An Investigation of Episodic Future Thinking, Episodic Foresight, and Prospective Memory in the Context of Acute Alcohol Consumption

Morgan Elliott

Bachelor of Science, Bachelor of Psychological Science (Honours)

Submitted in total fulfilment of the requirements for the degree of

Doctor of Philosophy

Submitted in partial fulfilment of the requirements for the degree of

Master of Psychology (Clinical)

School of Behavioural and Health Sciences,

Faculty of Health Sciences,

Australian Catholic University.

23rd October 2020

Declaration

This thesis contains no material that has been extracted in whole or in part from a thesis that I have submitted towards the award of any other degree or diploma in any other tertiary institution. No other person's work has been used without due acknowledgement in the main text of the thesis. All research procedures reported in the thesis received the approval of the relevant Ethics Committees (where required).

Signed: 

Date: 23/10/2020

Acknowledgements

Submitting my thesis feels bittersweet. After 100 + days in lockdown due to a global pandemic, isolated from my family and friends, I would say my thesis has become my best friend, my purpose, my biggest stressor, and my greatest challenge. I am sad that it is finished, but relieved that it is over. It is time to celebrate my PhD on alcohol, with alcohol.

"You ought to be thankful, a whole heaping lot, for the places and people [that helped you a lot!]" – Dr Suess

To my supervisors: To my principal supervisor, Associate Professor Gill Terrett, I am forever grateful for your support and guidance over the past six years. From Honours through to Masters/PhD, I often reflect on how lucky I was to begin my research with you all those years ago. I have learned and grown so much under your guidance. Thank you for your invaluable feedback on my many many drafts, for setting deadlines, for always being ready and willing to meet with me, for challenging me to reach my potential as a researcher and writer, but most of all for instilling a passion for learning. I will forever marvel at your ability to craft beautifully sophisticated sentences, all the while creating a seamless story.

To my secondary supervisor, Emeritus Professor Peter Rendell, I would like to thank you for regaling me with many many stories from your time as a PhD student, professor, and supervisor, for providing a welcome distraction, and for letting yourself 'indulge' in the recollection of these memories (HAHA!). In all seriousness, I am immensely grateful for your sense of humour, your enthusiasm and encouragement, but also your expertise on every aspect of my research project. Thank you for being on call at all hours of the day and night, for talking me through various statistical analyses, for

making bold claims, and for sharing your editing and referencing tips and tricks with me.

To Gill and Peter, it has been a privilege to be supervised by you both and I wish you every happiness in ‘retirement’.

To my PhD support team: To Professor Val Curran, thank you for your invaluable contribution to my research project, for suggesting that I administer alcohol, for your expertise and guidance in setting up the testing protocol, for your enthusiasm in reviewing my results, and for taking the time to provide feedback on my papers. Although COVID-19 may have spoiled my plans to visit your lab and attend a conference in Europe, I am hopeful for the future.

To Professor Julie Henry, I am thankful for your constructive feedback on my papers and especially, your ‘brutal culling skills’.

To the Cognition and Emotion Research Centre staff, Natalie, Bernardo, Laila, and Jennie, I cannot thank you enough for your contributions to my project. To Natalie, I am so grateful for your assistance in setting up and conducting my project, from the ethics application, to participant recruitment and testing. Your passion and willingness to assist me have been unrivalled. To Bernardo and Laila, thank you for your commitment to testing at all hours, for channelling your inner bar tender, and for doing a superb job!

To my immediate family: To my parents, Jackie and Glenn, I thank you for your unwavering love and support, for encouraging me to pursue my dreams, for providing me a shoulder to cry on, and for always picking me up when I fall. There are no words to describe my gratitude for you both. This project is as much yours as it is mine.

To my brothers, Tom and Cam, and their partners, Felicity and Molly, I thank you for always making me laugh, for listening to my rants, and for supporting me in any

way you can. It's been four looong months since I've seen you all, and I miss you dearly.

Last but not least, to Josh, my best friend, my biggest support, my lockdown cellmate, thank you for tolerating me, for bearing the brunt of my mood swings, and for sharing my every success and failure. I especially appreciate you for always taking the time to make me laugh, to try and calm me down, and to provide me with the occasional words of wisdom ("It is what it is" and "Stick with it, darl").

To my extended family: To my grandparents, Jenny and Stan, Marj and Bill, I thank you for your enthusiasm and always checking how I was going with my studies. A special thank you to my Aunty Denise for instilling my passion for research and encouraging me to undertake a PhD during my time in England. You have inspired me more than you know. Also, to my Aunty Julie and cousin Bridget, thank you for checking in on me, particularly during Melbourne's lockdown. I am excited to celebrate the completion of this project with you all!

To my fellow PhD students and friends: To Kate and Serene, I don't think anyone understands this experience quite like you do. Thank you for validating my struggles and always being my first point of call when I need to ask a 'dumb' question or vent about something PhD, iThenticate, or stats-related. An especially special thank you to you, Kate. We have studied together since Honours in 2015, and I honestly don't think I could have done this without you. Congratulations to you for submitting your own thesis in this crazy year! You're going to do great things.

Finally, to my participants: To those who generously donated their time to 'getting paid to have a couple of drinks and play some games' with me, I thank you, as without you, I would have no thesis.

Abstract

Background and Objectives: This research project aimed to investigate the effect of a moderate dose of alcohol on three key forms of prospection, namely episodic future thinking (EFT), episodic foresight, and prospective memory (PM). To date, limited research has directly examined the effect of acute alcohol consumption on prospection, with no studies investigating EFT or episodic foresight in the context of acute alcohol use, and only five studies investigating its effect on PM. Furthermore, very little is known about the cognitive abilities that have been proposed to underpin these forms of prospection, and thus, what may drive any acute alcohol-related impairment in these abilities. Additionally, research investigating the interrelations between the various forms of prospection is scarce, with the majority of empirical studies to date having investigated these abilities in isolation. Three empirical studies were therefore devised to directly investigate the effect of acute alcohol use on EFT, episodic foresight, and PM, as well as their potential cognitive underpinnings, and their interrelations. Specifically, Study 1 aimed to provide the first empirical assessment of EFT following a moderate dose of alcohol, and to examine if any observed difficulties were underpinned by acute alcohol-related difficulties in retrospective episodic memory and/or executive dysfunction. Study 2 aimed to provide the first empirical assessment of episodic foresight following a moderate dose of alcohol, and to examine the extent to which any observed impairment may be contributed to by difficulties in retrospective memory, executive functions, and/or EFT. Study 3 aimed to extend past research by clarifying the nature and magnitude of acute alcohol-related impairment in PM. In addition, Study 3 investigated the cognitive abilities that have been proposed to underpin PM, namely retrospective memory, executive functions, and EFT. Finally, this

research project investigated sex differences in each of the key forms of prospection assessed.

Method and Results: A single sample of 124 healthy adult social drinkers aged 18-37 years were recruited and randomly assigned to either the alcohol (n = 61) or placebo (n = 63) condition in a double-blind independent group design. Participants were administered a dose of 0.6g/kg alcohol or a matched placebo drink and completed a comprehensive battery of measures selected to address all research questions of the three studies. Study 1 identified that EFT was impaired by acute alcohol consumption, and that this impairment was underpinned by difficulties engaging in retrospective episodic memory, but not executive functions. Study 2 found that episodic foresight was also impaired by acute alcohol use, and that acute alcohol-related deficits in retrospective memory contributed to episodic foresight performance in the alcohol group. However, executive functions and EFT were not found to underpin episodic foresight performance. Study 3 identified pervasive impairments in PM following acute alcohol consumption, but did not identify any contribution of retrospective memory, executive function, or EFT in PM performance. Finally, the results showed no sex differences in performance on any of the three forms of prospection following acute alcohol consumption.

Conclusions: Overall, this research project provided novel insights into the effect of acute alcohol consumption on cognition and suggests that prospection may be highly sensitive to the adverse effects of acute moderate alcohol consumption. Further research is now needed to clarify the mechanisms through which acute alcohol use induces impairment in these forms of prospection. Future research should also consider replicating this study using a range of doses of alcohol to produce a dose-response curve. These results increase understanding about the difficulties associated with

consuming even a moderate dose of alcohol and have significant implications for policy making and the treatment of individuals with an alcohol use disorder.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

AI	Adapted Autobiographical Interview
ANOVA	Analysis of Variance
AUQ	Alcohol Use Questionnaire
BAC	Blood Alcohol Concentration
EFT	Episodic Future Thinking
FSIQ	Full Scale IQ
GABA	Gamma-aminobutyric
HADS	Hospital Anxiety and Depression Scale
HVLT-R	Hopkins Verbal Learning Test- Revised
PM	Prospective Memory
TMT	Trail Making Test
VW-Foresight	Virtual Week- Foresight
VW-PM	Virtual Week- Prospective Memory

Chapter 1: Thesis Introduction and Overview

1.1 Thesis Structure

This thesis comprises eight chapters. The current introductory chapter (Chapter 1) provides an overview of the thesis, its structure, and the research area of interest (i.e. acute alcohol consumption and prospection), as well as the rationale and aims of the research project. Chapter 2 provides a critical review of the three key forms of prospection central to this thesis, namely episodic future thinking (EFT), episodic foresight, and prospective memory (PM), including definitions, a review of the cognitive abilities that have been proposed to underpin them, and methods of assessment. Chapter 3 provides a review of the research to date investigating the effect of acute alcohol consumption on prospection and its proposed cognitive underpinnings. Chapter 4 provides a complete and detailed methodology for the empirical work undertaken in this thesis, covering the recruitment process, the measures used, and procedures employed. Chapter 5, 6, and 7 report the three empirical studies that were undertaken to address key gaps identified in the research literature to date. These chapters are written as three standalone empirical papers and therefore necessarily contain some repetition of information from the previous chapters. The first empirical study (Chapter 5) investigated the effect of acute alcohol consumption on EFT and the cognitive abilities that have been proposed to underpin it. The second empirical study (Chapter 6) investigated episodic foresight and its potential contributors following acute alcohol consumption. The third and final empirical study (Chapter 7) investigated PM and its cognitive underpinnings in the context of moderate alcohol consumption. Finally, Chapter 8 concludes the thesis with a general discussion of the findings from the three empirical studies, as well as contributions, implications, directions for future research in this area, and strengths and limitations of the current project.

1.2 Alcohol in Australian Society

Alcohol represents an integral part of Australian culture and is generally seen by Australians as a way to relax, to socialise, to celebrate achievements and to enjoy life. Day-to-day, many Australians drink to unwind after work, while on weekends many look forward to the opportunity to have a few drinks and relax and socialise with friends and family. Alcohol also plays a significant role in celebrating special occasions, such as birthdays, weddings, and graduations, and is often seen as a way to enhance these celebrations. However, alcohol use is not restricted to personal and social events, with alcohol consumption also frequently occurring within the workplace. From 'pub lunches' with workmates, to work functions and office celebrations, drinking alcohol is seen as a way for individuals to engage socially and connect with co-workers on a range of levels.

It is therefore not surprising that alcohol is the most widely used psychoactive substance in Australia (Australian Institute of Health and Welfare [AIHW], 2019), largely consumed for relaxation, social, and mood-enhancing purposes (Abbey et al., 1993; Doyle et al., 2011; Farber et al., 1980). Although most people consume alcohol at a level that is low in immediate risk most of the time, it also presents a significant source of harm to society. Well-documented alcohol-related harms include an increased risk of physical illness and injury, psychological consequences such as anxiety and memory loss, violence, crime, sexual risk-taking, road accidents and related deaths, and financial strain (Brewer & Swahn, 2005; Chikritzhs et al., 2001; Field et al., 2010; Fillmore, 2007). Moreover, alcohol is the most abused drug in Australia, with approximately one in ten drinkers likely to meet diagnostic criteria for an alcohol use disorder (AIHW, 2019). Alcohol use disorders not only severely impact the health and wellbeing of the person with the disorder, increasing the risk of the individual

developing a range of serious health problems, but they also contribute to significant socioeconomic strain (Rehm & Shield, 2019). The harms associated with alcohol use reinforce the importance of research in this area to better understand the mechanisms involved and inform policy development in order to prevent or reduce adverse outcomes for individuals who consume alcohol and society as a whole. In particular, it is important to understand the adverse effects of acute alcohol consumption, which refers to the immediate effects of alcohol ingestion, given its widespread use in the community.

1.3 Effects of Acute Alcohol Consumption

Alcohol contains ethanol, a central nervous system depressant drug that is produced by the fermentation of sugar. Once ingested, alcohol is absorbed into the bloodstream through the stomach and small intestine, and is then distributed to the central nervous system and various organs in the body, including the brain (Marco & Kelen, 1990). Alcohol begins to exert its psychoactive effects approximately 5 minutes following consumption but reaches peak concentration at around 30-45 minutes post ingestion. The effect of acute alcohol consumption depends on its concentration in the blood (blood alcohol concentration [BAC]) which is determined by how quickly it is absorbed, diluted, metabolised, and excreted by the body (Zakhari, 2006). Alcohol is metabolised by the liver at a rate of approximately one standard drink per hour (containing about 10 grams of alcohol), leaving excess alcohol to circulate throughout the body in the bloodstream. Thus, rapid consumption of multiple alcoholic drinks results in a higher BAC. BAC is also influenced by factors including age, sex, ethnicity, physical condition, family history, use of drugs and prescription medication, amount of food present in the stomach, the type of alcohol consumed, and the rate of alcohol

consumption, and therefore varies from one individual to another (Cederbaum, 2012; Zakhari, 2006).

Acute alcohol consumption has been associated with a range of physical side effects, which are a function of the quantity of alcohol consumed (Vonghia et al., 2008). In general, research suggests that at low to moderate doses (BAC = 0.05% to 0.1%), alcohol induces relaxation, followed by dizziness, slurred speech, and a loss of coordination and control over body movements as BAC increases (Vonghia et al., 2008). Many people who consume alcohol at this level do not experience any lasting health consequences. However, when alcohol is consumed in excess, individuals may experience a hangover, which is characterised by headache, nausea, and fatigue, usually the day after drinking (Wiese et al., 2000). At high to extremely high doses (BAC = 0.2% to 0.4%), alcohol may induce nausea and vomiting, double vision and amnesia, with an increased risk of respiratory depression, coma, and even death (Vonghia et al., 2008).

Due to the structural properties of alcohol, it can passively diffuse through the bloodstream and into the brain where it causes significant changes in the physical properties of cell membranes and disrupts the function of various proteins involved in synaptic transmission (Charness, 1990). Specifically, alcohol increases levels of the inhibitory neurotransmitter, gamma-aminobutyric (GABA), whilst also decreasing levels of the excitatory neurotransmitter (glutamate), which lead to a reduction in neural activity and affect healthy brain functioning (Charness, 1990; Jacob & Wang, 2020; Zorumski et al., 2014). Additionally, alcohol increases levels of dopamine in the brain's reward centre, which enhances the sense of pleasure the individual experiences while drinking alcohol (Charness, 1990). Imaging studies suggest that the effect of acute alcohol use stems from altered cellular activity in a wide range of brain regions

including the cerebral cortex, cerebellum, hypothalamus, pituitary, hippocampus, and medulla (Jacob & Wang, 2020; Oscar-Berman & Marinković, 2007; Van Skike et al., 2019; White et al., 2000). The presence of these changes in cellular activity provides a neurobiological basis for the association between acute alcohol use and a number of well-documented changes in psychomotor performance, subjective mood states, and cognitive functioning (Eckardt et al., 1998; Fillmore, 2007; Holloway, 1994; Hull & Bond, 1986; Weissenborn & Duka, 2003).

1.4 Sex Differences in Alcohol Pharmacokinetics and Effects on the Brain

There is some evidence to suggest sex differences in the impact of alcohol consumption due to sex differences in the pharmacokinetics of acute alcohol use (Erol & Karpyak, 2015; Haut et al., 1989; Jones & Jones, 1977; Mumenthaler et al., 1999). More specifically, whilst evidence suggests that males and females eliminate approximately the same amount of alcohol per unit of body weight per hour (i.e. elimination rate; Frezza et al., 1990; Kwo et al., 1998), females eliminate significantly more alcohol per unit of lean body mass per hour (i.e. disappearance rate; Ammon et al., 1996; Thomasson, 2002). Despite this, females appear to achieve a higher BAC than males after drinking equivalent amounts of alcohol, even when the dose has been adjusted to account for body weight (Ammon et al., 1996; Cole-Harding & Wilson, 1987; Ely et al., 1999; Frezza et al., 1990; Taylor et al., 1996). This finding has been partly attributed to differences in body composition, as a male's body typically contains more water and less body fat than a female's body (Cederbaum, 2012; Frezza et al., 1990). Therefore, as alcohol is dispersed in body water, females obtain a higher BAC than males (see Mumenthaler et al., 1999 for a review). In addition, high blood alcohol levels appear to persist for a longer duration in females, which is attributed to the

smaller volume of distribution of alcohol within the females body (Baraona et al., 2001).

There is also some evidence to suggest that sex differences in hormonal levels may contribute to variability in alcohol metabolism (Erol & Karpyak, 2015; Ramchandani et al., 2001). For example, a study by Dettling et al. (2008) found that increased serum progesterone levels were associated with increased alcohol elimination rate in females, but not in males. Conversely, evidence suggests that menstrual cycle-related changes in oestradiol and progesterone levels do not affect alcohol metabolism (Lammers et al., 1995; Mumenthaler et al., 1999).

In addition to sex differences in pharmacokinetics and hormone levels, there is some evidence to suggest sex differences in the effect of acute alcohol use on the brain and neurotransmitter release. In relation to acute alcohol use and the brain, Rickenbacher et al., (2011) found that alcohol resulted in bilateral increases in arterial perfusion in frontal regions of the brain in males, but not in females, which has been proposed to contribute to differences in alcohol intoxication. Differential patterns of neurotransmitter release have also been identified in males and females. For example, a study by Urban et al. (2010) identified a significant positive correlation between ventrostriatal dopamine release and alcohol-induced subjective behavioural activation in men, but not in women. Together, these findings regarding sex differences in pharmacokinetics, hormones, neurotransmitter release and alcohol effects on the brain raise the possibility of sex differences in the effect of acute alcohol consumption on cognition, however research in this area is remains limited and requires further investigation (Erol & Karpyak, 2015; Mumenthaler et al., 1999).

1.5 Introduction to Cognitive Functioning Following Acute Alcohol Consumption

There is a large body of literature investigating the effect of acute alcohol consumption on cognition. Historically, alcohol was believed to produce a global reduction in brain function (Wallace, 1932). However, towards the end of the 20th century, a substantial amount of evidence indicated that alcohol actually selectively effects neural activity, resulting in specific deficits in brain function (Crews et al., 1996; Criswell et al., 1993). Consistent with these findings, more recent behavioural evidence suggests that the effect of alcohol on cognition is not as global as previously assumed (White et al., 2000), with evidence of selective impairments in various cognitive abilities, including memory (Curran & Hildebrandt, 1999; Söderlund et al., 2007; White et al., 2000), decision making (George et al., 2005), and executive functions (Day et al., 2015; Giancola, 2000), such as working memory (Boha et al., 2009; Fillmore et al., 2009), planning (Montgomery et al., 2011; Weissenborn & Duka, 2003), cognitive flexibility (Day et al., 2014; Guillot et al., 2010), and inhibitory control (Abroms et al., 2003; Abroms et al., 2006; Curtin & Fairchild, 2003; Fillmore et al., 2000; Finn et al., 1999). However, one area of cognition that has largely been neglected in this field of research is the capacity for prospection. This area of cognition is therefore the focus of the current thesis.

One critical issue of note highlighted in the existing literature investigating the effect of alcohol on cognition is the importance of considering alcohol dosage. More specifically, this research suggests that the impact of alcohol on cognition depends on the alcohol concentration level in the blood (i.e. BAC), and typically occurs on a dose-related continuum such that the greater the dose of alcohol, the greater the impairment in cognitive functioning (Dry et al., 2012; Field et al., 2010; Fillmore, 2007; Ryback,

1971; White, 2003). However, it has also been noted that the dose of alcohol required to produce some degree of impairment varies according to the complexity of the cognitive task, with more effortful tasks typically impaired at lower doses of alcohol (Field et al., 2010; Fillmore, 2007), somewhat less demanding tasks generally impaired at moderate doses of alcohol (BAC greater than 0.06%; Day et al., 2015; George et al., 2005; Holloway, 1994; White, 2003), and simple tasks reportedly unaffected by much higher doses of alcohol (BAC greater than 0.08%; Fillmore, 2007; Holloway, 1994). The empirical studies in this thesis focus on the effect of a moderate dose of alcohol on prospection.

