Original Paper

Episodic foresight is impaired following acute alcohol intoxication

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Abstract

Background: Alcohol intoxication disrupts many aspects of cognition, including the generation of phenomenological characteristics of future events (a component of episodic foresight), and the execution of directed preparatory behaviours (a component of prospective memory). However, no study has tested whether alcohol intoxication is also associated with deficits engaging episodic foresight to *guide* future-directed behaviour.

Aims: This study was designed to provide the first test of how alcohol intoxication influences the functional application of episodic foresight. The secondary aim was to establish the degree to which any observed episodic foresight difficulties associated with alcohol use might reflect broader problems in retrospective memory and executive control. Sex differences were also examined.

Methods: Healthy adult social drinkers randomly received either a moderate dose of 0.6 g/kg alcohol ($n=61$) or a matched placebo drink ($n=63$) and then completed a validated measure that met strict criteria for assessing the functional application of episodic foresight as well as a broader cognitive test battery.

Results: Relative to the placebo condition, episodic foresight was impaired by acute alcohol consumption, with this impairment related to poorer retrospective memory, but not executive control. The negative effects of alcohol intoxication on episodic foresight did not differ as a function of sex.

Conclusions: Even a moderate level of intoxication impairs the ability to use episodic foresight in a functionally adaptive way. These findings have implications for understanding many of the maladaptive behaviours that are often associated with acute alcohol use.

Keywords

Acute alcohol consumption, episodic foresight, prospective cognition, neurocognition, behavioural effects

Introduction

Episodic foresight is one of the most adaptive and functionally important forms of future-oriented thinking (Atance and O'Neill, 2001; Bar, 2007; Suddendorf and Corballis, 2007; Szpunar et al., 2014), referring to one's ability to use the imagination of personally relevant future scenarios to guide current behaviour in anticipation of future needs (Lyons et al., 2014; Suddendorf and Moore, 2011). By being able to flexibly adapt behaviour in response to an imagined future, humans are better able to both secure future rewards and prevent future problems (Schacter and Addis, 2007; Suddendorf and Moore, 2011). Because episodic foresight facilitates predictive control over one's environment, allowing current action to be organized in view of anticipated events, it is considered a critical prerequisite for independent living (Suddendorf and Henry, 2013).

There are strong grounds for predicting deleterious effects of alcohol intoxication on episodic foresight. Acute alcohol use alters cellular activity in many brain regions believed to be implicated in episodic foresight, including structures in the frontal lobes and hippocampus (Addis et al., 2007; Schacter et al., 2012; White et al., 2000). Moreover, at a behavioural level, acute alcohol use is often associated with maladaptive behaviours that may reflect a failure of episodic foresight. For instance, social drinkers have been found to heavily undervalue future rewards following acute alcohol consumption (Moore and Cusens, 2010) and to be more likely to engage in risky behaviours, such as excess spending and driving after drinking (Field et al., 2010). Episodic foresight also imposes demands on other cognitive abilities known to be affected by alcohol use, including retrospective memory (memory for past information and events) and executive functions (higher order cognitive operations, such as inhibitory control and cognitive flexibility; Suddendorf and Corballis, 2007). Broader literature also shows that acute alcohol intoxication negatively impacts other important aspects of prospective cognition such as prospective memory (Elliott et al., 2021).

Reduced episodic foresight might also potentially be one of the mechanisms that contributes to alcohol myopia (Steele and Josephs, 1990). Alcohol myopia is a cognitive-physiological theory that attributes many of alcohol's social and anxiety-reducing effects to a narrowing of perceptual and cognitive function. A central tenet of this model is that because alcohol causes people who are intoxicated to respond more strongly to immediate contextual cues, there is an attendant loss of ability to consider future

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consequences of their actions or to exercise control over their immediate behaviour.

Recent research has also shown the potential therapeutic benefits of deliberate engagement in episodic foresight. Cueing episodic foresight can be sufficient to encourage preferences for larger, later rewards in intertemporal choice tasks (Bulley et al., 2017) and may reduce both the desire for alcohol and the discounting of delayed rewards generally (Bulley and Gullo, 2017; Voss et al., 2022).

