings Questionnaire (29).

Procedure

Participants were required to abstain from alcohol, drugs, and mediation for 24 hours before the test day. To control for stomach content, participants were instructed to refrain from eating or drinking anything except water for 4 hours before the test. Smokers were requested to have their last cigarette one hour before the test.

Upon arrival at the laboratory, participants gave informed consent to participate in the study. They were breathalyzed, first to ensure blood alcohol levels were zero and second to familiarize them with the breathalyzing procedure. Females were then asked to take a pregnancy test. Volunteers were then randomly assigned

Table 1. Description of the individuals allocated to the Control and Alcohol conditions

	Group	Mean	Std.Dev
Age in years	Control	27.83	6.81
	Alcohol	29.92	7.86
SMAST	Control	0.50	0.80
	Alcohol	0.58	0.67
Weight in kg	Control	70.50	15.62
	Alcohol	71.08	13.29
Height in cm	Control	173.67	7.15
	Alcohol	171.75	5.53
Years in Education	Control	16.92	3.60
	Alcohol	18.42	3.65
Previous week's drinking: Quantity in units of alcohol	Control	20.83	19.79
	Alcohol	31.54	14.91
Previous week's drinking: Frequency in drinking sessions	Control	2.67	2.10
	Alcohol	3.83	1.34
Age first alcoholic drink (in years)	Control	13.17	2.92
	Alcohol	13.42	3.94
Age first drunk (in years)	Control	15.00	2.04
	Alcohol	14.92	3.82
Age started drinking at current levels (in years)	Control	18.33	1.72
	Alcohol	19.58	3.73
Self-reported Quantity consumed during an average drinking session in units	Control	10.33	10.36
	Alcohol	8.45	5.52
Self-reported Frequency of drinking in drinking sessions	Control	2.44	1.90
	Alcohol	3.21	1.67
Family history of drinking problems (missing?)			

to an alcohol/placebo condition. Demographic details were obtained. The participants then completed a practice session on the SART, consisting of ten non-target and two target stimuli presented in a random order. Pilot studies had shown that such practice provided good performance stability. Following practice, baseline SART performance measures were obtained. Participants consumed the 'Tyrozet' and 'Hall' lozenges during baseline testing and then received their drink, which had to be consumed within 10 min. All drinks were prepared out-with the laboratory. Over the next 10 minutes, participants completed the questionnaires and drinking diaries.

To ensure that our study measured the effects of alcohol over the ascending and descending limbs of the blood alcohol curve (BAC) and at peak, testing commenced and continued every 20 minutes over an 80-minute period (giving five data points for each participant) with BAL and subjective feelings measured before each testing session and the thinking component of the DSSQ assessed at the end of each test session. After the final breath test (2 hours after drinking), participants were debriefed, given tea/coffee, and directed to the university refectory to offset the effects of fasting.

RESULTS

Table 1 contains demographic information, physical characteristics and drinking history information. Independent sample t-test on these variables revealed no significant group differences, $p > .05$ for all comparisons.

Effects of alcohol over the blood alcohol curve

Figure 1 shows BAL over the 80-minute observation period as a function of alcohol dose. As expected, there was no evidence of alcohol ingestion for those who had ingested placebo. A mixed ANOVA indicated that the difference between the two groups was reliable [$F(1,21)= 520$, $p < .001$]. A test session by group interaction was significant, indicating that the BALs for those in the alcohol group decreased systematically over the course of the five test sessions [$F(4,87)=17.2$, $p < .001$].

Verbal reports as a consequence of group

The frequency with which each group reported 'task appraisal' and 'task disengagement' is presented in figure 2 (A, B). Mixed ANOVA revealed no group differences in the frequency for 'task appraisal' although a general decrease in this measure was observed for both groups over the five test sessions [$F(4,88)=3.55$, $p < .01$]. By contrast, the analysis of 'task disengagement' indicate an increase in this measure over the same test period [$F(4,88)=5.7$, $p < .01$]. In addition, marginally higher levels of 'task disengagement' were reported for those participants in the alcohol condition [$F(1,22)=2.9$, $p = .09$]. Individual ANOVA conducted for each test session of the task over the 80-minute test period of this group revealed that the self-reported higher levels of 'task