1.6 Introduction to Prospection

Prospection has been the subject of increasing attention within psychology and neuroscience research in the past decade and encompasses a broad range of future-oriented cognitive abilities that involve the capacity to mentally represent future events (Gilbert & Wilson, 2007; Seligman et al., 2013; Szpunar et al., 2014). For example, people simulate plausible future events and encounters with friends, family, and colleagues, they regularly make predictions about the outcome of an event, such as who will win a sporting match, they form intentions to complete actions, such as taking prescription medication and attending appointments, and they plan events, such as birthdays, daily routines, and future vacations. Indeed, people spend a significant proportion of their day simulating, predicting, forming intentions, and planning, all of which reflect future-oriented thought (D'Argembeau et al., 2011). Furthermore, these future-oriented cognitive abilities have recently been conceptualised as a taxonomy of interrelated abilities that may build on and interact with one another (Szpunar et al., 2014, 2016). Prospection has major survival implications as it allows a person to mentally assess potential threats and plan their actions accordingly (Suddendorf &

Corballis, 2007). Furthermore, these abilities have been consistently linked to independence and a wide range of functional behaviours necessary for daily functioning (Suddendorf et al., 2009; Suddendorf & Henry, 2013). It is therefore not surprising that a reduced capacity for such future-oriented thinking has been found in a number of clinical groups that exhibit poor daily functioning, including substance users (e.g. Griffiths et al., 2012; Mercuri et al., 2015; Mercuri et al., 2018; Terrett, Lyons, et al., 2016).

Despite general acceptance of the critical functional importance of prospection and evidence of deficits in clinical populations, limited research to date has directly examined the effect of acute alcohol consumption on different forms of prospection. To address this, the current thesis focuses on the effect of acute alcohol consumption on three specific forms of prospection; EFT, episodic foresight, and PM. EFT refers to the ability to simulate a personal future event (Atance & O'Neill, 2001), such as imagining a conversation with a friend or imagining yourself providing a presentation at university. In contrast, episodic foresight refers to the functional capacity to use the simulation of a future event to organise current behaviour in anticipation of the future (Lyons et al., 2014; Suddendorf & Moore, 2011). This is illustrated, for example, when a person who imagines going out for dinner immediately after work chooses to pack a change of clothes before leaving the house in the morning. The final form of prospection, PM, refers to the capacity to remember to perform a task at a specific future time point (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007), such as remembering to buy bread when at the supermarket, or remembering to make a doctor's appointment at 9am. No studies to date have examined the effect of acute alcohol consumption on EFT or episodic foresight, while only five studies have investigated PM following alcohol consumption. A reduced capacity for these forms of prospection in

the context of acute alcohol use may present one plausible explanation for the increased likelihood of a person engaging in suboptimal decision making and increased risk taking whilst under the influence of alcohol (Field et al., 2010). Thus, an investigation into EFT, episodic foresight, and PM in the context of acute alcohol use is necessary to gain a greater understanding of the effect of acute alcohol consumption on cognition, whilst also providing valuable insights into why individuals engage in deleterious behaviours under the influence of alcohol.

1.7 Objectives of the Current Research Project

The overall objective of the current research project was to examine the effect of a moderate dose of alcohol on prospection in social drinkers. Three empirical studies were conducted to address research questions regarding three specific forms of prospection (i.e. EFT, episodic foresight, and PM) in the context of acute alcohol consumption. These studies are reported in three separate chapters in the current thesis (Chapters 5, 6, and 7).

1.7.1 Study 1

No studies to date have investigated the effect of acute alcohol consumption on EFT. Therefore, the first empirical study was designed to provide the first direct assessment of EFT following a moderate dose of alcohol. In addition, this study explored other cognitive abilities that have been argued to be important for EFT and may therefore contribute to any observed impairment, namely retrospective episodic memory and executive functions. As an exploratory component, this study also examined sex differences in EFT performance following alcohol administration. Thus, the aims of the first study were:

- To investigate if EFT performance was impaired following a moderate dose of alcohol.

- To examine whether any observed impairments in EFT were underpinned by acute alcohol-induced deficits in retrospective episodic memory or executive functions.
- To examine sex differences in EFT following acute alcohol consumption.

1.7.2 Study 2

The second empirical study was conducted to provide the first experimental investigation of the effect of a moderate dose of alcohol on episodic foresight. In addition, this study also addressed the potential role of retrospective memory, executive functions, and EFT in any identified alcohol-related impairments in episodic foresight and explored sex differences in performance as an exploratory component. As such, the aims of the second empirical study were:

- To investigate, for the first time, whether acute alcohol consumption adversely affected episodic foresight.
- To examine whether acute alcohol consumption adversely affected cognitive abilities proposed to underpin episodic foresight, namely retrospective memory, executive functions, and EFT, and if any difficulties were related to impairment in episodic foresight.
- To examine sex differences in episodic foresight following acute alcohol consumption.

1.7.3 Study 3

Given the limited and mixed findings in studies investigating the effect of acute alcohol consumption on PM, the third empirical study was conducted to clarify the nature and magnitude of PM impairment following a moderate dose of alcohol. The third study also examined cognitive abilities that may underpin acute alcohol-related PM impairment, including retrospective memory, executive functions, and EFT. In

addition, as an exploratory component, this study also examined the potential for sex differences in PM performance in the context of acute alcohol use. The aims of the third study were therefore:

- To clarify the nature and magnitude of PM impairment following acute alcohol consumption.
- To investigate the effect of acute alcohol use on cognitive abilities that have been suggested to contribute to PM, including retrospective memory, executive functions, and EFT, and to identify if these abilities may underpin PM performance.
- To examine whether sex differences emerged in PM performance following a moderate dose of alcohol.

Chapter 2: A Review of Episodic Future Thinking, Episodic Foresight and Prospective Memory

Preamble

This chapter provides a review of the three forms of prospection that are the focus of this thesis, namely episodic future thinking (EFT), episodic foresight, and prospective memory (PM). The chapter defines each of the constructs and discusses the cognitive mechanisms that have been proposed to underpin these abilities, in addition to identifying the various methods of assessment used to assess each of these constructs.

2.1 Definition of Episodic Future Thinking

EFT refers to the ability to imagine or pre-experience future personal events by simulating oneself in hypothetical situations (Atance & O'Neill, 2001; Schacter et al., 2008; Szpunar, 2010). The application of EFT can range from everyday plans such as imagining what to wear to dinner tonight, to more complex scenarios, such as imagining oneself attending a job interview in three weeks' time. EFT comprises two key features which differentiate it from other forms of prospection. The first key characteristic of EFT is the incorporation of autonoetic consciousness, which refers to a person's awareness of their own existence in the past, present, and future (Atance & O'Neill, 2001; Tulving, 1985). Autonoetic consciousness is central to experiencing events in subjective time and thus, EFT, as without it, humans are left with only general knowledge of the event (Suddendorf & Corballis, 2007; Tulving, 2002). For example, *imagining* yourself having dinner at a restaurant, which involves autonoetic consciousness and EFT, can be differentiated from *knowing* the name of the restaurant that you are imagining attending. The latter ability is often referred to as semantic future thinking. The second key characteristic of EFT is that the event being imagined must be *plausible* and grounded in reality (Szpunar, 2010). Although it is possible to imagine an endless number of scenarios with any combination of people, places, and objects, EFT refers to the ability to imagine *specific* events that are *relevant* to the person and their life circumstances, and thus further differentiates EFT from broader types of future thought such as daydreaming (Atance & O'Neill, 2001, 2005; Szpunar, 2010). For example, imagining yourself being interviewed for a job that you have just applied for, which involves engaging in EFT, can be differentiated from imagining that you win the lottery and will never have to work a day in your life.

Humans spend a significant amount of time engaged in thinking about the future, a large proportion of which is devoted to EFT (Barsics et al., 2016; D'Argembeau et al., 2011). Furthermore, evidence suggests that EFT is a fundamental human capacity that is involved in a variety of complex functions, including planning, decision making and problem solving, emotion regulation and coping, goal achievement, and intention formation and implementation (Schacter, 2012; Schacter et al., 2017; Szpunar, 2010). For example, EFT allows an individual to carefully plan their behaviour by pre-experiencing an event and imagining the consequences of their actions, thus enhancing the likelihood of achieving the desired outcome (Suddendorf & Corballis, 2007). Additionally, EFT has been shown to facilitate adherence to longer-term goals rather than focusing on current needs, and increases the probability of achieving a goal when used in conjunction with the formation of an intention to implement an action (i.e. implementation intentions; Gollwitzer, 1993, 1999; Gollwitzer & Bargh, 1996; Szpunar, 2010). These findings provide evidence for the prominent role that EFT plays in daily life and highlights the potential functional implications of impaired EFT. More specifically, a breakdown in EFT may represent a possible mechanism for poor functional, social, and economic outcomes.

2.1.1 Cognitive Abilities Involved in Episodic Future Thinking

Research suggests that EFT is a complex mental ability that may rely on the integration of a number of component processes including retrospective episodic memory (Schacter et al., 2007, 2008; Schacter et al., 2017; Suddendorf, 2010a), semantic memory (Irish, 2016; Irish & Piguet, 2013), executive functions (Suddendorf et al., 2009; Suddendorf & Corballis, 2007; Suddendorf & Redshaw, 2013), theory of mind (Buckner & Carroll, 2007; Suddendorf & Corballis, 2007), and relational binding (Wiebels et al., 2020). However, the exact contribution of each of these abilities to EFT

remains a source of debate within the literature (Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Schacter et al., 2008). Two cognitive abilities, namely retrospective episodic memory and executive functions, have received the most attention in recent times.

2.1.1.1 The Role of Retrospective Episodic Memory in Episodic Future Thinking

Retrospective episodic memory is a type of long-term memory that involves the encoding, storage, and retrieval specifically of past personal events and experiences (Tulving, 2001, 2002). There is an abundance of literature examining the nature of the relationship between the ability to re-experience a past event and the ability to pre-experience an event that may occur in the future, that is, retrospective episodic memory and EFT respectively (see Schacter et al., 2008; Suddendorf, 2010a; Szpunar, 2010 for reviews). In general, this research suggests that EFT relies directly on retrospective episodic memory. A prominent theory that reflects this view is referred to as the *constructive episodic simulation hypothesis* (Schacter & Addis, 2007a). This theory postulates that engaging in EFT comprises two main processes. The first of these processes is the construction phase in which memories of past personal events are accessed to provide the basic building blocks from which novel future events are simulated (Schacter et al., 2007). The second of these processes, the elaboration phase, involves holding the memory in mind and flexibly recombining it into a novel event, whilst also inhibiting the possibility of merely recounting the memory (Addis et al., 2007; Schacter & Addis, 2007a). However, this theory has recently evolved to focus more on the processes that support and connect the ability to remember the past with the ability to imagine the future, proposing that retrospective episodic memory and EFT engage the same constructive processes, in which schemas, episodic, and semantic

content are initiated, integrated, and encoded to mentally construct past and future events (Addis, 2018, 2020).

There are three major lines of support for the *constructive episodic simulation hypothesis* and the relationship between retrospective episodic memory and EFT. Firstly, there is neuropsychological evidence that patients with brain damage that resulted in a deficit in the ability to recall past personal events, also exhibited difficulties imaging the future (Hassabis et al., 2007; Klein et al., 2002; Rosenbaum et al., 2005; Szpunar, 2010; Tulving, 1985). For example, a study by Klein et al. (2002) investigated memory and future thinking ability in amnestic patient D.B. They found that D.B showed a deficit in both the ability to remember and imagine personal events (Schacter & Addis, 2007a; Szpunar, 2010). A similar result had been documented previously by Tulving et al. (1988) in amnestic patient K.C. Although these two studies only involved a single patient, additional support comes from empirical studies of clinical groups that showed impaired retrospective episodic memory and EFT relative to healthy controls, such as patients with depression (Williams et al., 1996), children with Autism Spectrum Disorder (Terrett et al., 2013), and illicit substance users (Mercuri et al., 2015; Mercuri et al., 2018). The second line of support for the *constructive episodic simulation hypothesis* comes from behavioural evidence that retrospective episodic memory and EFT develop concurrently in humans (Atance & O'Neill, 2005; Busby & Suddendorf, 2005; Spreng & Levine, 2006; Suddendorf, 2010b; Ünal & Hohenberger, 2017). More specifically, developmental studies suggest that these abilities develop simultaneously between the ages of three and five (Addis et al., 2008; Atance & Meltzoff, 2005; Atance & O'Neill, 2005; Coughlin et al., 2014). The third line of support is provided by fMRI studies that have shown similar neuronal activity when participants are directed to engage in re-experiencing a past event and pre-experiencing

a future event, which is consistent with the idea that retrospective episodic memories are accessed when imagining future scenarios (Addis et al., 2007; Okuda et al., 2003; Schacter & Addis, 2007a; Schacter et al., 2012). Neuroimaging studies suggest that these abilities engage a core brain network that includes the activation of prefrontal, hippocampal and posterior regions, and the medial temporal lobe (see Miloyan et al., 2019; Schacter et al., 2012; Weiler et al., 2010b for reviews). Together, these findings point to a key role of retrospective episodic memory in EFT.

2.1.1.2 The Role of Executive Functions in Episodic Future Thinking

Executive functions refer to a range of complex higher-order mental processes that play a critical role in the regulation of goal-directed behaviour (Lezak et al., 2004). Theoretically, executive functions are central to the initiation, organisation, and retrieval of information that is used to construct thoughts about the future (Alvarez & Emory, 2006; Schacter & Addis, 2007b; Suddendorf & Corballis, 2007). In particular, cognitive flexibility, inhibitory control, and working memory, have been proposed to play a significant role in EFT. More specifically, it has been suggested that engaging in EFT requires cognitive flexibility to not only disengage from the present moment to focus on the future, but to also reformulate past experiences to simulate hypothetical future situations (Schacter & Addis, 2007a, 2007b). Additionally, EFT is thought to require inhibitory control to impede irrelevant information, both past and present, and to disengage from the present moment, whilst also ensuring the scenario is novel and not simply a recollection of the past (Suddendorf, 2010a). Furthermore, with regards to working memory, it has been suggested that EFT requires an active space to hold and manipulate information in order to construct thoughts about the future (Suddendorf et al., 2009; Suddendorf & Corballis, 2007; Suddendorf & Redshaw, 2013). However,

there is limited empirical research directly investigating the relationship between EFT and executive functions and the findings to date have been mixed.

Of the work that has been done, there is some evidence to support theoretical arguments that executive functions contribute to EFT. For example, a study by D'Argembeau et al. (2010) investigated component processes that have been proposed to underly EFT in young adults, which included executive functions (i.e. cognitive initiation and working memory). The authors found that the executive functions assessed correlated with EFT, and proposed that these executive functions play a key role in the retrieval and organisation of information that forms novel future events (D'Argembeau et al., 2010). Support for the relationship between EFT and executive functions has similarly been found in some other studies (e.g. Cole et al., 2013; de Vito et al., 2012; Mercuri et al., 2018). In contrast, however, other studies have demonstrated a lack of an association between EFT and executive functions in adults (Addis et al., 2008; Brown et al., 2014; Irish & Piguet, 2013; Mercuri et al., 2015) and children (Hanson et al., 2014; Terrett et al., 2013). These discrepancies may reflect differences in the type and administration procedures of the EFT and executive function measures, which vary significantly between studies, thereby reducing the ability to make direct comparisons between studies. Therefore, given that empirical studies investigating the relationship between EFT and executive functions are scarce with inconsistent findings, the exact contribution of executive functions to EFT remains unclear.

2.1.2 Assessment of Episodic Future Thinking

There are two common approaches used to assess EFT outlined in the literature. The first involves thought-sampling procedures, which have primarily been used to assess EFT outside of the laboratory and generally involve participants monitoring the frequency and content of their thoughts in daily life. Historically, participants were

asked to estimate the frequency with which they had various thoughts over the course of the day (Singer & Antrobus, 1963, 1972), or to carry a beeper and record their thought content when the beeper sounded at randomly programmed intervals (Klinger & Cox, 1987). However, more recent studies have employed a more systematic approach to thought-sampling in which participants were required to document the frequency, content, and function of their future-oriented thoughts in a diary for specific period of time (Berntsen & Jacobsen, 2008; D'Argembeau et al., 2011). For example, a study by D'Argembeau et al. (2011) asked participants to record the frequency with which they experienced future-oriented thoughts over the course of one day, and to then describe the content and function of some of their future-oriented thoughts. These thoughts were then coded and categorised as specific (i.e. EFT, referring to a specific personal event and time), non-specific (i.e. referring to a non-specific event or time), or abstract (i.e. no reference to a specific event) in nature. Overall, approximately 43% of future-oriented thoughts were classified as EFT (D'Argembeau et al., 2011).

The second approach involves word-cuing paradigms. These paradigms have been used to measure EFT primarily within laboratory settings and generally require participants to imagine and describe a personal hypothetical future scenario in response to a cue word (e.g. birthday; Addis et al., 2008), or mentally construct and describe a scene in response to a scenario cue (e.g. “imagine you’re sitting on a bench in a park”; Hassabis et al., 2007). The extended verbal description is then analysed and scored using a variety of methods to index EFT. For example, some studies categorise the details provided within the verbal response as either *internal* details (i.e. referring to episodic information that specifically relates to the event) or *external* details (i.e. referring to irrelevant information including semantic details, repetitions and error). In these studies, the total number of internal details generated about the future scenario is

used to index EFT, with a greater number of details generated considered to be representative of better EFT ability (e.g. Gaesser et al., 2011; Gott & Lah, 2014; Mercuri et al., 2015; Mercuri et al., 2018; Terrett et al., 2019). Another method commonly used to score word-cuing paradigms involves assessing the episodic specificity of the future event (see Williams & Broadbent, 1986), as measured by the ability to provide specific information about the future event, such as time and place (e.g. Busby & Suddendorf, 2005; Suddendorf, 2010b; Weiler et al., 2010a, 2010b). Deficits in EFT have been identified in a number of clinical groups using word-cuing paradigms, including individuals with schizophrenia, Autism Spectrum Disorder, and users of illicit drugs such as opiates and cannabis (D'Argembeau et al., 2008; Lind & Bowler, 2010; Mercuri et al., 2015; Mercuri et al., 2018).

2.2 Definition of Episodic Foresight

The second form of prospection of interest to the current thesis is episodic foresight which refers to the ability to imagine future events and organise current actions in anticipation of the future (Lyons et al., 2014; Suddendorf & Moore, 2011). To illustrate episodic foresight in daily life, consider the possibility that your medication will be finished by the end of the week, so you proactively make an appointment with the doctor to get a repeat prescription, and thereafter go to the pharmacy to fill the prescription and avoid running out of the medication. This example highlights the functional importance of episodic foresight, as by being able to imagine future needs and potential hazards, humans can flexibly adapt behaviour in the present and exercise predictive control over the environment, and are therefore better able to secure rewards and prevent future problems (Schacter & Addis, 2007b; Suddendorf, 2017; Suddendorf & Moore, 2011). Indeed, many complex everyday activities are believed to rely on episodic foresight, such as managing finances and food preparation (Suddendorf &

Henry, 2013). Furthermore, evidence suggests that episodic foresight has significant implications for the development of self, emotion regulation, decision making, and mental health and wellbeing (Bulley & Gullo, 2017; Suddendorf, 2017). For example, episodic foresight is proposed to encompass the ability to think ahead and contemplate one's future self and use this information to guide present behaviour. This ability therefore enables humans to make decisions in the present, such as what information to learn and what skills to acquire, with their future selves in mind, thus shaping the development of self (Suddendorf, 2017). Despite general acceptance of the critical adaptive and functional significance of this ability, however, empirical studies investigating episodic foresight are extremely limited.

2.2.1 Cognitive Abilities Involved in Episodic Foresight

There is a dearth of empirical studies investigating the cognitive abilities that may underpin episodic foresight. However, three cognitive abilities have been proposed to be contributors. These are retrospective memory, executive functions, and EFT (Schacter & Addis, 2007b; Suddendorf & Corballis, 2007; Suddendorf & Moore, 2011).

2.2.1.1 The Role of Retrospective Memory and Executive Functions in Episodic Foresight

Retrospective memory refers to the memory of general information (e.g. people, words and events) presented in the past and is one cognitive ability that has been argued to be an important contributor to episodic foresight (Suddendorf & Corballis, 2007). This is proposed to be because retrospective memory is required to remember what the original problem is (e.g. running out of medication) in order to take steps (e.g. go to the doctor) to avoid negative consequences in the future. In addition, when the opportunity arises to resolve the problem, retrospective memory is again likely to be employed as it is necessary to remember to complete the problem-solving action (e.g. remember to go

to the pharmacy to fill the prescription). Executive functions have also been argued to potentially contribute to episodic foresight performance (Suddendorf, 2017; Suddendorf & Corballis, 2007; Suddendorf & Redshaw, 2013). For example, it is possible that executive functions come into play particularly at the point when preparatory measures to solve a future problem should be enacted, arguably necessitating inhibition of ongoing normal daily activities and the application of cognitive flexibility in order to switch from one activity to another.