It is therefore surprising that, to date, there has only been one prior study that speaks to whether the deleterious effects of acute alcohol intoxication might also extend to episodic foresight. In this study, a phenomenological approach was used that assessed the capacity to generate a future event narrative, with a high quantity of episodic details presupposed to reflect more detailed pre-experience and thus a greater capacity for episodic foresight. The results revealed that a moderate dose of alcohol impaired the ability to pre-experience future scenarios via one's imagination (Elliott et al., 2022). These findings are potentially important, as the ability to imagine oneself in the future in order to identify personally relevant future needs is regarded as a core aspect of episodic foresight, as it is this pre-experiencing which is argued to trigger behavioural choices that ensure those future needs are met (Suddendorf and Moore, 2011).

However, although the episodic foresight literature in general has been dominated by paradigms such as the *Autobiographical Interview* used by Elliott et al. (2022), a limitation of phenomenological paradigms is that they lack any requirement to *use* episodic foresight to appropriately guide future-directed behaviour. This is because such tasks simply require participants to describe the details of possible future situations in response to specific prompts. In the context of alcohol intoxication this limitation is an important one, as it means that, at present, we simply do not know whether alcohol use impacts on the actual functional capacity to apply episodic foresight. Accordingly, the present study was designed to provide the first test of whether acute alcohol intoxication disrupts this functional aspect of episodic foresight.

To achieve this goal, we used the validated measure Virtual Week-Foresight (*VW-Foresight*). Suddendorf and Corballis (2010) have argued that tests aiming to demonstrate episodic foresight behaviourally must meet stringent experimental design criteria to rule out other causes for actions that have future benefits. At present, *VW-Foresight* is the only behavioural measure meeting these criteria that is suitable for adults (for development and task details, see Lyons et al., 2014). Although the sensitivity of *VW-Foresight* to a pharmacological experimental manipulation remains to be established, it has been shown to be sensitive to foresight difficulties associated with long-term opiate use (Terret et al., 2017), developmental changes in late adulthood (Lyons et al., 2014), and many neurological and psychiatric disorders (Coundouris et al., 2022; Lyons et al., 2016, 2019; Manchery et al., 2022).

In contrast to the more widely used phenomenological measures, *VW-Foresight* was developed to focus on how episodic foresight influences actual behaviour and indexes two key aspects of foresight: (i) the capacity to spontaneously acquire items to resolve future problems and (ii) the capacity to then subsequently use the correctly selected items at an appropriate future time-point. The central prediction of this study was that acute alcohol intoxication would significantly disrupt these capacities.

Table 1. Background participant characteristics.

	Alcohol condition $n=61$	Placebo condition $n=63$	Inferential statistics	
	M (SD)	*M* (SD)	*t* (122)	*d*
Age (in years)	24.25 (4.17)	24.46 (4.19)	0.29	0.05
Years of education	16.13 (2.24)	16.21 (2.08)	0.21	0.04
Premorbid IQ	47.00 (4.27)	46.87 (4.46)	0.16	0.03
Negative affect	10.10 (5.01)	9.37 (5.79)	0.75	0.14

Premorbid IQ as indexed by the *Spot the Word* test. *d*=Cohen's *d* index of effect size. Effect sizes: small=0.2; medium=0.5; large=0.8.

The secondary aim was to test the prediction that alcohol-related deficits in retrospective memory and executive function would also be identified and would be related to any observed alcohol-related effects on episodic foresight. Finally, because sex differences in the pharmacokinetics of acute alcohol use may make females more sensitive to its negative effects, an exploratory component of this study was to examine whether sex differences in episodic foresight emerged following acute alcohol ingestion.