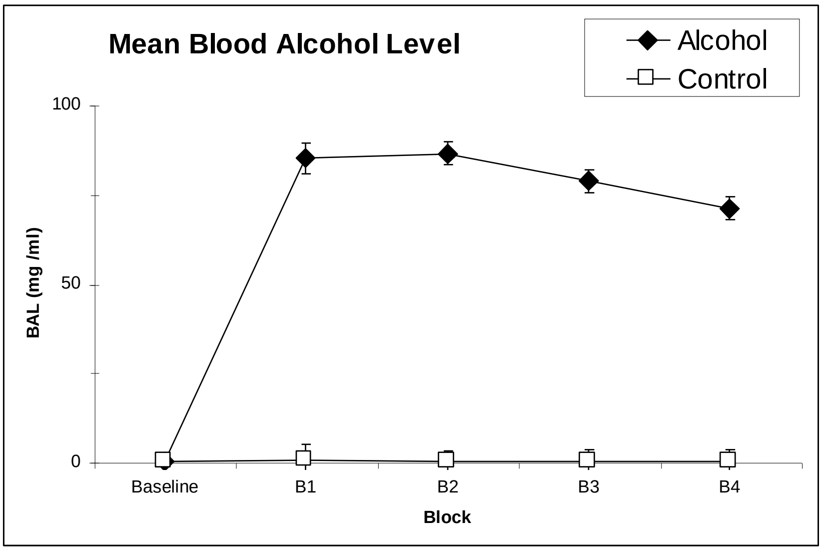

Fig. 1: Blood alcohol levels assessed by breath analysis as a function of alcohol dose. Alcohol was administered to approximate blood alcohol level of 80 mg/100 ml (see text).