As previously mentioned, research investigating episodic foresight and its correlates is extremely limited. Moreover, despite sound rationales for the roles of retrospective memory and executive functions in episodic foresight, studies by Lyons et al. (2016) and Lyons et al. (2019) failed to identify any correlations between these abilities in individuals with schizophrenia, stroke patients, and healthy controls. In contrast, a study by Terrett, Lyons, et al. (2016) assessed the effect of opiate use on episodic foresight and incorporated an extensive battery of executive function measures, including assessments of cognitive initiation, planning, working memory, cognitive flexibility, and inhibitory control, to identify whether any observed deficit in episodic foresight may be related to executive dysfunction. Interestingly, they found all measures of executive function except inhibitory control correlated with episodic foresight in the control group, although only cognitive initiation and inhibitory control were associated with episodic foresight in the opiate-using group. Currently then, given the inconsistencies within the limited empirical research, firm conclusions regarding the contribution of retrospective memory and executive function to episodic foresight cannot yet be drawn.

2.2.1.2 The Role of Episodic Future Thinking in Episodic Foresight

A third key ability that has been proposed to underpin episodic foresight is EFT (Atance & O'Neill, 2001; Schacter et al., 2008; Szpunar, 2010). From a theoretical standpoint, episodic foresight has been argued to first employ the imagination of the self in the future (i.e. EFT) in order to identify future needs, which in turn leads to the performance of actions in the present to ensure that those future needs are met (Suddendorf & Moore, 2011). This would therefore suggest that EFT is a core element of episodic foresight. Surprisingly however, no published research to date has assessed the possible role of EFT in episodic foresight in either normal or clinical populations, representing a major gap in the literature.

2.2.2 Assessment of Episodic Foresight

A potential explanation for the dearth of research investigating episodic foresight is the difficulty in capturing behaviours that demonstrate this ability, as not all future-directed actions reflect episodic foresight. To address this issue, Suddendorf and Corballis (2010) proposed a set of stringent criteria that measures of episodic foresight should meet. These criteria are: "(a) the use of single trials to avoid repeated exposure to the sample stimulus-reward relationships and to demonstrate memory of a specific event, (b) the use of novel problems to avoid relative learning histories and to demonstrate cognitive processes, (c) the use of different temporal and/or spatial contexts for the crucial future-directed action to avoid cuing and to demonstrate long-term memory, and (d) the use of problems from different domains to avoid specific behavioural dispositions and to demonstrate flexibility" (Suddendorf et al., 2011, p. 27). In line with these criteria, Suddendorf et al. (2011) developed the two-rooms task primarily for use with children, in which participants are required to solve novel problems using episodic foresight. For example, participants commence the experiment

in a room that contains a triangular key and a box with a square keyhole. Participants are then taken to another room where they engage in 15 minutes of unrelated activities. They are then asked to choose one of three keys (circle, square or star) before returning to the first room. Suddendorf et al. (2011) suggest that children who are able to anticipate returning to the previously encountered problem (i.e. the inability to open the box) will be more likely to choose the square key to solve the problem, thus displaying the ability to successfully engage in episodic foresight. To date, only two published studies have utilised the two-rooms task to assess episodic foresight, both of which involved typically developing preschool children (Redshaw & Suddendorf, 2013; Suddendorf et al., 2011).

More recently, Lyons et al. (2014) developed a computerised boardgame in line with Suddendorf and Corballis (2010) criteria to assess episodic foresight in adults and children. This measure, called *Virtual Week- Foresight* (*VW-Foresight*), simulates everyday situations and requires the use of episodic foresight to resolve a range of life-like problems. In this measure, participants are required to register a problem, take an opportunity when presented to acquire an item that will help resolve the problem in the future, and use that item when the problem situation is revisited later in the game. Importantly, at each of these phases, the participant receives no prompts or instructions but rather must self-initiate the actions, thereby paralleling the demands of daily living. Using this measure, deficits in foresight have been reported in older relative to younger adults (Lyons et al., 2014), and in a number of clinical populations that exhibit difficulties with daily functioning, including individuals with schizophrenia (Lyons et al., 2016), opiate users (Terrett, Lyons, et al., 2016), and stroke patients (Lyons et al., 2019).

2.3 Definition of Prospective Memory

PM refers to the ability to remember to complete an intended action at a future point in time (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). Forgetting to remember to complete a task is a common occurrence in everyday life and generally reflects a failure of PM (Dismukes, 2012). The implications of these memory lapses are widespread, often resulting in mild irritation when a person forgets to do something minor but can also be potentially life-threatening and have devastating consequences. Examples of PM failures include forgetting to take essential medication on time or forgetting to turn off the oven after cooking dinner. PM therefore plays a critical role in health and safety-related behaviours and has important implications for daily functioning (Henry et al., 2014; Hering et al., 2018; Raskin, 2018).

Successfully remembering to do something in the future can be broken down into a number of stages. In the first stage, an individual must form an intention to carry out an action at a future point in time. This intention must then be encoded and retained in memory until the presentation of the target cue. Upon the presentation of this cue, the intention then needs to be retrieved from memory and the appropriate action executed and evaluated at the appropriate time (Ellis & Kvavilashvili, 2000; McDaniel & Einstein, 2007). PM tasks have therefore been described as having three defining features: (1) a delay between forming the intention to perform a task and the completion of this task; (2) the individual self-recalls the intended action at the appropriate point in the future, without prompting; and (3) the individual interrupts their current activity to perform the intended action (Ellis & Kvavilashvili, 2000; McDaniel & Einstein, 2007).

2.3.1 Types of Prospective Memory

PM tasks can be differentiated as being event-based, time-based, or time-check tasks, and vary in complexity. Event-based PM tasks require an individual to perform an

action when prompted by an event (e.g. remembering to take medication *at dinner*). Time-based PM tasks require an individual to perform an action at a particular time of day (e.g. remembering to catch the train *at 12am*), and time-check PM tasks require the performance of an action following a period of time (e.g. phone a friend *in 15 minutes*). Time-based and time-check tasks are generally considered to be more cognitively effortful than event-based tasks as they lack environmental cues and as such rely more on self-initiated mental activities, such as clock-checking and the monitoring of time (Einstein & McDaniel, 1990, 1996; Field & Groeger, 2004). Event- and time-based PM tasks can also be distinguished in terms of their regularity. Regular PM tasks are comprised of activities that are performed routinely (e.g. remembering to feed the dog *every night* after dinner or catch the train to work *at 8:30am every week day*), whereas irregular PM tasks include the occasional 'one-off' tasks of everyday life (e.g. remembering to buy milk when at the supermarket or attend a doctor's appointment at 4:00pm tomorrow).

2.3.2 Cognitive Abilities Involved in Prospective Memory

There are a number of cognitive abilities that have been theorised to play a role in PM function. These abilities, including retrospective memory (Burgess & Shallice, 1997b; Ellis & Freeman, 2008; Zöllig et al., 2010), executive functions (Martin et al., 2003), and more recently, EFT (Terrett, Rose, et al., 2016), have been proposed to support the various stages involved in PM (Zöllig et al., 2010). Therefore, difficulties with retrospective memory, executive function, and/or EFT may prevent the successful completion of a PM task (Graf & Uttl, 2001; McDaniel & Einstein, 2007).

2.3.2.1 The Role of Retrospective Memory in Prospective Memory

Retrospective memory has been identified to be one of the key component processes involved in PM. Theoretically, the successful implementation of a PM task

requires not only remembering *that* you have to complete a task at the specific point in time (the prospective component), but also the recollection of task content, which includes *what* you have to do and *when* you have to do it (the retrospective component; Einstein & McDaniel, 1990; Kliegel et al., 2000). Therefore, the retrospective component of PM is essential for remembering the details of the task and the circumstances in which the task is to be carried out, and relies on successfully encoding and retaining the specific information related to the PM task (Ellis & Freeman, 2008; Zöllig et al., 2010).

The claim that retrospective memory plays a key role in PM is supported by empirical studies showing an association between these two constructs in adults (e.g. Cavuoto et al., 2017; Foster et al., 2013; Henry et al., 2007; Mattli et al., 2014; Terrett, Rose, et al., 2016; Zimmermann & Meier, 2006), and in children (e.g. Mahy et al., 2018; Terrett et al., 2019; Wang et al., 2008). However, there is some evidence to suggest that the relationship between PM and retrospective memory may vary depending on the task used to assess retrospective memory and its relevance to the PM task. For example, Terrett, Rose, et al. (2016) found that retrospective memory, as measured by the recollection of PM task content (the retrospective component of the PM task), significantly contributed to PM performance in both healthy young and older adults. Conversely, they found that the contribution of retrospective memory to PM performance did not translate when using a measure of retrospective episodic memory ability as indexed by the recollection of past personal events (Terrett, Rose, et al., 2016).

2.3.2.2 The Role of Executive Functions in Prospective Memory

Executive functions, including cognitive flexibility, working memory, and inhibitory control have also been suggested to play a role in PM task performance.

Theoretically, the successful completion of a PM task requires cognitive flexibility and working memory to monitor the environment for the specific PM cue, and to disengage from the individual's current activity and switch to the PM task (Altgassen et al., 2014). Additionally, PM is proposed to necessitate inhibitory control to impede all irrelevant stimuli that may hinder the individual's ability to perform the PM task (Martin et al., 2003). However, the extent to which PM draws on these abilities is thought to vary depending on the complexity of the PM task. For example, as previously mentioned, time-based tasks are proposed to be more cognitively effortful than event-based tasks, and therefore rely more heavily on executive functions (Einstein & McDaniel, 1990, 1996).

Empirical support for the relationship between PM and executive functions, however, is scarce and findings inconsistent. There is some evidence that PM is associated with inhibitory control (e.g. Gonneaud et al., 2011; Henry et al., 2007; Rendell et al., 2009; Schnitzspahn et al., 2013), and working memory (e.g. Marsh & Hicks, 1998; Rose et al., 2010; Smith et al., 2015; West & Bowry, 2005). In contrast, a study by Altgassen et al. (2014) found no relationship between PM and executive functions including working memory, cognitive flexibility, and inhibitory control in young adults. Findings regarding the role of cognitive flexibility in PM have also been inconsistent, with evidence to suggest a relationship in healthy controls but not in clinical populations. For example, a study by Mioni et al. (2013) investigated PM and its cognitive correlates, including cognitive flexibility, in healthy controls and individuals who sustained a traumatic brain injury (TBI). They found that performance on both event- and time-based PM tasks were associated with cognitive flexibility in the healthy control group, but not the TBI group. Another study by Terrett et al. (2014) investigated PM and its cognitive correlates in healthy controls and opiate users, and

similarly found that overall PM performance was associated with cognitive flexibility in the healthy control group, but not the opiate-using group (Terrett et al., 2014). Therefore, the exact nature of the relationship between PM and executive functions remains somewhat unclear in the literature to date.

2.3.2.3 The Role of Episodic Future Thinking in Prospective Memory

Recent research has theorised that EFT may play an important role in PM performance (Schacter et al., 2008; Szpunar et al., 2016). More specifically, it has been suggested that EFT enhances the encoding of a PM task as a result of mentally simulating the performance of that action, thus increasing the likelihood of successfully completing the PM task (Atance & O'Neill, 2001; Schacter et al., 2008; Szpunar, 2010). There are three lines of evidence in support of a role of EFT in PM. The first comes from studies showing future event simulation to be an effective strategy for improving PM performance in clinical populations (Mioni et al., 2017), heavy social drinkers (Platt et al., 2016), and healthy adults (Altgassen et al., 2015; Brewer & Marsh, 2010; Neroni et al., 2014), even when under the influence of alcohol (Paraskevaides et al., 2010). This strategy requires the participant to imagine themselves performing a PM task in as much detail as possible at the time when the task is presented. For example, the task may involve remembering to go to the supermarket to buy some milk. Using future event simulation, the participant might imagine their local supermarket, walking down the aisle to retrieve the milk, and then paying for the item at the register. This strategy is thought to strengthen the encoding of the link between the PM cue and the required action, thereby increasing the likelihood of automatic retrieval of the intended action and thus the chance of successfully remembering to carry out the PM task (Foster et al., 2017). The second source of evidence in support of a relationship between PM and EFT comes from neuroimaging studies that have identified activation in overlapping regions

of the brain whilst engaging in these two cognitive abilities (Burgess et al., 2003; Schacter et al., 2007; Weiler et al., 2010b). The final line of evidence comes from research that has shown a positive correlation between PM and EFT, with better EFT performance associated with better PM performance (Terrett et al., 2019; Terrett, Rose, et al., 2016).

2.3.3 Assessment of Prospective Memory

A range of tasks have been developed to assess PM in naturalistic and laboratory-based settings. Early studies focussed on naturalistic paradigms to assess PM in daily life. These tasks typically required participants to remember to perform a task, such as remembering to call the experimenter on a specific day (e.g. Harris, 1983). More recent studies, however, have developed and utilised laboratory-based measures, such as dual-task paradigms and *Virtual Week- Prospective Memory* (*VW-PM*; Rendell & Craik, 2000). Dual-task paradigms require participants to engage in PM by performing a prescribed intention at specific points during the experiment (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). For example, participants are instructed to press a specific key on a keyboard in response to a specific cue whilst engaging in an ongoing activity that is unrelated to the PM task. Dual-task paradigms have been widely used in the PM literature across a range of clinical populations and age groups (e.g. Mäntylä et al., 2007; Phillips et al., 2018; Schnitzspahn et al., 2013; Williams et al., 2014; Zinke et al., 2010).

VW-PM, by contrast, is a computerised board game that simulates PM in everyday life. *VW-PM* is an extensively validated paradigm with strong psychometric properties (Henry et al., 2007; Rendell & Henry, 2009; Rose et al., 2010). In *VW-PM*, participants are presented with a number of different tasks that they are required to remember and execute when the appropriate cue is presented. PM cues are event (e.g. perform a task *at*

breakfast), time (e.g. perform a task *at 5pm*) and time-check (e.g. perform a task *in 2 minutes* time), thus creating conceptual distinctions between event-based, time-based, and time-check PM tasks. Moreover, *VW-PM* tasks vary in regularity, and therefore the game also provides a measure of regular (i.e. tasks are performed multiple times) and irregular (i.e. one off) tasks. Using the *VW-PM* measure, deficits in PM have been found in a number of clinical populations, such as individuals with TBI (Mioni et al., 2013), Parkinson's disease (Foster et al., 2013), multiple sclerosis (Rendell et al., 2012), schizophrenia (Henry et al., 2007), and users of illicit substances (Rendell et al., 2007; Rendell et al., 2009; Terrett et al., 2014).

Chapter 3: A Review of Acute Alcohol Consumption and Prospection

Preamble

This chapter provides a review of the limited empirical research investigating the effect of acute alcohol consumption on episodic future thinking (EFT), episodic foresight, and prospective memory (PM) and their underpinning cognitive abilities. This chapter concludes by outlining the current gaps in the literature in relation to these aspects of prospection and acute alcohol consumption.

3.1 Acute Alcohol Consumption and Prospection

Given the adaptive and functional significance of prospection in daily living, an investigation of EFT, episodic foresight, and PM following acute alcohol consumption is crucial, as findings may shed light on the difficulties experienced by individuals under the influence of alcohol. It is therefore surprising that to date, no studies have assessed the extent to which EFT or episodic foresight are impaired in the context of acute alcohol use, and only five studies have assessed PM following acute alcohol consumption.

In relation to the five studies that have objectively investigated the effect of acute alcohol consumption on PM, the results have been mixed, with one study showing impairment across all types of PM tasks (Leitz et al., 2009), three studies reporting PM impairment on some, but not all types of tasks (Montgomery et al., 2011; Paraskevaides et al., 2010; Smith-Spark et al., 2016), and one study that did not identify a deficit in PM at all (Walter & Bayen, 2016). These discrepancies could be attributed to differences in the dose of alcohol administered and/or the tasks used to assess PM. For example, a study by Leitz et al. (2009) assessed PM performance in social drinkers using the well-validated *VW-PM* task (Rendell & Craik, 2000; Rose et al., 2010) following a dose of 0.6 grams alcohol per kilogram of bodyweight. They identified a significant deficit in PM performance across all task types. However, using the same alcohol dosage but a shortened version on *VW-PM* as the measure of PM, Paraskevaides et al. (2010) found that alcohol significantly impaired event- but not time-based PM. A somewhat different pattern of results, however, was reported by Smith-Spark et al. (2016) using the same dosage of alcohol as Leitz et al. (2009) and Paraskevaides et al. (2010), but a different measure of PM, namely the *Memory for Intentions Test* (Raskin

& Buckheit, 2010). They found that acute alcohol consumption significantly impaired all PM task types except event-based PM tasks.

The remaining two studies investigated the effect of acute alcohol use on PM following the administration of a lower dose of alcohol (i.e. 0.4g/kg) and different measures of PM. In the first of these, Montgomery et al. (2011) used the *Jansari-Agnew-Akesson-Murphy* task (Jansari et al., 2004) to assess PM performance in virtual reality and found that acute alcohol use impaired both event- and time-based PM tasks, but not action-based PM tasks (i.e. where a particular action functions as a trigger to remember to perform another task). By contrast, however, Walter and Bayen (2016) did not find that alcohol adversely affected PM performance as measured using a computerised colour-matching PM task. Overall then, it is noteworthy that the weight of the evidence has identified deficits in at least some aspects of PM, however, the exact nature and magnitude of PM impairment remains unclear.

3.2 Cognitive Contributors to Acute Alcohol-Related Impairment in Prospection

As previously mentioned, there are currently no studies investigating the effect of acute alcohol consumption on EFT and episodic foresight. However, there have been numerous studies investigating alcohol's impact on aspects of cognition that have been theoretically argued to underpin EFT and episodic foresight, and indeed PM, most notably of which are retrospective memory and executive functions (See Chapter 2). The following section will therefore review this literature to shed light on potential avenues through which EFT, episodic foresight, and PM might be adversely affected by alcohol consumption.

3.2.1 Acute Alcohol Consumption and Retrospective Memory

As previously highlighted, retrospective memory has been argued to underpin all three forms of prospection focused on in this thesis. There is a considerable amount of research examining the effect of acute alcohol consumption on human memory (Mintzer, 2007; White, 2003). In general, this research suggests that the effect of acute alcohol consumption is dose dependent and occurs on a dose-related continuum, with a small to moderate dose of alcohol (BAC < 0.15%) producing small to moderate memory impairments (Bisby et al., 2010; Ryback, 1971; White, 2003). As the dose of alcohol increases, the resulting memory impairment becomes much more significant and may even result in the person being unable to recall information and events that occurred for a period of time while intoxicated, referred to as a blackout (Curran & Weingartner, 2002; Ryback, 1971; White, 2003). Furthermore, research suggests that acute alcohol use typically impairs the encoding process (the process of learning information) more than memory retrieval (the process of re-accessing previously learned information; Birnbaum et al., 1978; Goodwin et al., 1969; Petersen, 1977; Söderlund et al., 2007; Söderlund et al., 2005). Söderlund et al. (2007) suggest that alcohol ingestion does this by interfering with activity in regions of the brain that are involved in the encoding of information.

One of the most common measures used to assess the effect of acute alcohol consumption on retrospective memory is the recall of word lists. These tasks require the participant to memorise a list of words which they are then asked to recall under three conditions; immediate free recall, delayed free recall, and recognition recall. Immediate free recall requires the participant to immediately recite the list of words following their presentation. Delayed free recall involves the participant recalling the list of words after a time delay without prompting. Finally, in the recognition recall condition, participants

are provided with a longer list of words containing some words from the original word list. Participants must distinguish the words they recognise from the words they have not heard previously. Research has generally found that individuals under the influence of alcohol are able to recall new information immediately following its presentation (immediate free recall) and can often retain this information in short-term memory for up to a few minutes in the absence of distraction (Ryback, 1971; White, 2003). However, acute alcohol intoxication has been found to impair the recollection of information following a time delay (delayed free recall) and distraction (Ryback, 1971; White, 2003). For example, a study by Acheson et al. (1998) administered a moderate dose of alcohol (0.6g/kg) and investigated the effect of acute alcohol intoxication on the memory of word lists using the *Hopkins Verbal Learning Test* (*HVLT*). They found that alcohol selectively impaired the participants ability to recall words following a 20-minute time delay (delayed free recall; Acheson et al., 1998). Additionally, Acheson et al. (1998) identified age-dependent effects, with the younger subgroup's (21-24 years of age) memory performance significantly more impaired than the older subgroup's (25-29 years of age). Support was also found in a more recent study by Wetherill and Fromme (2011) who identified an impairment in delayed recall following acute alcohol consumption.

Additionally, there is some evidence to suggest acute alcohol-induced retrospective memory impairment may be associated with impairment in prospection. Specifically, there are two studies that have assessed retrospective memory and PM concurrently following acute alcohol use (Leitz et al., 2009; Paraskevaides et al., 2010). Both studies reported acute alcohol-related retrospective memory and PM deficits, and Leitz et al. (2009) additionally reported a positive correlation between retrospective memory and irregular PM performance.