Methods

Participants and design

A total of 124 healthy adult social drinkers aged 18–37 years ($M=24.35$, SD=4.16) were randomly assigned to receive either alcohol ($n=61$; 30 males) or placebo ($n=63$; 32 males) in a double-blind independent group design. Table 1 shows that the two groups did not differ significantly in age; years of education; premorbid intelligence; or negative affect as indexed by total scores on the *Hospital Anxiety and Depression Scale*. Participants were recruited via community advertisements and reimbursed AU$60 for their time. To be eligible, participants were required to be social drinkers, defined by Griffiths et al. (2012) as consuming on average between 2 and 25 standard units of alcohol per week for females, and 2 and 36 standard units of alcohol per week for males. One standard unit of alcohol in Australia contains 10 g of alcohol.

Supplemental Table 1 presents descriptive and inferential alcohol use statistics for males and females separately, as well as independent-sample t-tests comparing the alcohol and placebo conditions for each of the variables. The two groups did not differ in age of first alcoholic drink, average quantity of alcoholic standard units consumed per week, speed of drinking, number of times 'drunk' in the past 6 months and percentage of times drinking until drunk, as well as *Alcohol Use Questionnaire* (*AUQ*; Mehrabian and Russell, 1978) outcome scores.

Exclusion criteria included the use of prescription medication that required abstinence from alcohol, previous or current neurological condition, major psychiatric illness, history of alcohol or other substance dependence, acquired or traumatic brain injury, and English not being a first language. Participants were asked to refrain from using alcohol or any other illicit substance in the 24 h prior to testing and were reminded of this via text message at least a day in advance of the testing session. Participants confirmed abstinence via self-report and a blood alcohol concentration (BAC) measurement of zero prior to commencing the experiment. Participants were also advised not to eat a heavy meal in

the 2 h prior to the testing session; however, if they did need to eat something, they were advised to consume only a light (non-fatty) meal (such as fruit/vegetable snacks).

Alcohol administration

The drinks were prepared by a research assistant in a room separate to the participant and the researcher, to ensure that both were blind to the drink content (alcohol or placebo). First, the research assistant applied an alcohol mist to the cups and drink tray. For participants assigned to the alcohol condition, alcohol was administered at a dose of 0.6 g of alcohol per kilogram of body weight, closely following Leitz et al. (2009). Each participant in the alcohol condition was administered a total of 500 mL of liquid containing 96% ethanol (vodka), tonic water and lime cordial (which served to mask the taste of alcohol), which was divided equally into 10 cups of 50 mL portions. Each participant assigned to the placebo condition was provided with 500 mL of liquid equally divided into 10 cups of 50 mL portions containing tonic water and lime cordial only. All participants were required to consume one cup every 3 min in the presence of the researcher, until all 10 drinks were consumed. To maintain a stable BAC level over the entire testing session, participants in the alcohol condition were given two additional sets of drinks (top-up drinks) consisting of two 50 mL portions each, administered at approximately 80 and 120 min into the testing session. Each top-up drink contained 0.1 g of alcohol per kg of body weight, again diluted with tonic water and lime cordial. Participants in the placebo condition were also provided with two sets of top-up drinks (two 50 mL portions of tonic water and lime cordial only). All participants completed four BAC measurements taken by the research assistant using a Lion Alcolmeter 700 breathalyser. Participants were breathalysed at least 20 min after consuming the drinks to ensure that residual alcohol within the mouth did not affect the BAC reading.

Measures

Episodic foresight. *VW-Foresight* (see Figure 1) is a computerized task designed to meet strict experimental design criteria for demonstrating episodic foresight and that is sensitive to episodic foresight difficulties associated with normal adult ageing (Lyons et al., 2014) as well as various clinical disorders (Coundouris et al., 2022; Lyons et al., 2016, 2019;Manchery et al., 2022; Terrett et al., 2017). *VW-Foresight* has the appearance of an engaging board game. Participants move the token around the squares of the board on the roll of a dice using a computer mouse, with each circuit around the board representing one virtual day. As participants move around the board, they are required to make decisions about daily activities and are given the opportunity to engage in episodic foresight tasks.