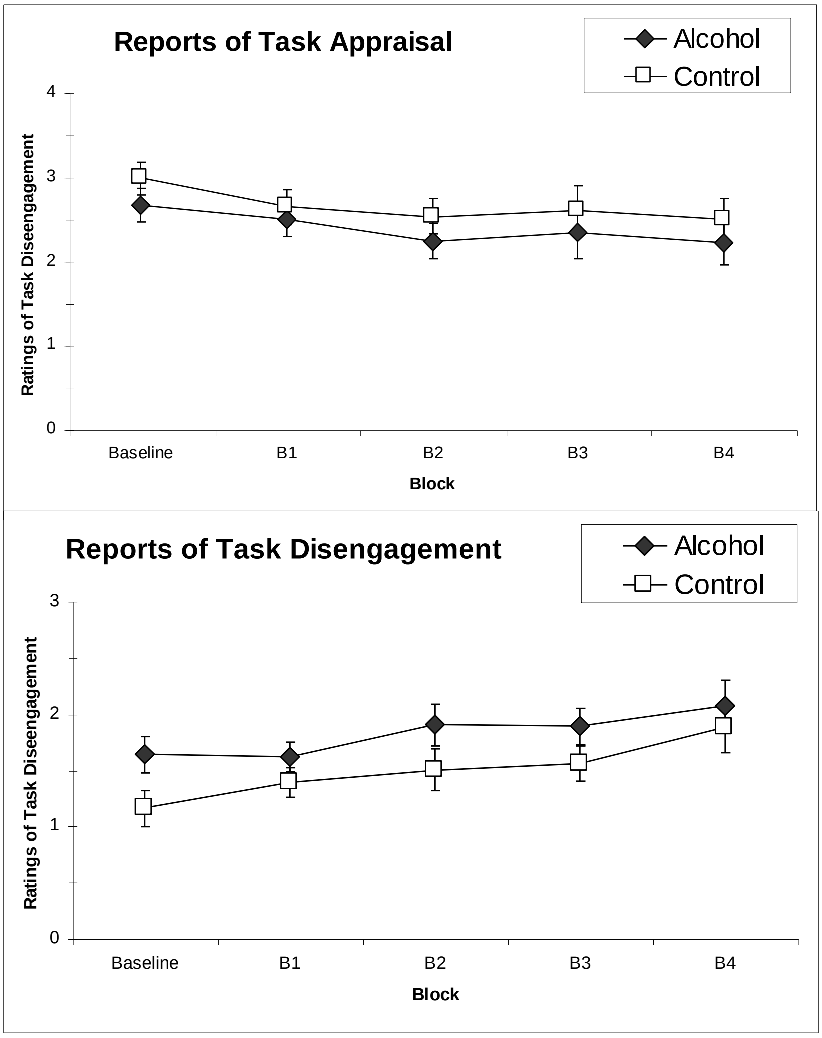

Fig. 2: The likelihood of verbal reports of task appraisal (Top) and task disengagement (Bottom) over the five sessions of the task.

disengagement' was significant during the first test session only [F(1,22)=4.38, p < .05].

Behavioral performance as a consequence of group

The consequences of alcohol ingestion on the probability of making errors on the SART over time are presented in figure 3. One participants allocated to the alcohol condition failed to respond to 202 of the correct targets and was excluded. Mixed ANOVA revealed a reliable interaction between the effects of alcohol and SART errors over time [F (4, 84) = 2.85, p<.05, Partial Eta Squared = .12]. Post hoc tests constrained to each experimental condition and containing these outlier individuals revealed that participants in the alcohol condition made greater errors across all cells relative to baseline [p<.01 for each block]. In the control group the number of errors was only greater at block 3 (p < .05). Alcohol, therefore, led to increases in the extent to which SART errors accrued during task performance.

Response time

The study used mixed ANOVA to contrast the effects of alcohol on the RT associated with failures to withhold a response correctly. Alcohol condition was included as a between-participant factor with repeated measures on block. Consideration of the average response time over four stimuli before failing to withhold a response yielded an effect of Block only [F(4,88) = 3.1, MSE = 959,

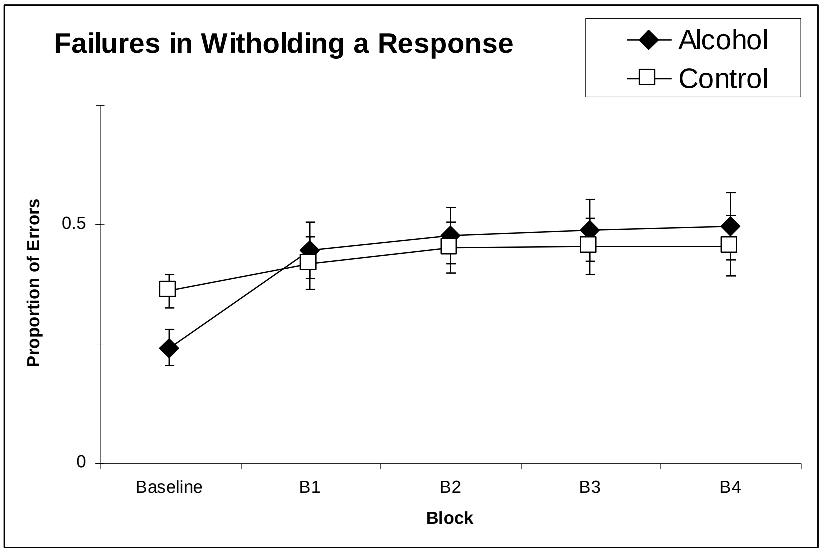

Fig. 3: Probability of an error over the course of the experiment

Partial Eta Squared = .12] indicating that response time before errors tended to decrease over the course of the testing session, irrespective of alcohol consumption (figure 4, Upper Panel). A comparable pattern was identified when comparing the response time following an error (figure 4, Lower Panel). Finally, we examined the lengthening in RT following an error. This analysis tended toward a Block X Condition interaction [F (4, 88) = 2.1, p =.07, MSE = 32, Partial Eta Squared = .09]. Subsequent contrast analysis indicated that the time course of this interaction fitted a reliable linear trend [F (1,22) = 6.6, p <.05, MSE = 17, Partial Eta Squared = .23] indicating that participants in the control condition showed maximal decreases in RT following an error in the early sessions, whereas participants in the alcohol condition showed maximal deceleration in later blocks of the task. Consistent with these different time courses, the decrease in RT was reliably larger in the control condition than the alcohol group in Block 1 [t (22) = 2.4, p = .023].