3.2.2 Acute Alcohol Consumption and Executive Functions

Executive functions have also been argued to play a role in prospection, and as such, may also present a possible source of impairment in EFT, episodic foresight, and PM under the influence of alcohol. Research has investigated the effect of acute alcohol consumption on executive functions including cognitive flexibility, inhibitory control, and working memory, but findings have been somewhat inconsistent (Day et al., 2015; Fillmore, 2007; Montgomery et al., 2011). In addition, as with other alcohol use research, the effect of acute alcohol consumption on executive functions appears to occur on a dose-related continuum (Dry et al., 2012; Field et al., 2010; Fillmore, 2007).

In relation to cognitive flexibility, mixed results have been found following acute alcohol consumption. Cognitive flexibility refers to the ability to shift attention between multiple mental tasks (Monsell, 1996). One of the most common measures of cognitive flexibility is the *Trail Making Test* (*TMT*), which contains two parts and requires participants to join numbered dots in ascending numerical order, and then numbered and lettered dots in ascending and alternating numerical and alphabetical order (Arbuthnott & Frank, 2000). Research has shown that cognitive flexibility, as measured by the *TMT*, is impaired at high doses of alcohol (BAC > 0.073%; Dry et al., 2012; Duning et al., 2008), but not at lower doses of alcohol (BAC < 0.068; Dry et al., 2012; Duning et al., 2008). Cognitive flexibility performance following alcohol consumption therefore appears to be dose dependent.

Another executive function that has been researched following acute alcohol use is inhibitory control. Inhibitory control refers to the ability to suppress a proponent response in favour of a goal directed action (Hofmann et al., 2012). Research suggests that the effect of acute alcohol consumption on inhibitory control is largely dependent on the dose of alcohol and the measure used to assess inhibitory control. For example,

some studies have found that a moderate to high dose of alcohol (BAC > 0.07%) is associated with impairment on various measures of inhibitory control, including an increased error rate (Dry et al., 2012), and increased reaction time (Gan et al., 2014). One task that has been used in a number of acute alcohol studies to provide a measure of inhibitory control is the *Stroop task*. Research using the *Stroop task* has generally shown that higher doses of alcohol (BAC > 0.071%) impair performance (Schweizer et al., 2006), while lower doses of alcohol (BAC < 0.05%) show no effect on performance (Volkow et al., 2006). However, another study that used a *stop-signal task* to index inhibitory control did not find a deficit in performance following a high dose of alcohol (BAC > 0.089%; Dougherty et al., 2008). This discrepancy may reflect the sensitivity of various inhibitory control tasks, with some tasks, such as the *stop-signal task*, possibly not as sensitive to acute alcohol consumption as *Stroop* type tasks.

Finally, the impact of alcohol on working memory also appears to be dose dependent. Working memory refers to the ability to hold, store and manipulate information, and is another executive function that has been studied in the context of acute alcohol consumption. Studies investigating working memory have also yielded mixed results. While studies that administered a higher dose of alcohol (BAC > 0.07%) appear to report consistent impairment to working memory (Saults et al., 2007; Spinola et al., 2017), findings following the administration of a lower dose of alcohol (BAC < 0.07%) are less consistent, with some studies reporting impairment in working memory performance (Casbon et al., 2003; Magrys & Olmstead, 2014), while others do not (Dougherty et al., 2000; Weissenborn & Duka, 2003). For example, Finn et al. (1999) reported that moderate doses of alcohol (BAC = 0.07% and BAC = 0.09%) impaired participants working memory, as measured by the backward digit span, whereas

Weissenborn and Duka (2003) did not find an effect of a moderate dose of alcohol (BAC = 0.06%) on a measure of spatial working memory.

3.2.3 Acute Alcohol Consumption and Episodic Future Thinking

Currently, there are only theoretical arguments to suggest that EFT underpins episodic foresight and PM, and therefore the extent to which acute alcohol-related deficits in EFT may contribute to episodic foresight and PM deficits remains unclear. Indeed, at this point there is no empirical data to show that EFT is impaired in the context of acute alcohol consumption, let alone that such potential deficits might contribute to acute alcohol-induced impairment in episodic foresight and PM.

3.3 Summary of the Effect of Acute Alcohol Consumption on Memory, Executive Functions, and Prospection

Given the review of the literature presented above, it is plausible to suggest that acute alcohol use may affect EFT, episodic foresight, and PM for a number of reasons. Firstly, these abilities may be vulnerable to the effects of acute alcohol consumption due to the close relationship between the ability to think about the future and the ability to remember the past. Thus, it could be anticipated that acute alcohol-induced retrospective memory impairment which, as noted, has been consistently found in the literature (Mintzer, 2007; Söderlund et al., 2007; Söderlund et al., 2005; White, 2003), may subsequently present one avenue for impairment in EFT, episodic foresight, and PM. Secondly, alcohol-related deficits in executive functions may also contribute to difficulties engaging in EFT, episodic foresight, and PM. However, research investigating the effect of acute alcohol consumption on executive functions suggests that the impact of alcohol depends on the complexity of the executive function and the dose of alcohol administered (Day et al., 2015). Therefore, it is possible that acute alcohol-related impairment in executive functions may contribute to impairment in EFT,

episodic foresight, and PM, however, the extent to which this is the case remains unclear. Finally, it should also be noted that possible EFT impairment induced by acute alcohol use could affect episodic foresight and PM, however no studies to date have been undertaken to establish whether EFT is in fact impaired in the context of acute alcohol consumption, let alone considering EFT as a contributor to episodic foresight and PM deficits in the context of alcohol use, thus this proposal remains speculative.

3.4 Gaps in the Literature

Prospection is currently one of the most rapidly growing areas of research in cognitive neuroscience and psychology. However, while there is a significant amount of research investigating the effect of acute alcohol use on cognition, research directly investigating the three forms of prospection focused on in the current thesis in the context of acute alcohol consumption is currently limited. Indeed, there are only a handful of empirical studies examining the effect of acute alcohol consumption on PM, with inconsistent findings, and no studies investigating EFT or episodic foresight. The current literature is also lacking investigation into cognitive abilities such as retrospective memory and executive functions that may underpin any observed deficits in these three abilities, and has not yet assessed the potential role of EFT in episodic foresight and PM. Future research should therefore seek to undertake a comprehensive investigation of EFT, episodic foresight, and PM and their proposed underpinning abilities following acute alcohol consumption. Such investigations may shed light on the deleterious effects of acute alcohol consumption, and increase understanding of the risk taking behaviours and maladaptive decision making commonly associated with acute alcohol use (Bechara et al., 2001; Field et al., 2010; George et al., 2005). The current study therefore aimed to address these identified gaps in the literature.

Chapter 4: Methodology for Empirical Studies

Preamble

In light of the current gaps in the literature regarding the effect of acute alcohol consumption on prospection, three empirical studies were designed to address the key research questions outlined in Chapter 1. The purpose of this chapter is to describe the methodology used to test the aims of the three empirical studies. It provides a comprehensive overview of the data collection process and detailed descriptions of the measures used in this research project. The results of these studies are presented in the subsequent chapters.

4.1 Research and Study Design

Three empirical studies were conducted, all of which comprised a double-blind, independent groups, cross-sectional design, with an equal number of males and females randomly assigned to either the experimental (alcohol) or control (placebo) condition. The data for all three studies were collected in a single session.

4.2 Participants

The same participants took part in all three empirical studies and were required to be healthy adult social drinkers. All participants were screened for a number of inclusion and exclusion criteria. These criteria are outlined below.

4.2.1 Eligibility Criteria for Healthy Adult Social Drinkers

To be eligible for the study, healthy adult social drinkers had to meet the following inclusion criteria:

a) Be aged 18 years or over.

b) Be a social drinker and thus familiar with the effects of acute alcohol ingestion. This required an average weekly consumption of between 2 and 25 standard units of alcohol for women, and between 2 and 36 standard units of alcohol for men, as per the criteria outlined by Griffiths et al. (2012). One standard unit of alcohol in Australia contains 10 grams of alcohol.

c) Have English as a first language.

Participants were excluded if they met any of the following conditions:

a) Pregnant or breastfeeding.

b) A history of alcohol or drug dependence.

c) Previously required or sought support or rehabilitation services for alcohol or drug use.

d) A medical condition and/or current use of medication that requires abstinence from alcohol.
e) Currently using prescription medication for mental health or sleep difficulties.
f) A history of head injury that led to hospitalisation.
g) A diagnosis of a neurological condition or acquired or traumatic brain injury (ABI or TBI).
h) A current diagnosis of a psychiatric disorder (participants reporting diagnoses of anxiety and/or depression were not excluded, however other Axis I disorders, such as schizophrenia and bipolar, were excluded).

4.2.2 Participant Recruitment

Healthy adult social drinkers were recruited through personal networks, social media, classified advertisements (e.g., Gumtree), the Australian Catholic University psychology research participation program, and via flyers distributed throughout the local community in places that healthy adults commonly attend (e.g., gyms, libraries and community centres; see Appendix A for a copy of the flyer). Flyers encouraged all potential participants to call or send a text message to the dedicated research mobile phone, or to email the researcher's university email account. Potential participants were then contacted over the phone and screened prior to scheduling the testing session (see Appendix B for recruitment script).

4.2.3 Protocols for the Day of Testing

Participants who met the eligibility criteria for the study were informed of further inclusion criteria that they were required to adhere to on the day of testing. These additional criteria included:

a) Be abstinent from alcohol and illicit drugs for at least 24 hours prior to the testing session.
b) Do not eat a heavy meal in the two hours prior to the testing session. However, if the participant did require something to eat, they were advised to consume only a light (non-fatty) meal (such as fruit/ vegetable snacks).
c) Do not to drive to the testing session and pre-arrange alternative transport arrangements to and from the session.

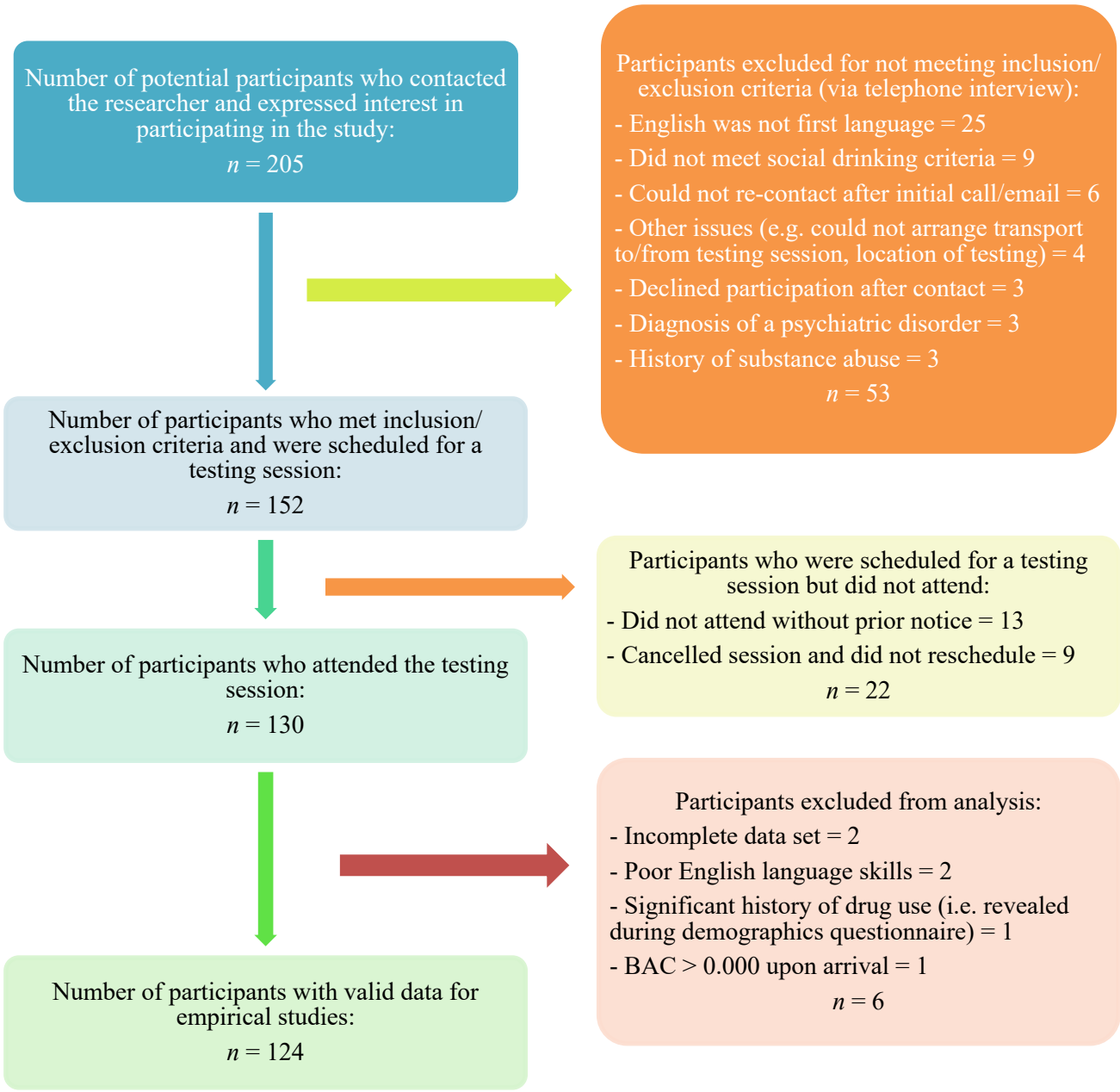
Participants who did not meet these criteria were excluded from testing.

4.2.4 Participants Included in the Empirical Studies

Figure 4.1 displays a flow chart outlining the recruitment process and the final number of participants included in the empirical studies. In total, 124 healthy adult social drinkers (61 assigned alcohol, 63 assigned placebo) provided valid data for empirical studies 1, 2 and 3.

Figure 4. 1

Flow Chart of Participant Recruitment Process for Studies 1, 2 and 3



4.3 Background Measures

Participants who were recruited to partake in the studies completed a range of measures in one testing session of up to 180 minutes, one-on-one with the researcher. These measures are detailed below.

4.3.1 Background Questionnaire

Background information was obtained in the form of an interview, and comprised a brief screening questionnaire, and thorough background questionnaire. The screening questionnaire reconfirmed participants eligibility to participate in the study, and included questions such as, "Have you used alcohol or any other illicit drug within the 24 hours prior to testing?". Participants then completed a background questionnaire which was designed to obtain background information including demographics, such as age, sex, and years of education. The questionnaire also gathered a detailed drug use history and contained questions regarding recent physical and mental wellbeing, and quality of sleep. A copy of this questionnaire can be found in Appendix C.

4.3.2 Alcohol Use Characterisation

The *Alcohol Usage Questionnaire* (*AUQ*; Mehrabian & Russell, 1978) was used to characterise each participant's current alcohol use. The *AUQ* is a 12-item self-report questionnaire that provides a reliable measure of alcohol drinking habits within the past six months (Townshend & Duka, 2002). The *AUQ* includes questions about the specific type of alcohol consumed (beer, wine and spirits), the amount of alcohol consumed in standard units, the average number of drinks consumed per hour (i.e. speed of drinking), the number of times being drunk[1] in the past six months, and the percentage of drinking occasions that resulted in getting drunk. Two outcome scores were calculated using Townshend and Duka's (2002) equations. The first was the *AUQ* score which was calculated based on the total number of alcohol units consumed per week, speed of drinking, number of times being drunk, and the percentage of times getting drunk whilst drinking alcohol. The second outcome score was the *AUQ* binge score, which was

[1] 'Drunk' is defined as the loss of coordination, nausea, and/or inability to speak clearly.

calculated based on speed of drinking, number of times being drunk, and the percentage of times drinking until drunk only.

4.3.3 General Intelligence

General (premorbid) intelligence was assessed using a highly reliable word-recognition test called the *Spot the Word* task (Baddeley et al., 1993). In this task, participants are provided with 60 pairs of items. Each pair of items contains a real word and an invented word constructed to resemble a real word but has no meaning. Participants are required to identify and circle which item is the real word in each pair of items. The *Spot the Word* task has been shown to be strongly correlated (r = .83) with the *National Adult Reading Test* (Baddeley et al., 1993), a well-established measure of premorbid IQ.

4.3.4 Anxiety and Depression

The *Hospital Anxiety and Depression Scale* (*HADS;* Zigmond & Snaith, 1983) is a valid and reliable 14-item self-report questionnaire that was used to assess generalised symptoms of anxiety (7 items) and depression (7 items; Bjelland et al., 2002). Research suggests that the *HADS* is a sensitive indicator of depression and anxiety symptomology in both healthy and clinical populations (Bjelland et al., 2002). The *HADS* requires participants to respond to statements, such as “I feel cheerful” and “I feel tense”, on a four-point Likert scale to indicate how much the statement applied to them over the past week, with 0= “not at all” and 3= “very often”. A total score is calculated between 0 and 21 for anxiety and depression separately, with total scores from 0-7 indicating a normal level of anxiety or depression, 8-10 in the borderline range, and 11-21 indicating a high level of anxiety or depression

4.3.5 Alcohol Intoxication Measures

Alcohol intoxication was measured subjectively and objectively. The subjective measure comprised a *Visual Analogue Scale* in which participants were required to respond to descriptors regarding their current subjective experience of the effects of alcohol, such as “tipsy” and “excited”. Participants were required to respond on a ten-point Likert scale, with 0= “not at all” and 10= “extremely” (see Appendix D). The objective measure of alcohol intoxication comprised a measure of blood alcohol concentration (BAC) using a Lion Alcolmeter 700 breathalyser.

4.4 Executive Functions

4.4.1 Cognitive Initiation

The *Verbal Fluency Task* is a highly reliable task (r = .83) that was used to provide a measure of the cognitive initiation component of executive function (Strauss et al., 2006; Tombaugh et al., 1999). Two variants of verbal fluency were calculated: phonemic fluency, which required the generation of words on the basis of orthographic criteria (in the present study, F, A, and S), and semantic fluency, which required the generation of words according to categorical criteria (in the current study, types of animals). Both variants required participants to generate as many words as they could pertaining to the relevant criteria within one minute. A total verbal fluency score was calculated by tallying the number of acceptable responses for phonemic and semantic fluency.

4.4.2 Inhibitory Control

The *Hayling Sentence Completion Test* was used to provide a measure of the inhibitory control component of executive function (Burgess & Shallice, 1997a). This task contains two parts and was administered and scored according to Burgess and Shallice's (1997a) instructions. In Part A, participants are required to sensibly complete

15 sentences (e.g., “He posted a letter without a … [*STAMP*]”). In Part B, participants are required to complete an additional 15 sentences, but with unrelated words (e.g., “Her new shoes were the wrong… [*PENCIL*]”). Participant performance is measured by tallying the number of errors and the total time taken to complete both parts of the test, and then converting these raw scores to a scaled score. This task has been shown to have good test-retest reliability (r = .76; Burgess & Shallice, 1997a).

4.4.3 Cognitive Flexibility

The *Trail Making Test* (*TMT*) was used to provide a measure of the cognitive flexibility component of executive function (Arbuthnott & Frank, 2000). The *TMT* contains two parts that are timed and recorded in seconds. In Part A, participants are required to draw one continuous line to connect the numbers 1 to 25 in numerical order, and therefore provides a baseline measure of psychomotor speed. In Part B, participants are required to draw one continuous line to connect numbers and letters in sequential increasing and alternating order (i.e., 1-A-2-B-3-C, etc.). Cognitive flexibility is calculated by subtracting the time taken for Part A from Part B, with lower scores indexing better cognitive flexibility. The *TMT* has good test-retest reliability for both Part A (r = .76 to.89) and Part B (r = .86 to .94; Wagner et al., 2011).

4.5 Retrospective Memory

The *Hopkins Verbal Learning Test- Revised (HVLT-R;* Benedict et al., 1998) was used to provide a measure of retrospective memory. The *HVLT-R* assesses immediate and delayed recall. Participants are orally presented with a list of 12 words pertaining to three semantic categories over three times and are required to recall as many words as they can in any order immediately following their presentation (immediate recall). After a 30-minute delay, participants are again asked to recall the list of words in any order without prompting (delayed recall).

4.6 Key Measures

4.6.1 Episodic Future Thinking and Retrospective Episodic Memory

Episodic future thinking (EFT) was measured using the adapted version of the *Autobiographical Interview* (*AI*; Addis et al., 2008). The *AI* is a semi-structured interview that provides a measure of episodic and non-episodic content in two temporal directions (past and future), thereby indexing retrospective episodic memory and EFT respectively. All administration, training of scorers, and scoring procedures closely followed Addis et al.'s (2008) adaptation.