Ten foresight tasks are presented in each virtual day, each of which consists of three components. These are (1) a plausible situation in which a problem arises (problem, e.g., the first component of one of the foresight tasks is 'Your cat Whiskers is meowing insistently around his empty food bowl. You go to the cupboard, but you're out of cat food. Poor Whiskers!'). The second component (2) is a daily activity which presents an opportunity to select an item that would later allow the problem to be solved (e.g., 'You run out of time to do the grocery shopping today. Instead, you go to the local convenience store but only have enough money to buy one item. You purchase___'.). Respondents choose an item from a list of five items, only one of which provides a potential solution to the situation (in the current example, cat food). Finally (3) there is a return to the initial situation context, in which the problem is still present, and which provides the context to use the correctly selected item to solve the problem (resolution; 'Home again, Whiskers greets you at the door, still meowing very loudly and circling your ankles!').

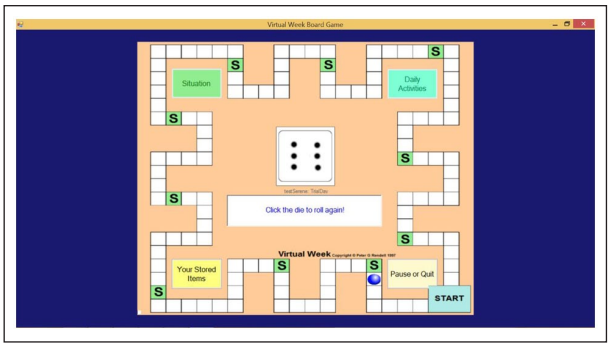

Figure 1. Virtual Week-Foresight game interface.

After completing the trial day, participants were asked to complete three virtual days. These three virtual days presented 30 situation cards, 20 of which comprised the episodic foresight task (i.e., 10 presented an episodic foresight problem; 10 presented the context for a resolution of that problem). The remaining 10 featured similar narrative content but did not present an episodic foresight problem (these cards simply feature virtual day narrative content to act as distractor situations). In addition, of the 20 daily activity cards, 10 featured an item (in a list of five items, with four being distracter items). Once acquired, these items could be used to resolve the episodic foresight problem. An additional 10 daily activities cards featured five distracter items (i.e., no items that were relevant to resolve the problems). Problem, resolution, and distracter situation cards were presented intermittently with daily activities cards. To introduce a temporal delay between the three task components (and thereby ensure the task measured episodic foresight, and not basic problem solving), there was an average delay of two intervening cards between a problem presentation and item acquisition, and two further intervening cards occurred between item acquisition and problem resolution context.

The key dependent measures in *VW-Foresight* are item acquisition and item use. Item acquisition is scored as the number of target items acquired on the daily activities cards (from 10 possible items). For item use, given that the ability to use an item is contingent on first acquiring that item, the number of items correctly used is first conditionalized on initial acquisition (i.e., the number of used items is divided by the number acquired, to produce a proportion of already acquired items; see Lyons et al., 2014).

Alcohol use. Participants' current alcohol use was indexed using the AUQ (Mehrabian and Russell, 2016), a measure of drinking quantity and patterns within the past 6 months (Townshend and Duka, 2002). Participants answer 12 questions that assess their typical alcohol drinking habits. This measure was also used to provide a binge drinking score, calculated using Townshend and Duka's (2002) AUQ binge score equation.

Retrospective memory. Retrospective memory was measured using the *Hopkins Verbal Learning Test*. Participants were orally presented with a list of 12 words pertaining to three semantic categories for three trials and asked to recall as many words as they could remember in any order following each trial and once again after a 30-min delay. Immediate recall was calculated by tallying the total number of words correctly recalled following the initial three trials, and delayed recall by tallying the number of words recalled following the 30-min delay.