DISCUSSION

The results of this investigation indicated that acute alcohol ingestion could lead to increases in the extent to which the mind wanders during sustained attention. As can be observed from figure 3, participants in the alcohol condition showed a statistically significant increase in errors across the five test session. Although an increase in errors was also observed for those in the control group, this effect was less consistent. Additional analysis of response time suggested that recovery from an attentional lapse was impaired in the alcohol group early in the session (figure 5). In addition, verbal reports (see figure 2) indicated a higher level of subjective accounts of 'task disengagement' for those in the alcohol condition, however, this effect was significant for the early points in the testing session only. No significant group differences were found for 'task appraisal'.

Although a significant effect of alcohol consumption was observed across several different measures of mind wandering, the specific pattern varied across different sessions of the task. For example, the participants' ability to recover from an attentional lapse and questionnaire measures of 'task disengagement' showed the greatest discrepancy between the alcohol and control conditions in the early blocks of the session (blocks 1 and 2), and so broadly paralleled the BAL curve. On the other hand, the probability of errors on the SART was greater over each of the five test sessions for the alcohol conditions. One explanation for these discrepancies may be that these measures of attentional lapses could be differentially related to the experience of being intoxicated. For example, it has been found (29) that participants rate themselves most drunk within the first 15 minutes of drinking, and progressively rate themselves less intoxicated as time elapses, despite rising blood alcohol concentrations. It is thus possible that the explicit experience of intoxication engenders particularly elaborate mind-wandering from which the participants have difficulty disengaging. As the session progressed, the acute experience of intoxication could decrease and, the resultant alcohol 'come down' could

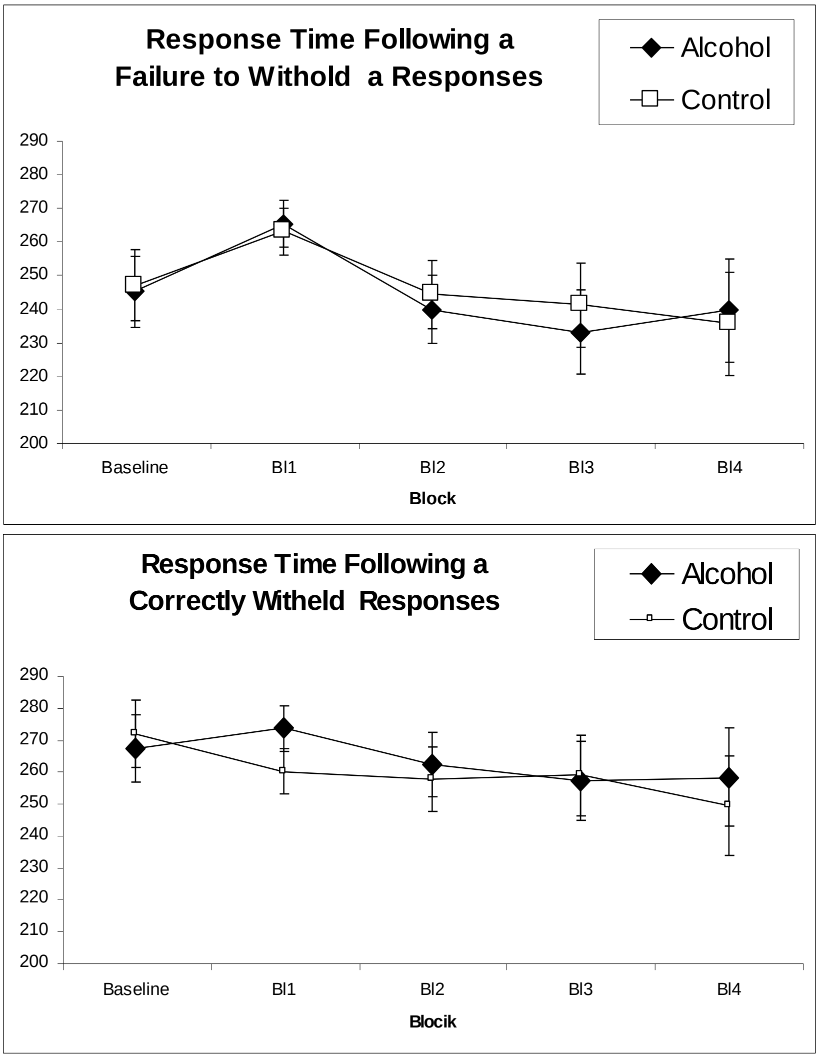

Fig. 4:

be responsible for the increase in the number of attentional lapses.