4.6.1.1 AI Procedure and Cue Words

One interviewer was trained in the administration of the AI. In this task, participants are instructed by the interviewer to recall or imagine an event in response to a cue word, and to generate as many details about the event as possible within a 3-minute time interval. The event the participant provides must be described from the participant's subjective perspective, rather than that of an observer. Additionally, participants are told that the event must refer to a specific time and place and be no longer than one day in duration. All participants are provided with the instructions, followed by a demonstration of an event description before they are administered the test cue words.

Cue words were selected from the "*Affective Norms for English Words*" list (*ANEW*; Bradley & Lang, 1999) and included two positive words (*birthday, vacation*), two negative words (*nightmare, accident*), and two neutral words (*taxi, bench*; valence ratings $M = 8.0$, $M = 2.0$, $M = 4.8$, respectively). Three cue words, one from each valence, were administered for each temporal condition (i.e. past and future). To reduce cognitive load, and facilitate participants' understanding and adherence to the instructions, participants were administered three cue words in one temporal direction

before commencing the other temporal direction. When necessary, general probes were given to clarify instructions, such as "*Has this happened to you before? How is this future event different?*", and encourage further description of details, such as "*Can you tell me more about it?*". The presentation of temporal direction and cue words was counterbalanced across participant, leading to six different versions of the task. Responses were recorded using a digital audio recorder and transcribed for scoring.

4.6.1.2 AI Scoring

The scoring of interview transcripts followed the standardised procedure outlined by Addis et al. (2008). For each cue word trial, a central event was identified. The details in the transcript were then broken down into parts and classified as either *internal* details (i.e. episodic information specific to the main event described) or *external* details (i.e. non-episodic information, including repetitions, semantic information, and information not specific to the main event described). The total number of internal details generated across the three future trials was the primary measure of EFT, and the total number of internal details generated across the three past trials was the primary measure of retrospective episodic memory. The total number of external details generated across the three future and three past trials represents error.

Three trained independent scorers who were blind to the aims of the project and the condition to which the participant had been assigned, scored the transcripts. Training manuals were provided by Donna Rose Addis, which included an annotated scoring example and 20 practice scoring events for training scorers. Inter-rater reliability calculated using Cronbach's alpha was .98 for internal details and .90 for external details. The three scorers coded equal portions of the full data set and each scorer was assigned an equal number of transcripts to score from both experimental conditions.

4.6.2 Episodic Foresight

Virtual Week- Foresight (*VW-Foresight;* Lyons et al., 2014) is a computerized board game that provides a measure of the ability to engage in episodic foresight in the context of everyday living. It does this by simulating situations that are similar to those encountered in everyday life. In this game, participants are required to roll a dice to move a token around a board, with one circuit of the board representing one virtual day (see Figure 4.2 for the game's interface). As participants move around the board, they are presented with a number of situations, some of which contain problems that cannot be solved straight away (episodic foresight tasks). Participants are required to remember the problems that they encounter and collect items that they may be able to use to solve these problems at a later stage. Each episodic foresight task consists of three components. First, the participant is presented with a plausible situation that contains a problem that cannot be solved immediately (problem). Second, the participant is subsequently presented with a daily activity in which there is an opportunity to select an item that could be used to address the earlier problem that they encountered (item acquisition). Third, the participant is returned to the original problem later in the game and is provided with the opportunity to use the correctly selected item to solve the problem (item use and problem resolution).

One circuit of the board contains ten green 'S' squares, and each time that a participant lands on or passes an 'S' square, they are required to pick up a *Situation Card* by selecting the green button in the top left corner of the board. Some *Situation Cards* contain life-like daily activities related to the virtual time of day, such as eating breakfast. These tasks act as distractors and are not related to the foresight tasks. In these tasks, participants are provided with three options in response to the situation and are required to choose one of the options on the card before continuing with the game.

For example, the situation is breakfast time and the participant is required to choose something to have with their cereal. The participant may choose either: *yoghurt, honey*, or *blueberries*. After the participant selects one of the three options, they are prompted to again roll the dice and continue to move the token around the board.

Some *Situation Cards,* however, make reference to a problem that the participant is required to identify on their own, without an external prompt. To provide a specific example, participants work their way around the board until they encounter a *Situation Card* such as *"You drop your reading glasses and they shatter! "I need to finish writing those birthday invitations tonight!" you think, annoyed. You ring the optometrist, and they tell you it will be about a week to get a new pair."* Problems, such as the one presented in this example, cannot be solved immediately, and the participant is asked to hold in mind. In keeping with the structure of the other *Situation Cards*, however, there is also a set of three options unrelated to directly solving the problem for the participant to choose from before they can continue with the game. In this example the *Situation Card* informs the participant that they are going to the university to participate in an experiment, but before leaving, they must choose one of three options to perform: *brush your teeth*, *do some push-ups*, or *turn off the lights*.

At a later point during the game, the participant is asked to pick up a *Daily Activity Card* by selecting the blue button in the top right corner of the board. Participants are told on the card that they are completing an activity and are provided with the opportunity to acquire and store one of five items presented. The chosen item is stored in *Your Stored Items* for later use but can be accessed at any time during the game by selecting the yellow *Your Stored Items* button in the bottom left corner of the board. Some *Daily Activity Cards* contain distracter items, while some contain an item that if acquired, may be used to resolve an earlier presented foresight problem. For

instance, in relation to the previous example, the participant is presented with a daily activity which involves rifling through the contents of a desk drawer. The participant is provided with the opportunity to select one of five items for later use: *a stapler, magnifying glass, ruler, hole punch, or measuring tape*. In this case, the suitable item to resolve the earlier problem which involved the participants glasses being shattered is the *magnifying glass*. *Daily Activity Cards* such as this are presented to allow the opportunity for participants to acquire an item to solve a problem that they previously encountered. The chosen item is then stored, and the participant continues to move around the board until another *Situation Card* appears in which the original problem is presented, however remains unresolved. At this point, participants are required to retrieve and use the appropriate item to solve the problem. Continuing with the previous example, another *Situation Card* is presented which says; *"You arrive home and look for a comfy spot to settle in and finish your birthday invitations. You pick up a pen to start writing and realise the words are all blurry!"* At this point, the participant is required to access their stored items without prompting by selecting the *Your Stored Items* button at the top of the *Situation card*, and then selecting the relevant item that they were provided with the opportunity to obtain earlier (i.e. *the magnifying glass*). If the participant continues on with the game without using the relevant item at the appropriate point, they do not get another opportunity to resolve that particular problem. All three components of each task are spatially and temporally separated on the game board with distractors presented in between. The game contains an average of two distractor tasks between a problem being presented and item acquisition, and item acquisition and resolution.

Participants are first taken through a trial day during which time they are provided with instructions on how to play the game. Once the trial day is completed,

participants are asked to complete two additional test days (Monday and Tuesday). Participants are presented with a total of seven episodic foresight tasks over the two test days. Critically, participants are not provided with any additional instructions on the test days and are instead required to independently identify problems, acquire items to solve the problems, and use the correctly acquired items to resolve the problem. It is ensured that all participants understand the instructions of the game before they proceed to the test condition as no prompts are given following the trial day.

VW-Foresight generates two outcome scores at the conclusion of the game. These are the *number of correct items acquired* and the *number of correct items used*. The *number of correct items acquired* variable reflects the ability to act in the present (i.e. to obtain a correct item) with the anticipated future in mind, whereas the *number of correct items used* reflects the ability to perform a self-generated intention to resolve a problem at the appropriate time (i.e. to use the correct item). Together, these variables provide a basic measure of episodic foresight capacity (Lyons et al., 2014).

Figure 4. 2

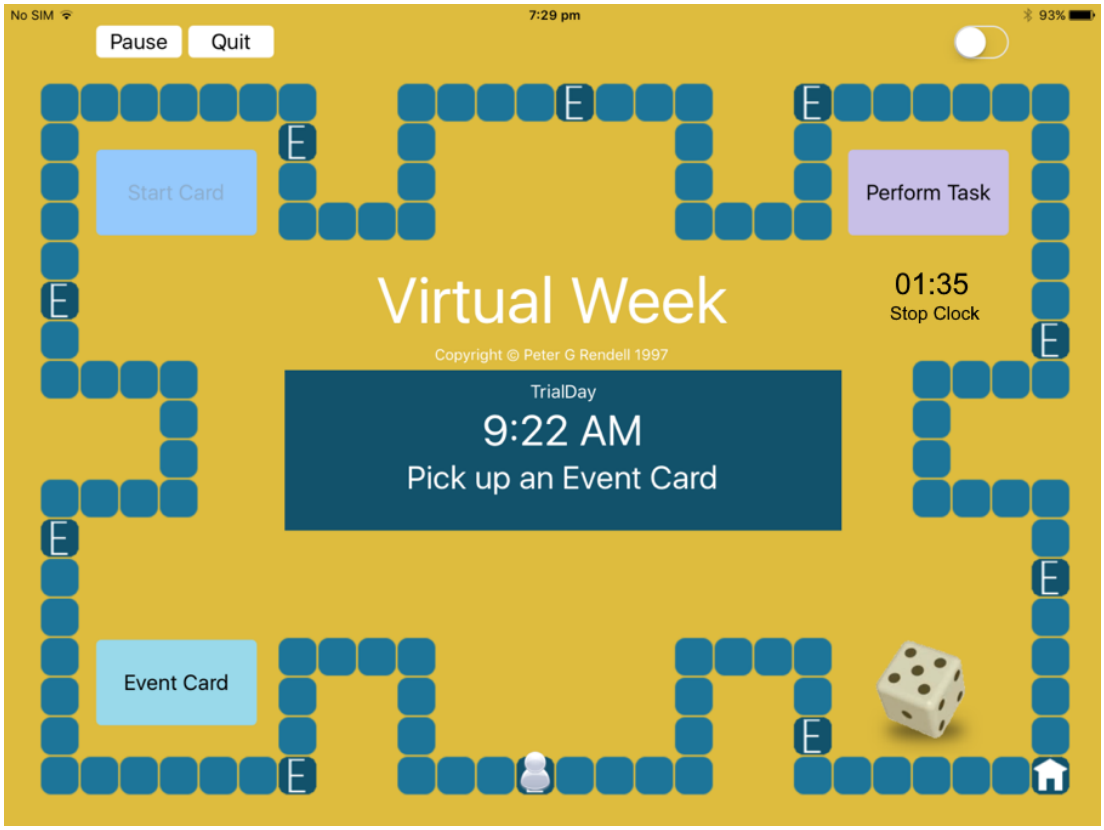
VW-Foresight Game Interface

4.6.3 Prospective Memory

Virtual Week-Prospective Memory (*VW-PM*; Rendell & Craik, 2000) is a computerised board game that simulates prospective memory (PM) tasks in life-like situations. *VW-PM* has a similar interface to the *VW-Foresight* game but involves different activities and therefore places different cognitive demands on participants (see Figure 4.3 for the *VW-PM* interface). Unlike the *VW-Foresight* game, which was presented on a laptop, the *VW-PM* game was administered on an iPad. This adjustment was designed to minimise any possible carry over effects from completing the *VW-Foresight* task.

Figure 4. 3

VW-PM Game Interface



In the *VW-PM* game, participants are required to roll a dice to move a token around the board, with one virtual day represented by one circuit of the board. As participants move around the board, they are tasked to remember to carry out a number of activities at a point in the future (PM tasks) that simulate everyday life, whilst also making decisions involving regular daily activities. The time of the virtual day is displayed in the centre of the board and is calibrated to the position of the token on the board, with fifteen virtual minutes lapsing with every two squares moved on the board. Participants are first taken through a trial day in which they are provided with the instructions to play the game, before commencing the test condition. Once the trial day

is completed, participants are required to indicate that they understand the procedures of the game before two test virtual days are administered (Monday and Tuesday).

During the game, participants are prompted to pick up an *Event Card* each time they land on or pass an 'E' square by pressing the blue button in the bottom left corner of the screen. Each *Event Card* presents a different activity that relates to the time of the day, such as eating breakfast at 7am. *Event Cards* also require participants to select a response from the options presented on the card in relation to that activity. For example, the event is going to the doctor and the participants are asked to choose one of three options while waiting to see their doctor (e.g. *read a magazine, read a novel your brought with you,* or *check your mobile phone for messages*). The participant is then prompted to roll the dice and continues to move the token around the board. These tasks act as distractors and are not related to the PM tasks.

In addition to distractor tasks, participants are required to remember to carry out additional tasks that closely resemble PM tasks in everyday life. Each virtual day contains ten PM tasks, which comprise four regular tasks, four irregular tasks and two time-check tasks. The regular tasks simulate tasks that occur regularly during normal daily activities and involve undertaking the same task on each virtual day. These tasks include two time-based tasks (take asthma medication *at 11am and 9pm*) and two event-based tasks (take antibiotics *at breakfast and dinner*). In relation to time-based tasks, participants are instructed to refer to the virtual clock in the centre of the board. The irregular tasks simulate 'one-off' tasks that are performed occasionally in everyday life and involve a different task on each virtual day. These tasks include two time-based tasks (e.g. phone the plumber *at 4pm*) and two event-based tasks (e.g. dropping the dry cleaning off *when shopping*). The final two tasks are time check tasks which require participants to monitor real time on a stop clock and to perform a task when a specific

amount of time has passed (e.g. check lung capacity when *two minutes* in real time have lapsed). For time-check tasks, participants are instructed to refer to the stop clock on the right-hand side of the board. All tasks are embedded in the ongoing activity of rolling the die, shifting the token, and reading and responding to each event card. Instructions to carry out the regular tasks and time-check tasks are provided once at the end of the trial day. Participants are prompted to review and memorise these tasks prior to beginning the test days. The remaining irregular PM tasks are presented throughout the game, with two irregular PM tasks presented on the *Start Card* at the start of each virtual day, and two presented later in the virtual day.

VW-PM scores are calculated for each task type (regular event-based, regular time-based, irregular event-based, irregular time-based, and time-check) by dividing the number of tasks of that specific type completed correctly by the total number of tasks of that type administered. The five outcome variables of interest in the present study were the *proportion of correct regular and irregular event-based tasks*, the *proportion of correct regular and irregular time-based tasks,* and the *proportion of correct time-check tasks*.

4.7 Manipulation Check

To test the effectiveness of the double-blind design, the researcher and each participant were asked to guess at the conclusion of the testing session which condition the participant had been assigned to (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 significant difference between correct and incorrect responses (χ^2 (1,124) = 38.12, p < .001). Analysis of the researcher's guess regarding which treatment condition the participant had been assigned also revealed a significant difference between correct and incorrect responses (χ^2 (1,124) = 71.25, p < .001).

4.8 Procedure

4.8.1 Informed Consent

This study, including testing materials and procedure, information letter, and consent forms, were approved by the Australian Catholic University Human Research Ethics Committee (Project number: 2018-122H; see Appendix E). Potential participants who met the initial phone screening criteria and agreed to proceed with the testing session were given a detailed description of the study over the phone. Participants were then provided with a copy of the information letter (see Appendix F) and consent form (see Appendix G) via email where possible. A testing session was then scheduled at a mutually convenient time and day. Participants were instructed to refrain from the use of alcohol or illicit drugs in the 24 hours prior to testing. Participants confirmed abstinence via self-report on the day of testing and were breathalysed to ensure that they had not consumed alcohol prior to the session. Participants were also advised not to eat a heavy meal in the two hours 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), unless they had a medical condition, such as diabetes, in which they were required to eat regularly. Participants were also advised not to drive to the testing session and that they should pre-arrange alternative transport arrangements to and from the session. Potential participants were required to indicate on the consent form whether they currently held a valid Learner Driver Permit, Probationary Drivers

Licence or Z Conditioned Driver Licence. If the participant reported holding any of these licence types, they were required to document that they had made non-driving transport arrangements.

4.8.2 The Testing Appointment

The testing session was undertaken at the Australian Catholic University (Fitzroy, Melbourne). Upon arrival to the laboratory, participants provided written informed consent and completed a baseline BAC measurement and *Visual Analogue Scale* to ensure that the participant had not consumed any alcohol prior to testing. Participants were then asked to remove their shoes and any heavy items of clothing and were weighed on a set of digital scales. This was to allow calculation of the appropriate dose of alcohol for participants subsequently assigned to the alcohol condition. Participants were reminded of the voluntary nature of the research and that they may withdraw from the study at any time. Participants then proceeded with the assessments detailed above in the order provided in Table 4.1. Testing took place in one session of 180 minutes, with breaks taken as needed.

4.8.2.1 Randomisation and Blinding

Participants were randomly assigned to the alcohol or placebo condition in a 1:1 ratio. The allocation of participants was conducted using a computer-generated block randomisation sequence (blocks of 6; pre-stratification by gender) by a single research assistant who was not involved in the recruitment of participants or the testing procedure.

The researcher and participants were blind to condition assignment. Several actions were taken to ensure that the researcher and participant remained blind to the drink content (alcohol or placebo). First, the drinks were prepared by a research assistant in a separate room to the researcher and participant and delivered to the testing

room. Second, the smell and taste of alcohol were concealed by mixing the drink with cordial and tonic water following well-established procedures published in previous studies in this area (for example, Leitz et al., 2009). Finally, BAC measurements were conducted by the research assistant and not disclosed to the researcher and participant.

4.8.2.2 Alcohol or Placebo Drink Administration

For those participants assigned to the alcohol condition, alcohol was administered at a dose of 0.6g/kg, closely following the procedure outlined by Leitz et al. (2009). This dose was chosen as it appears to be the dose at which many higher-order functions are impaired by acute alcohol consumption. Additionally, this dose can be considered a good representation of moderate alcohol intoxication, being slightly above Australia's legal driving limit (0.05%), but below that of other countries' such as the United States of America and England, whose legal driving limits are 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.

A total of 500mls of liquid was prepared, containing 96% ethanol diluted with tonic water and lime cordial. The liquid was divided into 10 cups, each containing 50ml portions. For those participants assigned to the placebo condition, a total of 500mls of liquid was prepared containing tonic water and lime cordial only. This placebo beverage was also divided into 10 cups, each containing 50ml portions. Participants in both conditions were provided with their respective drinks and were required to consume the 10 beverages at 3-minute time intervals in the presence of the researcher. To maintain the level of alcohol in the blood over the entire testing period of 180 minutes, participants were given two sets of top up drinks containing either 0.1g/kg dose of alcohol or a matched placebo drink. Each top up drink was divided into two cups

containing 50ml portions and administered at approximately 80- and 120-minutes into the testing session. Past research and pilot work has shown that this dose can be used to maintain a stable BAC over the entire testing period (Leitz et al., 2009; Paraskevaides et al., 2010).

Alcohol intoxication was measured four times throughout the testing session. Each time, each participant completed a *Visual Analogue Scale* and was administered a BAC test by the research assistant using a Lion Alcolmeter 700 breathalyser. To use the breathalyser, participants were instructed to steadily and continuously blow into the mouthpiece until they heard an audible click from the breathalyser and were instructed to stop. Participants were breathalysed at least 20 minutes after alcohol administration to ensure that the BAC reading was not affected by residual alcohol within the mouth.

4.8.3 Participant Debriefing and Reimbursement

Participant debriefing occurred immediately following the completion of final task (*VW-PM*) and included the administration of an additional *Visual Analogue Scale* and BAC measurement. Participants were then provided with an opportunity to reflect on their participation in the study and were prompted to state whether they thought they had been assigned to the alcohol or placebo condition. The researcher also noted which condition they thought the participant had been assigned to. All participants were offered a $60 reimbursement for their participation.

Table 4. 1

Empirical Studies Procedure: Tasks Performed with Corresponding Times (Mins)

Time (min)	Tasks and measures
0	Informed consent
	Baseline BAC and *Visual Analogue Scale*
	Weigh participant
	Spot the word
	Initial drink administration
	Background questionnaire
	HADS
	AUQ
45	End of drink administration
	HVLT-R (Immediate recall trial)
	Verbal Fluency Task
	Hayling Sentence Completion Test
	TMT
75	Time 2 BAC and *Visual Analogue Scale*
	HVLT-R (Delayed recall)
80	Top up drink 1
	VW-Foresight
120	Time 3 BAC and *Visual Analogue Scale*
	Top up drink 2
	Autobiographical Interview
	VW-PM
170	Time 4 BAC and *Visual Analogue Scale*
	Debrief, guess condition and payment

4.8.4 Alcohol Risk Management Procedures

In order to ensure the safety of each participant and the researcher, risk management procedures were established surrounding the administration of alcohol. Given that alcohol is illegal for people under the age of 18 years, participants were

required to provide proof of age (e.g. driver's licence or other documentation confirming their date of birth). As mentioned, a moderate dose of alcohol was administered with the aim inducing a moderate level of alcohol intoxication and as such, the impact on a participants' general ability to function was considered to be low and not a level to which the participant would consider themselves to be 'drunk' or cognitively impaired to any significant degree. Furthermore, this level of alcohol consumption would likely be commonly reached by social drinkers and thus the inclusion criteria required participants to be social drinkers (defined as a female who consumes an average of between 2 and 25 standard drinks and a male who consumes an average of between 2 and 36 standard drinks per week) which meant that all participants were likely to be familiar with this level of alcohol consumption. Participants were also breathalysed throughout the testing session with the aim of ensuring that the target level BAC was maintained.