Executive functioning. Executive control is a multifaceted construct (Lee et al., 2012), and so three distinct measures were used to index different components. The capacity for *cognitive initiation* was indexed using tests of phonemic and semantic fluency. For the former, participants were required to generate as many words as possible within 1 min that begin with the letters F, A and S separately. For the latter, participants were required to generate as many animal names as possible within 1 min. Total fluency was calculated by summing total phonemic and semantic fluency scores. *Inhibitory control* was indexed using the *Hayling Sentence Completion Test*. In Part A, participants are required to provide an appropriate word to complete 15 sentences. In Part B, participants are required to complete an additional 15 sentences with an unrelated word, thereby inhibiting the prepotent response tendency. Participants' performance was scored in accordance with standardized guidelines. Finally, *cognitive flexibility* was measured using the *Trail Making Task*. In Part A, participants are required to draw one continuous line connecting the numbers 1–25 in numerical order, and in Part B, to draw one continuous line to connect numbers and letters in sequential and alternating order. Performance is calculated by subtracting the time taken to complete Part A from Part B, with lower scores indexing better performance.

Manipulation check. To test the effectiveness of the double-blinding, the researcher and participant were asked to guess which condition they had been assigned to (alcohol or placebo) at the conclusion of the testing session.

Procedure

Testing took place in a single individual testing session of up to 180 min, with breaks taken as needed. After completing a baseline BAC measure, all participants were weighed to allow calculation of the appropriate dose of alcohol to be administered. Participants then completed the experimental protocol that included several tasks not used here but that were reported in separate studies (see Elliott et al., 2021, 2022). Full details of the procedures and tasks completed by participants are reported in Supplemental Table 2. The study was approved by the Australian Catholic University Human Research Ethics Committee and all participants provided written informed consent.

Analyses

All statistical tests were two-tailed and conducted using IBM SPSS Statistics, version 26.0, with an alpha level of $p < 0.05$. Three cases were identified as a univariate outlier on a single test, with *z*-scores of more than 3.29 and were replaced with scores ±3 SDs of the mean following the guidelines of Tabachnick and Fidell (2014). Given the exploratory nature of the study, an a priori analysis was not conducted. However, a sensitivity power analysis (G*Power version 3.1.9.6) conducted after the participants were recruited revealed that 124 participants would make a $2 \times 2 \times 2$ mixed ANOVA sensitive enough to detect a moderate effect size (f = 0.22, $\alpha = 0.05$, power = 0.80).

Results

Blood alcohol concentration

Supplemental Table 2 reports the mean (SD) BAC for all participants assigned to the alcohol condition, and then separately for males and females. An independent samples *t*-test was conducted to compare sex differences in BAC across the four BAC measurements. All participants recorded a baseline BAC of zero. At the second BAC measurement, males and females recorded a similar BAC, $t(59) = 1.67$, $p = 0.10$. However, females recorded a significantly higher BAC level on the third, $t(59) = 2.92$, $p = 0.005$, and fourth BAC measurements, $t(59) = 3.68$, $p = 0.001$.

Manipulation check

The effectiveness of the double-blind experimental design was assessed by examining participant and researcher guesses regarding assigned treatment condition (i.e., alcohol or placebo). Approximately 93% of participants assigned to the alcohol condition correctly guessed that they had received the alcoholic drinks, whereas approximately 59% of participants assigned to the placebo condition correctly guessed that they had received the placebo drinks. Additionally, the researcher correctly guessed that participants were assigned to the alcohol condition in 87% of cases, and the placebo condition in 89% of cases. Chi-square analysis of the participants' guess regarding which treatment condition they had been assigned revealed a difference between correct and incorrect responses (χ^2 (1,124) = 38.12, $p < 0.001$). Analysis of the researcher's guess on which treatment condition the participant had been assigned also revealed a difference between correct and incorrect responses (χ^2 (1,124) = 71.25, $p < 0.001$), thus confirming that both the participants and the researcher guessed the correct condition most of the time.

Background cognitive measures

Descriptive and inferential statistics for the measures of retrospective memory and executive functions are reported in Table 2. There were no differences between the alcohol and placebo conditions on any of the executive function measures. However, participants assigned to the alcohol condition performed significantly worse than those in the placebo condition on both measures of retrospective memory.