A second reason for the partial dissociation between the acute effects of alcohol on the two measures may reflect the nature of awareness of these attentional lapses. For example, the experience of mind wandering has been suggested (1) to be the result of two different cognitive processes—the decoupling of attention from the constraints of the task, and a simultaneous lack of awareness that one has temporarily ceased to monitor ones own performance. Possibly, the acute effects of alcohol on ‘task disengagement’ are such that they are targeted at the individual’s ability to recognize his/her own attentional lapse. Early in the session, alcohol impaired a participant’s ability to recover from an attentional lapse (block 1), whereas verbal reports of these episodes were higher in block 2. Recent neuro-imaging work indicating that the anterior cingulate is responsible for the detection of failures in both subjective (46) and behavioral lapses (47), and so it could be that our results further underlie that acute alcohol ingestion targets frontal brain regions leading attentional lapses to remain unrecognized or uncorrected for longer than when in a sober state (15). The relative failure for drunken individuals to lengthen their response time following an error is consistent with recent work, suggesting that alcohol may selectively impair the ability of participants to catch their own minds’ wandering (48).

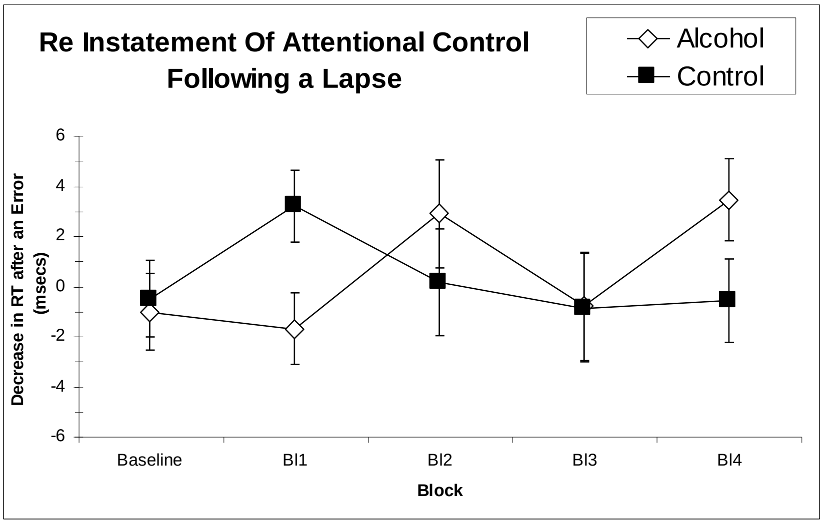

Fig. 5:

Taken together, the results of this preliminary study lends support to the suggestion that acute alcohol ingestion leads to an increase in mind wandering whilst performing a task that requires sustained attention. Crucially, acute alcohol ingestion may impair an individual's ability to recover from such lapses, particularly during periods of acute intoxication, a process that could be responsible for some of the consequences of alcohol in safety conscious settings like driving. Our data are consistent with the suggestion in the literature (49) that one reason why detecting the effects of acute alcohol ingestion is difficult is because the tasks employed are not sensitive to the drug's sedative effects. In routine tasks, which require sustained attention over a prolonged period, the detrimental consequences of alcohol may arise from brief failures in the individual's ability to maintain the necessary and continuous attentional supervision. Finally, an interesting possibility that emerges from our data presented is that if mind wandering is increased by acute intoxication, then this process could underscore some of the pleasurable effects of alcohol consumption. Moderate consumption of alcohol could plausibly reduce the inhibitory processes that normally constrains our thoughts upon the current environment, and by so doing, facilitate 'mental time travel' (10), allowing us to escape from some of the more mundane aspects of daily life.

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