Additionally, as previously noted, during initial contact with the researcher, participants were advised that they should not drive to the testing session and should make alternative arrangements to return home after testing (e.g., get picked up, take public transport etc.). This was also reiterated at the conclusion of the testing session. Valid Learner Drivers Permit, Probationary Drivers Licence and Z Conditioned Drivers Licence holders were required to document and sign off on their non-driving transport arrangements. Participants were also asked to remain in the research laboratory until their BAC level was below 0.05%. The final top up dose of alcohol was supplied at approximately 2 hours into the testing session which was 30 to 60 minutes prior to the completion of the testing session. The maximum effects of the last dose of alcohol were therefore likely to have been reached before the end of the session. Participants were however advised at the end of the session that they should not rely on the breathalyser

reading as a guarantee that they were/would remain under 0.05% BAC for a period of time. Participants were therefore advised that they should not drive a vehicle, use heavy duty machinery, or make life-changing decisions after leaving the testing session.

4.9 General Statistical Analyses

Power analyses were conducted using G*Power version 3.1.9.6 (Faul et al., 2007) to estimate the minimum sample size required to ensure that all analyses were sufficiently powered. An alpha level of .05, power of .80, and effect size of $\eta^2_p = .23$ obtained by Leitz et al. (2009) with a similar research design, were used in these calculations (Field, 2018; Tabachnick & Fidell, 2014). The estimated sample size of 20 (10 per group) that was calculated based on Leitz et al. (2009) effect size was considered too conservative as supplementary analyses, including correlational and regression analyses, and sex comparisons, were planned to be conducted. The current study therefore aimed to recruit 120 participants, with an equal number of males and females to also investigate sex differences. An alpha level of .05 and total sample size of 120 has power >.90 to detect moderate effect sizes ($\eta^2_p = .059$; Cohen (1988) defines η^2_p effect sizes of .01 as small, .059 as medium and .138 as large). In addition to group comparison analyses, the study was also adequately powered (.80) to detect moderate effect sizes for analyses involving sex differences. Specific data screening and analyses are described within the method section of each empirical study in Chapters 5, 6, and 7. All data analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 26 for Mac (IBM Corp).

Chapter 5: Study 1 - The Effect of Acute Alcohol Consumption on Episodic Future Thinking

Preamble

As reviewed in Chapter 3, there is limited research investigating the effect of acute alcohol consumption on prospection, with no research specifically examining the effect of a moderate dose of alcohol on episodic future thinking (EFT). The current study therefore aimed to provide the first direct assessment of EFT in the context of acute alcohol consumption. Study 1 also sought to examine whether any observed deficits in EFT following moderate alcohol consumption were associated with acute alcohol-induced executive dysfunction and/or retrospective episodic memory impairment. This study employed an adaptation of the *Autobiographical Interview* by Addis et al. (2008), a well-validated measure of EFT. This chapter was written as a standalone empirical paper for journal submission, and therefore necessarily contains some repetition of information presented in the introductory chapters of this thesis. To limit repetition, however, the descriptions of measures in the Methods section of this chapter have been abbreviated as all measures were described in full in the previous chapter (Chapter 4 - Methodology for Empirical Studies).

5.1 Introduction

Alcohol is one of the most commonly used substances worldwide, largely consumed for its relaxant and euphoric properties (Oscar-Berman & Marinković, 2007). Alcohol contains ethanol, a central nervous system depressant associated with changes in subjective mood, psychomotor performance, and cognitive functioning (Eckardt et al., 1998; Fillmore, 2007; Holloway, 1994; Hull & Bond, 1986; Weissenborn & Duka, 2003). Acutely, alcohol exerts its effects by altering the physical properties of neural membranes and disrupting synaptic transmission (Charness, 1990).

In terms of the effect of acute alcohol consumption on cognition, the primary mechanisms responsible implicate the inhibitory neurotransmitter, gamma-aminobutyric (GABA), and the excitatory neurotransmitter, glutamate. Specifically, it appears that alcohol potentiates the effect of GABA receptors, whilst also acting presynaptically to enhance GABA release in several brain regions (Flower et al., 2018; Grant & Lovinger, 2018; Roberto & Varodayan, 2017). Additionally, alcohol inhibits glutamatergic neurotransmission by inhibiting ionotropic glutamate receptor function, most consistently involving the NMDA receptor and synaptic responses mediated by NMDA receptors (Flower et al., 2018; Grant & Lovinger, 2018; Roberto & Varodayan, 2017). In combination, the pharmacological effects of alcohol provide a neurobiological basis for altered cellular activity in many key brain regions that subserve cognitive function, including the frontal lobes, amygdala, and hippocampal regions (Jacob & Wang, 2020; Van Skike et al., 2019; White et al., 2000).

Research literature investigating the effect of acute alcohol consumption on cognition has however also highlighted the importance of alcohol dosage. More specifically, the effects of alcohol on cognition depends on blood alcohol concentration (BAC) level and typically occurs on a dose-related continuum such that the greater the

dose of alcohol, the greater the cognitive impairment (Dry et al., 2012; Field et al., 2010; Fillmore, 2007; Ryback, 1971; White, 2003). However, the dose of alcohol required to produce impairment also varies as a function of the complexity of the cognitive task, with more effortful tasks typically impaired at lower doses of alcohol (Field et al., 2010; Fillmore, 2007), somewhat less demanding tasks generally impaired at moderate doses of alcohol (BAC greater than 0.06%; Day et al., 2015; George et al., 2005; Holloway, 1994; White, 2003), and simple tasks reportedly unaffected by much higher doses of alcohol (BAC greater than 0.08%; Fillmore, 2007; Holloway, 1994).

Two aspects of cognitive function that have attracted particular attention in this literature are memory and executive functions. Consistent with neurobiological evidence showing that the brain regions impacted by acute alcohol consumption include areas strongly linked to memory function, such as the hippocampus (Jacob & Wang, 2020; Squire et al., 2004), acute alcohol use has been shown to be associated with memory impairment (Curran & Weingartner, 2002; Mintzer, 2007; Ryback, 1971; White, 2003). However, although many of the key brain regions that support executive functions are also impacted by acute alcohol consumption (Oscar-Berman & Marinković, 2007; Van Skike et al., 2019), the executive function literature is more mixed. Because individual studies have varied considerably in exactly how they have operationalised executive functions, one possibility is that any relationship may not only be dose dependent, but also task dependent (for a review, see Day et al., 2015).

Another important aspect of cognition that may be affected by acute alcohol use, but which has not yet been tested empirically, is EFT. EFT refers to the ability to imagine or simulate a personal hypothetical future scenario (Atance & O'Neill, 2001; Schacter et al., 2008; Szpunar, 2010). It is therefore a highly adaptive ability that allows an individual to carefully plan their behaviour by pre-experiencing a future personal

event and imagining the consequences of their actions, thus enhancing the likelihood of achieving the desired outcome, and avoiding undesirable ones (Suddendorf & Corballis, 2007). Because deficits in EFT are linked to poor decision making, they have potentially profound consequences for daily functioning and independent living (Schacter et al., 2008; Schacter et al., 2017; Szpunar, 2010). Indeed, research has identified EFT deficits in many clinical groups that exhibit functional difficulties including schizophrenia, Autism Spectrum Disorder, and users of illicit substances (D'Argembeau et al., 2008; Lind & Bowler, 2010; Mercuri et al., 2015; Mercuri et al., 2018). In the context of acute alcohol use specifically, failures in EFT may potentially help to explain why acute alcohol consumption is linked to significantly elevated levels of risk taking behaviours, such as unprotected sex, aggression, and gambling (Field et al., 2010).

EFT difficulties in the context of acute alcohol consumption can be anticipated for a number of reasons. Firstly, EFT is known to impose substantial demands on retrospective episodic memory (for reviews, see Schacter et al., 2012; Schacter et al., 2017). Retrospective episodic memory refers to the ability to recall past personal experiences, and according to the *constructive episodic simulation hypothesis*, humans typically extract, recombine and integrate the recollection of such past experiences in the construction of novel future events (Addis, 2018; Roberts et al., 2018; Schacter & Addis, 2007b). That is, retrospective episodic memory provides the foundation from which the future is imagined (Suddendorf et al., 2009). EFT and retrospective episodic memory also engage a similar core brain network (Addis et al., 2008; Schacter et al., 2017), and are often significantly correlated (e.g. Mercuri et al., 2015; Mercuri et al., 2018). As a consequence, problems with EFT may be expected to be a corollary of the robust effects of acute alcohol consumption on memory.

Problems with EFT in the context of acute alcohol use may also be anticipated as a secondary consequence of acute alcohol-related executive function difficulties. As noted, EFT involves simulating a future scenario in imagination which is a constructive process that requires an individual to flexibly recombine past memories into coherent, novel future events (Schacter & Addis, 2007b; Suddendorf & Henry, 2013). As such, this process has been hypothesised to involve cognitive flexibility (an aspect of executive function) to not only disengage from the present moment to focus on the imagined future, but to also reformulate past experiences to simulate that future event. It has also been suggested that EFT requires inhibitory control to impede irrelevant information, and working memory to mentally manipulate information (Schacter & Addis, 2007b; Suddendorf, 2010a; Suddendorf & Corballis, 2007). However, empirical support for a relationship between EFT and executive function is mixed, with some studies identifying significant associations (e.g. Cole et al., 2013; Mercuri et al., 2018), while others have failed to identify any relationship (e.g. Gott & Lah, 2014; Mercuri et al., 2015). Additionally, as previously noted, findings in relation to the effect of acute alcohol use on executive functions have been similarly mixed. As a consequence, the extent to which problems with EFT may be expected to arise due to executive dysfunction is unclear.

The primary aim of the present study was therefore to provide the first empirical assessment of whether EFT performance is impaired following a moderate dose of alcohol (0.6g/kg). The second aim was to examine whether any observed impairments in EFT were related to acute alcohol-induced deficits in retrospective episodic memory and/or executive function. On the basis of the literature reviewed above, the key predictions were (i) relative to a placebo condition, participants in the alcohol condition would perform significantly worse on EFT, retrospective episodic memory, and

executive functions. It was also anticipated that (ii) retrospective episodic memory and executive functions would significantly contribute to EFT performance in both conditions. The final, exploratory aim of this study was to examine sex differences in EFT in the context of acute alcohol consumption. This question was of interest because there is some limited evidence to suggest that there are sex differences in the pharmacokinetics of acute alcohol use and its resulting impact on cognitive functioning (see Mumenthaler et al., 1999 for a review), with females disproportionately affected. Consequently, it was anticipated that, should EFT be adversely affected by acute alcohol consumption, these deficits would be greater for females than males.

5.2 Method

The study was approved by the Australian Catholic University Human Research Ethics Committee (Project number: 2018-122H) and all participants provided informed consent.

5.2.1 Participants and Design

One-hundred-and-twenty-four healthy adult social drinkers[2] (62 males) aged 18-37 (M = 24.4, SD = 4.2) were recruited to participate in the study via community advertisements and social networks. Using the criteria outlined by Griffiths et al. (2012), social drinking was defined as the average weekly consumption of between 2-25 standard units[3] of alcohol for females and 2-36 standard units of alcohol for males. Participant exclusion criteria were previous or current neurological condition or major psychiatric illness; history of alcohol or other substance dependence; the use of prescription medication that required abstinence from alcohol. Participants were also

[2] This sample of participants completed the full battery of cognitive measures required to conduct empirical studies 1, 2 and 3 (see Chapter 4 for details). However, only data from the *Autobiographical Interview* and executive functions was included in the analyses for Study 1, as they were the measures relevant to answer the research questions in this study.

[3] One standard unit of alcohol in Australia contains 10 grams of alcohol.

excluded if English was not their first language. Participants were asked to refrain from using alcohol or illicit drugs in the 24 hours prior to testing and were reminded of this requirement via text message at least a day in advance of the testing session. Participants confirmed abstinence via self-report and a BAC measurement of zero prior to commencing. All participants were reimbursed AU$60 for their time.

Participants were randomly assigned to either the alcohol (n = 61; 30 males) or placebo (n = 63; 32 males) condition in a double-blind, independent group design. As shown in Table 5.1, the groups did not differ in age, years of education, premorbid intelligence as measured by the *Spot the Word* test (Baddeley et al., 1993), and negative affect, as measured by the *Hospital Anxiety and Depression Scale* (Zigmond & Snaith, 1983).

Table 5. 1

Participant Characteristics

	Alcohol condition n = 61	Placebo condition n = 63		
	M (*SD*)	*M* (*SD*)	*t* (122)	*p*
Age (in years)	24.3 (4.2)	24.5 (4.2)	0.29	.78
Years of education	16.1 (2.2)	16.2 (2.1)	0.21	.83
FSIQ	47.0 (4.3)	46.9 (4.5)	0.16	.87
Mental health				
Depression	3.0 (2.7)	2.3 (2.3)	1.61	.11
Anxiety	7.1 (3.6)	7.0 (4.1)	0.05	.96

Table 5.2 presents descriptive and inferential statistics for alcohol use characteristics (total sample, males and females), and independent samples *t*-tests comparing total sample group differences (alcohol vs. placebo) for each of the alcohol use variables. The alcohol and placebo groups did not differ in age of first alcoholic drink, average quantity of alcohol consumed per week in standard units, speed of drinking, number of times 'drunk' within the past 6 months, and percentage of times drinking until drunk, in addition to *Alcohol Use Questionnaire* (*AUQ*; Mehrabian & Russell, 1978) outcome scores including the *AUQ* score and *AUQ* binge score.

Table 5. 1

Alcohol Use Demographics for the Total Sample and Separately for Males and Females

		Alcohol condition $n = 61$		Placebo condition $n = 63$			
		M	*SD*	*M*	*SD*	*t* (122) [a]	*p*
Age of first alcoholic drink	Total sample	15.2	2.0	15.1	1.9	0.15	.88
	Males	14.8	2.2	15.3	2.0		
	Females	15.6	1.8	15.0	1.7		
Alcohol units per week	Total sample	8.2	5.3	7.8	5.8	0.45	.65
	Males	9.9	5.7	8.7	6.1		
	Females	6.6	4.3	6.8	5.3		
Alcohol units per hour	Total sample	2.0	0.1	1.9	0.8	0.85	.40
	Males	2.5	1.2	1.9	0.7		
	Females	1.6	0.6	1.9	0.9		
Number of times drunk[b]	Total sample	12.1	13.4	11.0	17.7	0.39	.70
	Males	17.0	16.1	15.4	22.2		
	Females	7.3	7.8	6.4	9.6		
Percentage of times drinking until drunk[b]	Total sample	32.0	27.9	25.1	26.5	1.41	.16
	Males	37.8	28.5	31.7	31.1		
	Females	26.4	26.5	18.3	19.1		
AUQ score	Total sample	34.8	21.9	31.3	26.2	0.81	.42
	Males	44.3	24.3	38.0	31.6		
	Females	25.6	14.7	24.4	17.0		
AUQ binge score	Total sample	26.6	18.9	23.6	22.6	0.81	.42
	Males	34.4	21.6	29.4	27.7		
	Females	19.1	11.8	17.6	13.9		

[a] Independent samples t-tests comparing alcohol and placebo conditions total sample means.

[b] 'Drunk' is defined as the loss of coordination, nausea, and/or inability to speak clearly.

5.2.2 Alcohol Administration

A research assistant was responsible for the mixing of drinks and BAC measurements to ensure that the researcher remained blind to the participants' condition (alcohol or placebo). For participants assigned to the alcohol condition, alcohol was administered at a dose of 0.6g/kg of body weight. This dose was chosen because it is considered to be a good representation of moderate alcohol intoxication and a level of intoxication that is commonly experienced by social drinkers (Cui & Koob, 2017; De Pirro et al., 2020). Closely following the procedure outlined by Leitz et al. (2009), a total of 500ml of liquid was prepared containing 96% ethanol diluted with tonic water and lime cordial, and divided equally into 10 cups containing 50ml portions. Lime cordial was used to mask the taste of alcohol. For participants in the placebo condition, the placebo beverage consisted of 500ml of liquid divided equally into 10 cups containing 50ml portions of tonic water and lime cordial only. Participants in both conditions were provided with their respective 10 beverages and were required to consume the drinks at 3-minute time intervals in the presence of the researcher.

To maintain the level of alcohol in the blood over the entire testing period of up to 180 minutes, participants in the alcohol condition were given two sets of top-up drinks, each containing 0.1g/kg dose of alcohol, tonic water and lime cordial, while those assigned to the placebo condition were given two sets of placebo drinks. Each top-up drink contained two 50ml portions which were administered at approximately 80- and 120-minutes into the testing session. Previous research has shown that a dose of 0.1g/kg alcohol administered to participants in the alcohol condition as top-up drinks can be used to maintain a steady BAC over the entire testing period (Leitz et al., 2009; Paraskevaides et al., 2010). Each participant completed four BAC measurements administered by the research assistant throughout the testing session using a Lion

Alcolmeter 700 breathalyser. Participants were breathalysed at least 20 minutes after drink administration to ensure that the BAC reading for participants in the alcohol condition was not affected by residual alcohol within the mouth.

5.2.3 Procedure

Testing took place in one session of up to 180 mins duration, with breaks taken as needed. After completing the baseline BAC measurement, participants were weighed to allow the appropriate dose of alcohol to be calculated for those allocated to the alcohol condition. Participants then completed the tasks detailed in Table 5.3 (which includes a number of measures not relevant to the current study).

Table 5. 2

Procedure: Tasks Performed with Corresponding Times (Mins), Including Average BAC of Participants Assigned to the Alcohol Condition (Total Sample and Separately for Males and Females)

Time	Tasks and measures
0 mins	Informed consent
	Baseline BAC= total *M* = 0.000
	Weigh participant
	Spot the word
	Initial drink administration (0.6g/kg alcohol OR placebo)
	Background questionnaire
	Hospital Anxiety and Depression Scale
	Alcohol Usage Questionnaire
45 mins	End of drink administration
	Cognitive measures not used in the current study
	Verbal Fluency Task
	Hayling Sentence Completion Test
	Trail Making Test
75 mins	Alcohol group BAC Time 2 reading: total *M* = 0.064, *SD* = 0.014
	(Males *M* = 0.061 *SD* = 0.016; Females *M* = 0.067, *SD* = 0.011)
	Top up drink (0.1g/kg alcohol OR placebo)
	Cognitive measure not used in the current study
120 mins	Alcohol group BAC Time 3 reading: total sample *M* = 0.075, *SD* =0.013
	(Males *M* = 0.070 *SD* = 0.014; Females *M* = 0.079, *SD* = 0.011)
	Top up drink (0.1g/kg alcohol OR placebo)
	Autobiographical interview
	Cognitive measure not used in the current study
170 mins	Alcohol group BAC Time 4 reading: total sample *M* = 0.074, *SD* = 0.014
	(Males *M* = 0.068 *SD* = 0.013; Females *M* = 0.080, *SD* = 0.013)
	Debriefing, guess condition and payment

5.2.4 Measures[4]

5.2.4.1 Episodic Future Thinking and Retrospective Episodic Memory

The *Adapted Autobiographical Interview* (*AI;* Addis et al., 2008) is a semi-structured interview that was used to provide a measure of EFT and retrospective episodic memory. In this task, participants are required to generate as many details as possible about an event in relation to a cue word. These details are then broken down and classified as either *internal* details (episodic information relevant to the central event) or *external* details (non-episodic information not relevant to the central event). EFT is indexed by the total number of internal details generated across the future trials, and retrospective episodic memory is indexed by the total number of internal details generated across the past trials. The total number of external details generated across both future and past trials represents error.

5.2.4.2 Executive Functions

Participants completed the *Verbal Fluency Task* to provide a measure of cognitive initiation (Strauss et al., 2006) and the *Hayling Sentence Completion Test* to provide a measure of inhibitory control (Burgess & Shallice, 1997a). Cognitive flexibility was measured using the *Trail Making Test* (TMT; Arbuthnott & Frank, 2000).