Episodic foresight

VW-Foresight data were analysed using a mixed $2 \times 2 \times 2$ ANOVA with the between-subjects factors of assigned *condition* (alcohol,

Table 2. Performance on the measures of retrospective memory and executive control for participants in the alcohol and placebo conditions.

Measure	Alcohol ($n=61$)	Placebo ($n=63$)	Inferential statistics	
	M (SD)	*M* (SD)	*t* (122)	*d*
Retrospective memory				
Immediate recall	24.4 (4.6)	27.0 (4.2)	3.17**	0.57
Delayed recall	8.1 (2.3)	9.2 (1.8)	3.00**	0.53
Executive function				
Cognitive initiation	58.5 (12.1)	61.3 (13.1)	1.26	0.23
Inhibitory control	6.2 (1.0)	6.4 (0.9)	1.93	0.21
Cognitive flexibility	40.7 (25.7)	34.3 (17.9)	1.61	0.29

**$p < 0.001$.

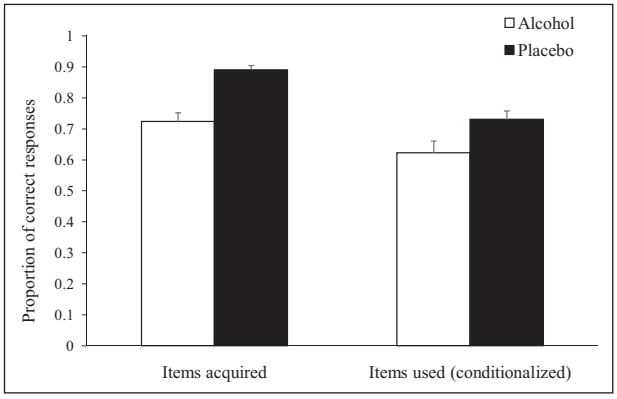

Figure 2. Mean proportion of the number of items acquired and used as a function of condition (alcohol, $n=61$; placebo, $n=63$). Items acquired are expressed as a proportion of seven possible items. Items used are expressed as a proportion of acquired items that were used. Error bars represent mean standard error.

placebo) and *sex* (males, females), and the within-subjects factor of *foresight task* (items acquired, items used). The data contributing to these analyses are shown in Figure 2. The results revealed no three-way interaction between condition, sex and foresight task, $F(1,120)=1.28$, $p=0.26$, $\eta^2_p=0.01$, nor any two-way interactions: foresight task and condition, $F(1,120)=1.26$, $p=0.26$, $\eta^2_p=0.01$; foresight task and sex, $F(1,120)<0.01$, $p=0.99$, $\eta^2_p<0.01$; and sex and condition, $F(1,120)=1.22$, $p=0.27$, $\eta^2_p=0.01$. The main effect of sex was also not significant, $F(1,120)<0.01$, $p=0.94$, $\eta^2_p<0.01$. However, a main effect of condition was identified, $F(1,120)=21.06$, $p<0.001$, $\eta^2_p=0.15$, with participants in the alcohol condition ($M=0.7$, SD=0.2) exhibiting poorer performance than those in the placebo condition ($M=0.8$, SD=0.2). There was also a main effect of foresight task, $F(1,120)=23.66$, $p<0.001$, $\eta^2_p=0.17$, with proportion of items acquired ($M=0.8$, SD=0.2) greater than the proportion of items subsequently used (conditionalized; $M=0.7$, SD=0.3). Descriptive statistical measures for the proportion of correct items acquired and items used (conditionalized) as a function of condition (alcohol, placebo) are displayed in Figure 2.

Table 3. Correlations between item acquisition and item use on *VW-Foresight* with retrospective memory, and executive control, reported separately for the alcohol and placebo conditions.

Measure	Alcohol condition ($n=61$)		Placebo condition ($n=63$)	
	Acquisition	Use	Acquisition	Use
Retrospective memory				
Immediate recall	0.53**	–0.01	–0.01	–0.04
Delayed recall	0.40**	0.05	0.11	–0.15
Executive control				
Cognitive initiation	0.18	0.18	0.04	0.05
Inhibitory control	0.08	0.37**	0.07	0.18
Cognitive flexibility	–0.09	–0.31*	–0.17	–0.11

*$p < 0.05$. **$p < 0.01$.