5.2.5 Statistical Analysis

All statistical tests were two-tailed and conducted using IBM SPSS Statistics, version 26.0 (IBM Corp). An alpha level of $p < .05$ was considered significant, and effect sizes were estimated either using partial eta squared (η^2_p), Cohen's *d*, or Pearson *r* correlations, depending on the analytic approach. Cohen (1988) defines η^2_p effect sizes

[4] Description of measures have been abbreviated in this chapter to limit repetition. See Chapter 4 (Methodology for Empirical Studies) for a detailed description of the measures used in this study.

of .01 as small, .059 as medium and .138 as large, *d* effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large, and *r* effect sizes of 0.1 as small, 0.3 as medium, and 0.5 as large. There were no missing values, however one case was identified as a univariate outlier in the *Verbal Fluency Task*, as were two cases in the *TMT*, with z-scores of more than 3.29 (Tabachnick & Fidell, 2014). These outliers were replaced with scores ± 3SDs of the mean following the guidelines of Tabachnick and Fidell (2014).

5.3 Results

5.3.1 Blood Alcohol Concentration

The mean (SD) BAC at baseline, 75-, 120- and 170-minutes testing are reported in Table 5.3, separately for males and females assigned to the alcohol group. Independent samples *t*-tests were conducted to compare sex differences in BAC across the four BAC measurements. All participants obtained a baseline BAC of zero. Males and females obtained a similar BAC on the second BAC measurement, t (59) = 1.67, p = .10. However, females obtained a significantly higher BAC level than males on the third, t (59) = 2.92, p = .005, and fourth BAC measurements, t (59) = 3.68, p = .001.

5.3.2 Episodic Future Thinking and Retrospective Episodic Memory

To investigate whether participants in the alcohol condition differed from participants in the placebo condition in the number of details generated about past and future events, a mixed 2 × 2 × 2 × 2 ANOVA was conducted. The between-groups variables were *condition* (alcohol, placebo) and *sex* (males, females), and the within-groups variables were *temporal direction* (past, future) and *detail type* (internal, external). The results revealed that the four-way interaction was not significant, F (1,120) = 0.68, p = .41, η^2_p < .01, and that sex was not a three-way interaction with temporal direction and condition F (1,120) = 1.34, p = .25, η^2_p = .01, detail type and condition F (1,120) = 0.13, p = .72, η^2_p < .01, nor temporal direction and detail type F

(1,120) = 0.07, p = .80, η^2_p < .01. The three-way interaction between condition, temporal direction, and detail type was also not significant, F (1, 120) = 0.56, p = .46, η^2_p < .01.

There was a two-way interaction between detail type and condition, F (1, 120) = 15.66, p < .001, η^2_p = .12, but the other two-way interactions were not significant: sex and condition, F (1,120) = 0.55, p = .46, η^2_p < .01, sex and temporal direction, F (1,120) = 0.07, p = .79, η^2_p < .01, temporal direction and condition, F (1, 120) < 0.01, p = .95, η^2_p < .001, temporal direction and detail type, F (1, 120) = 2.40, p = .12, η^2_p = .02, and sex and detail type, F (1,120) = 0.64, p = .43, η^2_p < .01.

The significant interaction between detail type and condition was formally followed up with tests of simple effects. This interaction revealed that for internal details, participants in the placebo condition produced more details (M = 197.0, SD = 51.0) than participants in the alcohol condition (M = 170.2, SD = 51.8), F (1, 120) = 8.29, p = .005, η^2_p = .07. Conversely for external details, participants in the alcohol condition produced more details (M = 112.3, SD = 42.3) than participants in the placebo condition (M = 85.6, SD = 42.3), F (1, 120) = 12.35, p = .001, η^2_p = .09.

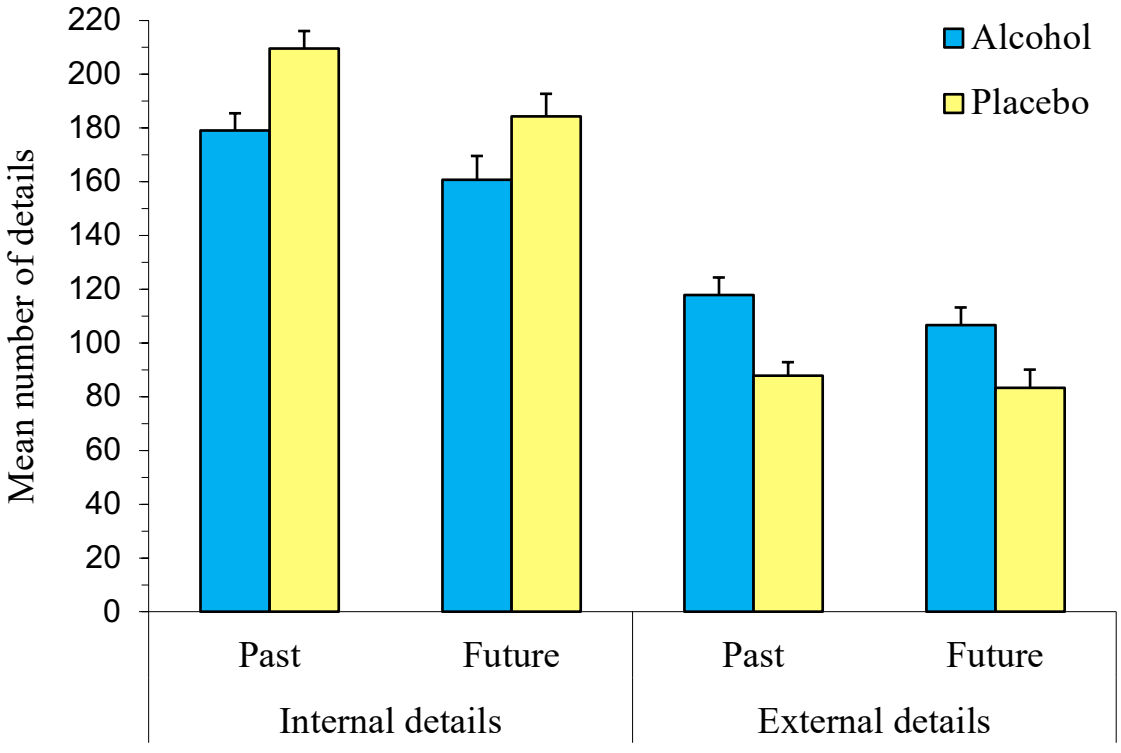
The results also revealed that there was a main effect of temporal direction, F (1, 120) = 47.95, p < .001, η^2_p = .29, indicating that collapsed across conditions, participants provided more details in the past condition (M = 148.6, SD = 28.7) than in the future condition (M = 133.9, SD = 33.4). Additionally, there was a main effect of detail type, F (1, 120) = 156.96, p < .001, η^2_p = .57, indicating that again, collapsed across conditions, participants provided more internal details as instructed (M = 183.6, SD = 51.8) than external details (M = 98.9, SD = 42.3). However, there was no main effect of condition, F (1, 120) < 0.001, p = 0.99, η^2_p < .001, or sex F (1,120) = 0.22, p = .64, η^2_p < .01. The number of details generated for past and future events is displayed in

Figure 5.1 as a function of *condition* (alcohol, placebo), *temporal direction* (past, future), and *detail type* (internal, external).

Finally, an independent samples *t*-test was conducted to examine if the alcohol and placebo conditions differed in the total amount of verbal output produced. The results revealed that there was no difference ($p = .99$) between the alcohol ($M = 564.7$, $SD = 122.5$) and placebo ($M = 565.1$, $SD = 105.2$) conditions in the total number of details generated across all six interview conditions, suggesting that the conditions did not differ in the overall amount of details generated.

Figure 5. 1

Mean Number of Internal and External Details Generated on the Autobiographical Interview as a Function of Condition (Alcohol, n = 61; Placebo, n = 63) and Temporal Direction (Past; Future). Error Bars Represent Mean Standard Error.



5.3.3 Executive Functions

Descriptive and inferential statistics for the executive function measures are reported in Table 5.4. There were no differences between the alcohol and placebo conditions on any of the executive function measures assessed.

Table 5. 3

Descriptive and Inferential Statistics for the Executive Function Measures for Participants in the Alcohol and Placebo Conditions

	Alcohol condition $n = 61$	Placebo condition $n = 63$		
	M (*SD*)	*M* (*SD*)	*t* (122)	*d*
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

* $p < 0.05$

5.3.4 Cognitive Correlates of Episodic Future Thinking

To investigate the cognitive correlates of EFT, Pearson product-moment correlations were calculated between EFT (indexed by future internal details), retrospective episodic memory (indexed by past internal details), and executive function measures, separately for each condition (i.e. alcohol, placebo). As shown in Table 5.5, significant correlations were found between EFT and retrospective episodic memory in both conditions, with better retrospective episodic memory performance associated with better EFT ability. However, for the executive functions, associations were inconsistent: EFT was positively correlated with only inhibitory control in the alcohol condition, and only cognitive initiation in the placebo condition.

Table 5. 4

Correlations Between Episodic Future Thinking and Measures of Retrospective Episodic Memory and Executive Function, Separately for the Alcohol and Placebo Conditions

	Episodic future thinking	
	Alcohol condition $n = 61$	Placebo condition $n = 63$
FSIQ	-.10	.16
Retrospective episodic memory	.45**	.60**
Executive function		
Cognitive initiation	.14	.30*
Inhibitory control	.29*	.03
Cognitive flexibility	-.19	.04

* $p < 0.025$, ** $p < 0.01$

5.3.5 Regression Analyses

To test whether the associations identified in the correlational analyses reflected unique contributions to EFT, hierarchical multiple regression analyses were conducted separately for the alcohol and placebo conditions (see Table 5.6). FSIQ was entered in Step 1 in the analyses, retrospective episodic memory (past internal details) in Step 2, and executive functions in Step 3. The results suggest that the variables in the overall model predicted significant variance in performance in both the alcohol (total $R^2 = .25$, $F(5,55) = 3.68$, $p = .006$) and placebo condition (total $R^2 = .38$, $F(5,57) = 6.88$, $p < .001$). However, retrospective episodic memory was the only variable that significantly contributed to EFT in the alcohol and placebo condition in the final model.

Table 5. 5

Hierarchical Multiple Regression Analyses Predicting Episodic Future Thinking from FSIQ, Retrospective Episodic Memory, and Executive Functions, Separately for the Alcohol and Placebo Conditions

	Episodic future thinking					
	Alcohol condition $n = 61$			Placebo condition $n = 63$		
Predictor	ΔR^2	*B* (*SE*)	β	ΔR^2	*B* (*SE*)	β
Step 1	.01			.02		
FSIQ		-1.61 (2.09)	-.10		2.32 (1.88)	.16
Step 2	.19**			.34**		
FSIQ		-0.73 (1.91)	-.05		0.27 (1.58)	.02
Retrospective episodic memory		0.62 (0.17)	.44**		0.77 (0.14)	.60**
Step 3	.05			.02		
FSIQ		-1.14 (2.00)	-.07		0.25 (1.75)	.02
Retrospective episodic memory		0.56 (0.17)	.40*		0.77 (0.15)	.59**
Inhibitory control		10.97 (9.73)	.16		-3.95 (8.48)	-.05
Cognitive flexibility		-0.19 (0.38)	-.07		0.42 (0.40)	.11
Cognitive initiation		0.20 (0.75)	.04		0.27 (0.69)	.05
Total R^2	.25*			.38**		

* $p < 0.01$, ** $p < 0.001$

5.4 Discussion

These data provide the first empirical assessment of the capacity for EFT following the administration of a moderate dose of alcohol, offering further novel insight into the neurocognitive effects of acute alcohol consumption. Consistent with predictions, the results showed that, relative to the placebo condition, EFT was disrupted by a moderate level of alcohol consumption, with significantly fewer episodic

details generated by participants in the alcohol condition when asked to imagine and describe a novel future scenario. These data supplement and extend prior research showing acute alcohol-related impairment in other aspects of cognitive functioning (e.g. Day et al., 2015; White, 2003) by demonstrating that the capacity to imagine the self in the future is also adversely affected.

It is also important to note that the production of fewer episodic details in the future did not simply reflect a generally lower level of overall verbal output. The alcohol and placebo conditions did not differ in the total amount of details produced when describing future events, but rather, only differed on the types of details (i.e. internal vs. external) that were generated. Specifically, the alcohol condition produced more external details than the placebo condition, despite explicit instructions given in the administration of the *AI* procedure to generate episodic content. As previously noted, overproduction of non-episodic (i.e. external) details, including repetition, semantic information, and information that is not relevant to the main event being described is considered indicative of error (Irish et al., 2011; Mercuri et al., 2015).

The identification of significant deficits in EFT following levels of acute alcohol consumption that would not be considered particularly high in modern society has potentially important practical implications. As noted earlier, EFT is important for daily functioning, decision making, and problem solving, allowing humans to assess potential dangers and carefully plan any actions before performing them, thereby reducing the risk of harm (Suddendorf & Corballis, 2007). Because EFT also plays a role in goal-oriented behaviour and emotion regulation, any difficulties engaging in EFT has the potential to cause motivational problems and irrational behaviour. In the context of substance use, problems with EFT may therefore present as increased risk-taking, maladaptive decision making, and a tendency to prioritise current needs over future

goals that may potentially be more beneficial (Grant et al., 2000; Suddendorf & Corballis, 2007). Indeed, deleterious behaviours commonly associated with alcohol intoxication include an increase in sexual risk taking, aggressive behaviour, and drink driving, all of which may be caused and/or potentially reinforced by a reduced capacity for EFT. In addition, many therapeutic techniques for the treatment of alcohol use disorder require some degree of future thought, such as goal setting and the weighing up of future consequences, thus difficulties with EFT could potentially jeopardise treatment progress and may present an additional target for treatment. As a consequence, the current findings have potentially important implications for policy making and the treatment of individuals with an alcohol use disorder.

5.4.1 The Potential Role of Other Acute Alcohol-Related Cognitive Difficulties

The second key result to emerge in the present study was the finding that the acute alcohol-induced problems with EFT appear to at least partially reflect broader problems with retrospective episodic memory. As predicted, and aligning with considerable prior literature, participants in the alcohol condition generated significantly fewer episodic details when asked to describe a personal past event relative to those in the placebo condition, indicating a deleterious effect of acute alcohol consumption on retrospective episodic memory. Additionally, a significant correlation was identified between retrospective episodic memory and EFT, and regression analyses revealed that retrospective episodic memory was the only cognitive variable to significantly contribute to EFT (with this effect evident in both the placebo and alcohol conditions). Taken together, whilst the current study does not allow for direct empirical investigation of the claim that a deficit in retrospective episodic memory following acute alcohol consumption contributes to poorer EFT, the pattern of findings are consistent with this proposal. Furthermore, these data align with the theoretical perspective of the

constructive episodic simulation hypothesis, which postulates that retrospective episodic memory provides the basic material from which hypothetical future scenarios are built (Addis et al., 2008; Buckner & Carroll, 2007; Hassabis et al., 2007; Schacter & Addis, 2007b; Schacter et al., 2017), by showing that retrospective episodic memory is recruited in the process of constructing novel future events.

Equally important however, was the absence of any evidence linking executive dysfunction to the negative effects of acute alcohol consumption on EFT. In contrast to the EFT deficit that emerged following acute alcohol use, the capacity to complete all three executive function tasks was preserved. Additionally, only one of the three executive function measures were related to EFT in each condition, and the specific executive measure to show a significant correlation was not consistent across the two conditions. Regression analyses also showed that none of the executive function measures predicted EFT performance in the alcohol condition. Taken together, these data suggest that the effects of acute alcohol consumption on EFT are unlikely to be underpinned by broader disturbances in executive function, or at least not the specific executive functions assessed in the present study, at the dose of alcohol administered. It does of course remain possible that a different picture may emerge at higher concentrations of alcohol, or with different executive function tasks, given the noted importance of task complexity in considering the effects of acute alcohol consumption on cognitive performance. This is an interesting question for future research to address. In addition, given that EFT has been argued to involve a range of other cognitive abilities, such as semantic memory (Irish, 2016; Irish & Piguet, 2013), and relational memory (Wiebels et al., 2020), future work is needed to identify additional processes that may be impacted by acute alcohol use and potentially contribute to EFT impairment.

Finally, an exploratory component of this study was to examine the presence of sex differences in EFT performance following acute alcohol administration. Interestingly and consistent with past research (Mumenthaler et al., 1999), females attained a higher BAC level than males even though they consumed an equivalent dose of alcohol that was adjusted for body weight. However, despite this difference, an elevated BAC level did not translate to increased impairment in EFT performance in females in the alcohol group. Rather, females' EFT performance in the alcohol group was found to be comparable to males in that group, indicating that the level of alcohol-related impairment in cognition, at least in terms of EFT, does not appear to be related to sex.

5.4.2 Strengths, Limitations and Future Directions

Key strengths of the current study included the use of well-validated measures and a well-powered design. However, these strengths aside, limitations should also be acknowledged. In particular, while the *AI* is a well-validated measure used in several previous studies to index EFT (Mercuri et al., 2015; Mercuri et al., 2018; Terrett et al., 2013), this task requires participants to provide detailed verbal descriptions of themselves experiencing past and future events (Addis et al., 2008). Therefore, it is possible that individual differences in basic verbal ability may affect performance. While this is unlikely to explain poorer performance in the alcohol condition in the current study given participants were randomly assigned to the two conditions and produced a similar amount of overall verbal output, future research would benefit from the inclusion of a measure of narrative ability to control for this possibility (see Gaesser et al., 2011). The lengthy nature of the testing session (typically 2.5 - 3 hours) also needs to be acknowledged. However, to mitigate any potential fatigue effects, regular

breaks were provided, and participants' subjective mood states were monitored throughout the session.

In conclusion, these data provide the first empirical evidence that a moderate dose of alcohol is sufficient to produce significant impairment in EFT and indicate that these difficulties may be at least partially linked to the effects of acute alcohol consumption on retrospective episodic memory. No evidence was found for a potential contributing role of broader executive function difficulties, and these effects did not vary as a function of biological sex. Further research is now required to better understand why EFT is compromised by acute alcohol use through the exploration of additional underlying cognitive and neural mechanisms. Future research may also consider replicating the study with a lower dose of alcohol to determine the point at which EFT is adversely affected by acute alcohol consumption. These results have important implications for policy making, individual decision making, and the treatment of individuals with an alcohol use disorder, whilst also furthering our understanding of why deleterious behaviours are so common under the influence of even moderate levels of alcohol.

Chapter 6: Study 2 - Episodic Foresight Following A Moderate Dose of Alcohol

Preamble

The previous chapter provided the first empirical evidence that acute alcohol consumption impairs episodic future thinking (EFT). The aim of the current study was to investigate whether this impairment extends beyond the ability to imagine the future, to also impact another form of prospection, specifically the capacity to organise current actions in light of the imagined future, known as episodic foresight. In other words, this study endeavoured to explore whether the ability to perform actions in the present in anticipation of future needs may be impaired by a moderate dose of alcohol. In addition, this study also examined the degree to which any identified deficits in episodic foresight may be related to executive dysfunction, retrospective memory impairment, and/or reduced EFT ability. This study employed Lyons et al.'s (2014) *Virtual Week- Foresight* to provide a measure of episodic foresight ability. As with the previous chapter, this chapter was written as a standalone empirical paper for journal submission. The descriptions of measures in the Methods section of this chapter have also been abbreviated, as all measures have been described in full in Chapter 4 (*Methodology for Empirical Studies*). Participant description and procedures are however, repeated in full to facilitate comprehension.

6.1 Introduction

Episodic foresight is one of the most adaptive and functionally important forms of future-oriented thinking (Atance & O'Neill, 2001; Bar, 2007; Suddendorf & 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 & 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 & Addis, 2007b; Suddendorf & Moore, 2011).

Despite general acceptance of the critical adaptive importance of episodic foresight, empirical studies investigating this ability are limited. This may reflect, at least in part, the complexity of measuring this construct, given that not all future-directed behaviours necessarily reflect this ability. To address this problem, Suddendorf and Corballis (2010) proposed a set of stringent criteria that measures of episodic foresight should meet, which Lyons et al. (2014) then used to develop the first behavioural measure of this construct appropriate for adult populations: *Virtual Week-Foresight* (*VW-Foresight*). Using this measure, problems engaging in episodic foresight have been shown to become more common in older relative to younger adults (Lyons et al., 2014), while moderate to large sized episodic foresight deficits have been identified in all clinical groups assessed using this measure to date: schizophrenia (Lyons et al., 2016), opiate users (Terrett, Lyons, et al., 2016), and stroke (Lyons et al., 2019). In the current study, *VW-Foresight* will be used to provide the first empirical assessment of whether episodic foresight is also impaired following acute alcohol consumption.

Assessment of episodic foresight in this cohort is important in light of evidence showing that 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 & Cusens, 2010), and to also be more likely to engage in risky behaviours, such as excess spending and driving after drinking (Field et al., 2010).