Cognitive correlates of episodic foresight

Correlations between *VW-Foresight* and the measures of retrospective memory and executive control are reported in Table 3, separately for the two conditions. For the alcohol condition, poorer item acquisition was associated with poorer retrospective memory, as indexed by both immediate and delayed recall, while reduced item use was associated with poorer inhibitory control and cognitive flexibility. In the placebo condition, no significant correlations were identified.

Discussion

The present study provides the first test of how acute alcohol use influences the ability to use episodic foresight to guide future-directed behaviour. The results showed that, relative to participants in the placebo condition, a moderate level of alcohol intoxication was associated with lower acquisition of the essential items necessary to resolve the presented problems, as well as a reduced likelihood of subsequently using these acquired items when these problems were re-presented. These results therefore reveal that this fundamental human capacity is disrupted by a level of alcohol consumption that would not be considered particularly high in modern society. Indeed, the level of alcohol in the current study was 0.6 g/kg which produces a BAC that is only slightly above Australia's legal driving limit (0.05%), but below that of other countries such as the United States and England, where the legal driving limit is currently 0.08%. Thus, this level of alcohol consumption (0.06–0.07%) would likely be commonly reached in social drinkers but would not be a level that people consider themselves to be intoxicated or cognitively impaired to a notable degree.

Given the critical adaptive importance of episodic foresight, any impairment in this capacity might lead to suboptimal decision-making and potentially contribute to many of the functional problems commonly associated with alcohol consumption (Field et al., 2010). In the context of alcohol use, problems with episodic foresight may cause and/or reinforce the tendency to prioritize current needs over future goals that may potentially be more beneficial. Some of the most common deleterious behaviours associated with alcohol use include precisely these types of behaviours – such as an increase in sexual risk-taking, aggression

and drink driving. Thus, it appears likely that a reduced capacity to appropriately assess potential future dangers, and carefully plan any actions before engaging in them to mitigate potential risk of harm, might contribute to these types of maladaptive behaviours.

The current findings also align with broader cognitive theorizing on alcohol's myopic effects. As noted earlier, alcohol myopia is a cognitive-physiological theory that attributes many of alcohol's effects to a narrowing of perceptual and cognitive function in which only the most salient stimuli are perceived and therefore responded to. The current findings suggest one of the cognitive mechanisms that might contribute to these myopic effects is a reduced capacity for episodic foresight. The next important steps in this literature are therefore to directly test how any breakdown in engaging episodic foresight is linked to the suboptimal decision-making and risky behaviours associated with alcohol intoxication – and to test the value of therapeutic interventions that involve deliberately engaging episodic foresight in people who struggle with alcohol misuse.

The second key contribution of the current study was to provide initial insights into whether the episodic foresight difficulties reflected a primary disturbance associated with alcohol use or was instead a secondary consequence of a breakdown in broader cognitive abilities. Uniquely for participants in the alcohol condition, a significant positive association was identified between one of the indices of episodic foresight (item acquisition) and both measures of retrospective memory. These results therefore suggest that reductions in episodic foresight associated with acute alcohol consumption may, at least in part, be a secondary consequence of broader retrospective memory impairment. One of the ways in which this may occur is by interfering with the process of remembering the initial problem to be solved and acting accordingly.

Interestingly, however, there was no evidence that problems with executive function contributed to the problems with episodic foresight seen in the alcohol use group. It is possible that these null findings reflected a specific problem with the executive control tasks selected. For instance, there has been some debate concerning whether measures of phonemic fluency do tap into executive control (Whiteside et al., 2016), and even if they do index this construct, task performance is also contingent on other cognitive abilities such as language function, processing speed, sustained attention, and so on. However, most, if not all other, executive control tasks suffer this same problem of not being 'pure' indicators of executive control, and associations between *VW-Foresight* and at least some of the executive control measures used here have been identified in other groups (see e.g., Lyons et al., 2014; Terrett et al., 2017). The absence of an association between executive control and episodic foresight in the present study therefore seems unlikely to be attributable to the choice of executive control tasks selected. Nevertheless, future research should endeavour to use different indicators of executive control distinct from those used here to more confidently conclude that executive losses do not contribute to poorer episodic foresight following alcohol consumption. In addition, given that evidence that alcohol disrupts executive control is mixed and grows harder to find at low doses (Zoethout et al., 2011), it would be valuable to assess whether the null effects and associations identified here also emerge at higher levels of alcohol intoxication.

The final key finding to emerge was in relation to the absence of sex differences in episodic foresight following the administration of a moderate dose of alcohol. Consistent with past research, females in the alcohol condition obtained a higher BAC level than males (Mumenthaler et al., 1999), even though the dose of alcohol administered was equivalent to the dose of alcohol provided to males and adjusted to account for body weight. Future studies might consider providing lower doses to females to avoid this discrepancy. However, females in the alcohol condition acquired a similar number of items to males in the alcohol condition and did not differ from males in their subsequent item use once initial item acquisition was accounted for. These data show that males' and females' capacity levels for episodic foresight were adversely affected by acute alcohol ingestion to a comparable degree.

Strengths and limitations

The current study had important strengths that included a well-powered design, as well as use of the only behavioural measure suitable for adult populations that currently meets strict criteria for episodic foresight. Nevertheless, several limitations need to be acknowledged. First, although *VW-Foresig*ht attempts to reflect real-life activities, the next important step in this literature is to directly measure episodic foresight using more ecologically valid methods. This will be challenging to achieve, but some important insights might be gained via experience sampling approaches, as well as immersive technologies. In the context of alcohol use specifically, this would greatly strengthen any conclusions that could be made about the specific mechanisms by which failures in episodic foresight might contribute to suboptimal decision-making and maladaptive behaviours. Second, the manipulation check results revealed that both the researcher and participants correctly guessed which condition the participant had been assigned most of the time, a finding that has similarly been reported in a number of previous studies involving alcohol administration (Bisby et al., 2010; Leitz et al., 2009; Walter and Bayen, 2016). Thus, although this study used a double-blind design, this finding highlights the difficulty in effectively blinding the administration of a substance such as alcohol with highly familiar and discriminable effects, particularly when there are only two drug conditions (alcohol and placebo). It is therefore possible that performance may have been influenced by the researcher or participants' correct perception of their intoxication status, by acting in a way that either compensated for or perpetuated any impairment due to alcohol intoxication. Because asking participants what condition they were assigned to is also limited such that it alerts participants to the fact that there were two distinct conditions, future research should also take subjective ratings of intoxication level prior to revealing the placebo deception.

Finally, it needs to be acknowledged that in the present study it is not possible to rule out task order effects, particularly given the lengthy nature of the total testing protocol. Although participants were provided with alcohol at three distinct points in the testing protocol to try and create consistency in participants' BAC alcohol levels across the different assessments, differential effects of acute alcohol consumption on memory and executive control tasks have previously been identified on the ascending and descending limbs of the blood alcohol concentration curve (Pihl et al., 2003; Soderlund et al., 2005). Future studies should therefore endeavour to use a randomized testing order to mitigate any potential task order effects.

Conclusion

These data provide the first empirical evidence that the ability to use episodic foresight in a functionally adaptive way is compromised in the context of acute alcohol intoxication, and that these effects are equally deleterious for males and females. While these deficits appear to be linked to reduced retrospective memory performance, further research is needed to increase understanding of the underlying cognitive and neural mechanisms that may explain the observed impairment and to clarify how these deficits manifest in daily life. These data have important implications for current understanding of how even moderate acute alcohol use may lead to suboptimal decision-making and increased risk-taking, as well as a range of well-documented functional problems.

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Author contributions

All authors were involved in the design of the study and/or data analysis and/or interpretation. All authors have contributed to and have approved the final manuscript.

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Supplemental material

Supplemental material for this article is available online.

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