Episodic foresight may be expected to be disrupted because of the demands it places on other cognitive abilities known to be affected by alcohol, such as retrospective memory (memory for past information and events) and executive functions (higher order cognitive operations, such as inhibitory control and cognitive flexibility; Suddendorf & Corballis, 2007). Specifically, retrospective memory is proposed to be required in order to remember the content of the problem, while executive functions come into play particularly at the point when preparatory measures to solve a future problem should be enacted. This process arguably necessitates the inhibition of ongoing normal daily activities and cognitive flexibility in order to switch from one activity to another. The negative effects of acute alcohol consumption on retrospective memory has been extensively documented (Mintzer, 2007; Söderlund et al., 2007; Söderlund et al., 2005; White, 2003), although the degree of impairment appears dose-dependent (Bisby et al., 2010; Curran & Weingartner, 2002; Mintzer, 2007; Ryback, 1971; White, 2003). Additionally, research investigating the effect of acute alcohol consumption on executive functions suggests that the impact of alcohol depends not only on the dose of alcohol administered, but also the complexity of the executive function being assessed (for a review, see Day et al., 2015), with more effortful tasks generally impaired at lower doses of alcohol (Field et al., 2010; Fillmore, 2007). However, no study to date

has directly tested whether one corollary of acute alcohol-related impairment in retrospective memory and/or executive functions is reduced episodic foresight.

A third key ability that has been argued to contribute to episodic foresight is EFT, which refers to the ability to imagine oneself pre-experiencing future scenarios (Atance & O'Neill, 2001; Schacter et al., 2008; Szpunar, 2010). From a theoretical standpoint, episodic foresight has been argued to require the ability to imagine oneself in the future in order to identify personally relevant future needs, as it is this pre-experiencing which is argued to trigger behavioural choices that ensure those future needs are met (Suddendorf & Moore, 2011). This would therefore suggest that EFT is a core element of episodic foresight. Surprisingly however, there has been a lack of empirical investigation of this association, representing a major gap in the literature. Indeed, no published research to date has assessed the possible role of EFT in episodic foresight in either normal or clinical populations, nor the extent to which it might contribute to episodic foresight impairment in the context of acute alcohol consumption.

In summary, the primary aim of the present study was to provide the first test of whether the administration of a moderate dose of alcohol (0.6g/kg of body weight) disrupts the capacity for episodic foresight. It was predicted that, relative to a placebo condition, participants in the alcohol condition would be significantly impaired on *VW-Foresight.* The secondary aim was to provide the first test of whether any identified impairments in retrospective memory, executive function, and EFT contributed to any identified acute alcohol-related deficits in episodic foresight. It was predicted that each of these abilities would be impaired by acute alcohol consumption and would be correlated with episodic foresight performance. The final, exploratory component of this study was to examine the presence of sex differences in episodic foresight following acute alcohol ingestion. This question was of interest because it has been suggested that

sex differences in the pharmacokinetics of acute alcohol use make females more sensitive to its negative effects (see Mumenthaler et al., 1999 for a review), and consequently it was anticipated that, should any deficits in episodic foresight emerge, these may be greater for females than males.

6.2 Method

This study was approved by the Australian Catholic University Human Research Ethics Committee (Project number: 2018-122H).

6.2.1 Participants and Design

One-hundred-and-twenty-four healthy adult social drinkers[5] (average weekly alcohol consumption of 2-25 standard units[6] for females and 2-36 standard units for males following the criteria of Griffiths et al., 2012), aged 18 to 37 years (M = 24.4, SD = 4.2) were recruited via community advertisements and social networks. Participants provided written, informed consent and were randomly assigned to either the alcohol (n = 61; 30 males) or placebo (n = 63; 32 males) condition in a double-blind independent group design. Participants were excluded if they had a previous or current neurological condition, a major psychiatric illness, a history of alcohol or other substance dependence, an acquired or traumatic brain injury, if they were using prescription medication that required abstinence from alcohol, or if English was not the participants first language. Participants were asked not to use alcohol or any other illicit substance in the 24 hours prior to testing and were reminded of this requirement via text message at least a day in advance of the testing session. Participants confirmed abstinence from

[5] This sample of participants completed the full battery of cognitive measures required to conduct empirical studies 1, 2 and 3 (see Chapter 4 for details). However, only data from the *VW- Foresight*, *Autobiographical Interview*, executive functions, and retrospective memory measures were included in the analyses for Study 2, as they were the measures relevant to answer the research questions in this study.

[6] One standard unit of alcohol in Australia contains 10 grams of alcohol.

alcohol via self-report and a blood alcohol concentration (BAC) measurement of zero prior to commencing the experiment. All participants were reimbursed AU$60 for their time.

As shown in Table 6.1, the groups also did not differ in age, years of education, premorbid intelligence as measured by the *Spot the Word* test (Baddeley et al., 1993), or negative affect, as indexed by the *Hospital Anxiety and Depression Scale* (Zigmond & Snaith, 1983).

Table 6. 1

Participant Characteristics

	Alcohol condition $n = 61$	Placebo condition $n = 63$		
	M (*SD*)	*M* (*SD*)	*t* (122)	p
Age (in years)	24.3 (4.2)	24.5 (4.2)	0.29	.78
Years of education	16.1 (2.2)	16.2 (2.1)	0.21	.83
FSIQ	47.0 (4.3)	46.9 (4.5)	0.16	.87
Mental health				
Depression	3.0 (2.6)	2.3 (2.3)	1.61	.11
Anxiety	7.1 (3.6)	7.0 (4.1)	0.05	.96

Descriptive and inferential alcohol use statistics are presented in Table 6.2, separately for males and females. Individual samples *t*-tests were performed to compare overall group differences (alcohol vs. placebo) on each of the alcohol use variables using total sample means. As shown in Table 6.2, the alcohol and placebo groups did not differ in age of first alcoholic drink, average quantity (standard units) of alcohol consumed per week, speed of drinking, number of times 'drunk' within the past 6 months, and percentage of times drinking until drunk. The groups also did not differ on the two *Alcohol Use Questionnaire* (*AUQ*; Mehrabian & Russell, 1978) outcome scores (i.e. *AUQ* score and *AUQ* binge score).

Table 6. 2

Alcohol Use Demographics for the Total Sample and Separately for Males and Females

		Alcohol condition $n = 61$		Placebo condition $n = 63$			
		M	*SD*	*M*	*SD*	*t* (122) [a]	*p*
Age of first alcoholic drink	Total sample	15.2	2.0	15.1	1.9	0.15	.88
	Males	14.8	2.2	15.3	2.0		
	Females	15.6	1.8	15.0	1.7		
Alcohol units per week	Total sample	8.2	5.3	7.8	5.8	0.45	.65
	Males	9.9	5.7	8.7	6.1		
	Females	6.6	4.3	6.8	5.3		
Alcohol units per hour	Total sample	2.0	0.1	1.9	0.8	0.85	.40
	Males	2.5	1.2	1.9	0.7		
	Females	1.6	0.6	1.9	0.9		
Number of times drunk[b]	Total sample	12.1	13.4	11.0	17.7	0.39	.70
	Males	17.0	16.1	15.4	22.2		
	Females	7.3	7.8	6.4	9.6		
Percentage of times drinking until drunk[b]	Total sample	32.0	27.9	25.1	26.5	1.41	.16
	Males	37.8	28.5	31.7	31.1		
	Females	26.4	26.5	18.3	19.1		
AUQ score	Total sample	34.8	21.9	31.3	26.2	0.81	.42
	Males	44.3	24.3	38.0	31.6		
	Females	25.6	14.7	24.4	17.0		
AUQ binge score	Total sample	26.6	18.9	23.6	22.6	0.81	.42
	Males	34.4	21.6	29.4	27.7		
	Females	19.1	11.8	17.6	13.9		

[a] Independent samples *t*-tests comparing alcohol and placebo conditions total sample means.

[b] 'Drunk' is defined as the loss of coordination, nausea, and/or inability to speak clearly.

6.2.2 Alcohol Administration

Participant assignment to condition, drink preparation, and BAC measurements were performed by a research assistant to ensure that the researcher and participant remained blind to the treatment condition (alcohol or placebo). The administration of drinks closely followed the procedure outlined by Leitz et al. (2009). Alcohol was administered to participants assigned to the alcohol condition at a dose of 0.6g/kg of body weight. This dose was chosen because it is considered to be a good representation of moderate alcohol intoxication and is an amount of alcohol that is commonly consumed by social drinkers (Cui & Koob, 2017; De Pirro et al., 2020). A total of 500mls of liquid was prepared, containing 96% ethanol, diluted with tonic water and lime cordial to mask the taste of alcohol. The liquid was then divided into 10 cups, each containing 50ml portions. The placebo beverage provided to participants in the placebo condition also contained a total of 500mls of liquid that was divided equally into 10 cups of 50ml portions, however it consisted of tonic water and lime cordial only.

Participants in both conditions were provided with their respective drinks and were required to consume the 10 beverages at 3-minute time intervals in the presence of the researcher. To maintain the level of alcohol in the blood over the entire testing period of up to 180 minutes, participants in the alcohol condition were given two sets of top up drinks containing a 0.1g/kg dose of alcohol, while participants in the placebo condition were provided with two sets of placebo drinks. Each top up drink consisted of two 50ml portions and was administered at approximately 80- and 120-minutes into the testing session. Previous research has shown that a 0.1g/kg dose of alcohol in the top up drinks provided to participants in the alcohol condition can be used to maintain a stable BAC over the entire testing period (Leitz et al., 2009; Paraskevaides et al., 2010). Each participant's BAC level was measured four times throughout the testing session by a

research assistant using a Lion Alcolmeter 700 breathalyser. Participants were breathalysed at least 20 minutes after drink administration to ensure that the BAC reading for participants in the alcohol condition was not affected by residual alcohol within the mouth.

6.2.3 Procedure

Testing took place in one session of up to 180 minutes, with breaks taken as needed. A baseline BAC measure was taken by the research assistant to ensure participant abstinence from alcohol prior to testing. Participants were then weighed to calculate the appropriate dose of alcohol for participants assigned to the alcohol condition. Participants then proceeded with the measures outlined in Table 3, which included several measures not of interest in the current study.

Table 6. 3

Procedure: Tasks Performed with Corresponding Times (Mins), Including Average BAC of Participants Assigned to the Alcohol Condition (Total Sample and Separately for Males and Females)

Time	Tasks and measures
0 mins	Informed consent
	Baseline BAC= total *M* = 0.000
	Weigh participant
	Spot the word
	Initial drink administration (0.6g/kg alcohol OR placebo)
	Background questionnaire
	Hospital Anxiety and Depression Scale
	Alcohol Usage Questionnaire
45 mins	End of drink administration
	Hopkins Verbal Learning Test
	Verbal Fluency Task
	Hayling Sentence Completion Test
	Trail Making Test
75 mins	Alcohol group BAC2 Time 2 reading: total *M* = 0.064, *SD* = 0.014
	(Males *M* = 0.061 *SD* = 0.016; Females *M* = 0.067, *SD* = 0.011)
	Top up drink (0.1g/kg alcohol OR placebo)
	VW-Foresight
120 mins	Alcohol group BAC Time 3 reading: total sample *M* = 0.075, *SD* =0.013
	(Males *M* = 0.070 *SD* = 0.014; Females *M* = 0.079, *SD* = 0.011)
	Top up drink (0.1g/kg alcohol OR placebo)
	Autobiographical Interview
	Cognitive measure not used in the current study
170 mins	Alcohol group BAC Time 4 reading: total sample *M* = 0.074, *SD* = 0.014
	(Males *M* = 0.068 *SD* = 0.013; Females *M* = 0.080, *SD* = 0.013)
	Debriefing, guess condition and payment

6.2.4 Measures[7]

6.2.4.1 Episodic Foresight

VW-Foresight (Lyons et al., 2014) is a computerized board game that simulates real-life situations to provide a measure of an individual's ability to engage in episodic foresight in the context of everyday living. *VW-Foresight* generates two scores at the end of the game. These are the *number of correct items acquired* and the *number of correct items used*. The *number of correct items acquired* variable reflects the ability to act in the present (i.e., to obtain a correct item) with the anticipated future in mind, whereas the *number of correct items used* reflects the ability to perform a self-generated intention to resolve a problem at the appropriate time. Together, these variables provide a measure of episodic foresight capacity (Lyons et al., 2014).

6.2.4.2 Retrospective Memory

Participants completed the *Hopkins Verbal Learning Test- Revised* (*HVLT-R*; Benedict et al., 1998) to provide a measure of immediate and delayed recall.

6.2.4.3 Executive Functions

Participants completed the *Verbal Fluency Task* to provide a measure of cognitive initiation (Strauss et al., 2006), the *Hayling Sentence Completion Test* to provide a measure of inhibitory control (Burgess & Shallice, 1997a), and the *Trail Making Test* (*TMT*) to provide a measure of cognitive flexibility (Arbuthnott & Frank, 2000).

6.2.4.4 Episodic Future Thinking

EFT was measured using the adapted *Autobiographical Interview* (*AI*; Addis et al., 2008). The *AI* is a semi-structured interview that provides a measure of episodic and

[7] Description of measures have been abbreviated in this chapter to limit repetition. See Chapter 4 (Methodology for Empirical Studies) for a detailed description of the measures used in this study.

non-episodic content, in two temporal conditions (past and future). Episodic content in the future condition was used to index EFT.

6.2.5 Data Analysis

All statistical tests were two-tailed and were conducted using IBM SPSS Statistics, version 26.0 (IBM Corp). An alpha level of $p < 0.05$ was considered significant, and effect sizes were estimated using partial eta squared (η^2_p), Cohen's *d* and Pearson *r* correlations. Cohen (1988) defines η^2_p effect sizes of .01 as small, .059 as medium and .138 as large, *d* effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large, and *r* effect sizes of 0.1 as small, 0.3 as medium, and 0.5 as large. There were no missing values, however one case was identified as a univariate outlier in the *Verbal Fluency Task*, as were two cases in the *TMT*, with z-scores of more than 3.29 (Tabachnick & Fidell, 2014). These outliers were replaced with scores $\pm$ 3SDs of the mean following the guidelines of Tabachnick and Fidell (2014).

6.3 Results

6.3.1 Blood Alcohol Concentration

Table 6.3 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 obtained a baseline BAC of zero. At the second BAC measurement, males and females obtained a similar BAC, $t\ (59) = 1.67$, $p = .10$. However, females obtained a significantly higher BAC level on the third, $t\ (59) = 2.92$, $p = .005$, and fourth BAC measurements, $t\ (59) = 3.68$, $p = .001$.

6.3.2 Cognitive Measures

Descriptive and inferential statistics for executive functions, retrospective memory, and EFT are reported in Table 6.4. There were no differences between the

alcohol and placebo conditions on any of the executive function measures. However, the alcohol condition performed significantly worse than the placebo condition on the measures of retrospective memory and EFT.

Table 6. 4

Descriptive and Inferential Statistics for the Cognitive Function Measures for Participants in the Alcohol and Placebo Conditions

	Alcohol condition $n = 61$	Placebo condition $n = 63$		
	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
Episodic future thinking	160.7 (68.9)	184.4 (66.3)	1.95*	0.35

* p = 0.05, ** p < 0.01

6.3.3 Episodic Foresight

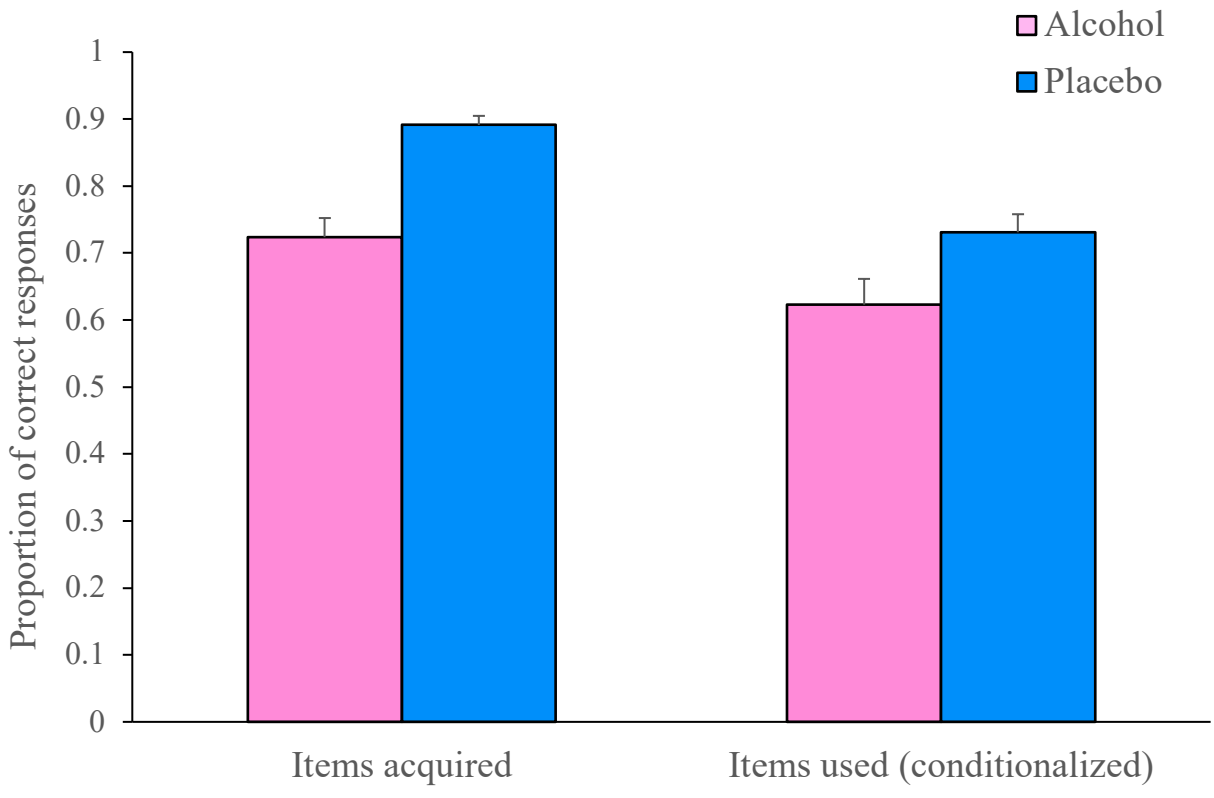
As previously noted, *VW-Foresight* generates two key scores: the proportion of items acquired, and the proportion of items used. These scores were analysed using a mixed 2 × 2 × 2 ANOVA, with the between-subjects factors of assigned *treatment condition* (alcohol, placebo) and *sex* (males, females), and the within-subjects factor of *foresight task* (items acquired, items used). For this analysis, the number of items acquired was expressed as a proportion of the total of the seven items that it was possible to acquire. The total number of items used was expressed as a proportion of acquired items that were subsequently correctly used. That is, the item use variable was conditionalized on acquisition, whereby the number of used items was divided by the number acquired to produce a proportion of acquired items that were correctly used for each participant. This was done to rule out any potential deficits in use of an item that might simply be attributable to the fact that participants in the alcohol condition were less likely to acquire the correct item in the first place.

The results revealed that the three-way interaction between condition, sex, and foresight task was not significant, F (1,120) = 1.28, p = .26, η^2_p = .01. Similarly, all two-way interactions were not significant: foresight task and condition, F (1,120) = 1.26, p = .26, η^2_p = .01, foresight task and sex, F (1,120) < 0.01, p = .99, η^2_p < .01, and sex and condition, F (1,120) = 1.22, p = .27, η^2_p = .01. Additionally, the main effect of sex was not significant, F (1,120) < 0.01, p = .94, η^2_p < .01. However, there was a main effect of condition, F (1,120) = 21.06, p < .001, η^2_p = .15, with participants in the alcohol condition (M = 0.7, SD = 0.2) exhibiting significantly poorer performance than those in the placebo condition's (M = 0.8, SD = 0.2). There was also a main effect of foresight task, F (1,120) = 23.66, p < .001, η^2_p = .17, with proportion of items acquired (M = 0.8, SD = 0.2) significantly greater than the proportion of items subsequently correctly used

(conditionalized; $M = 0.7$, $SD = 0.3$)[8]. Descriptive statistics for the proportion of correct items acquired and items used (conditionalized) as a function of condition (alcohol, placebo) are displayed in Figure 6.1.

Figure 6. 1

Mean Proportion of the Number of Items Acquired and Used (Conditionalized) as a Function of Condition (Alcohol, n = 61; Placebo, n = 63). Items Acquired is Expressed as a Proportion of Seven Possible Items. Items Used (Conditionalized) is Expressed as a Proportion of Acquired Items that were Used. Error Bars Represent Mean Standard Error.



[8] A similar mixed 2 × 2 × 2 ANOVA was also conducted for items used (unconditionalized) i.e. the raw score for items used, thus not taking into account the number of items acquired. See Appendix H. The results revealed a significant three-way interaction between condition, sex, and foresight task, which was followed up with separate two-way ANOVAs for foresight task: item acquisition and item use. On item acquisition, there was no hint of sex differences, with all participants in the alcohol condition exhibiting a similar and substantial level of impairment. On item use, there was a two-way interaction of sex and condition, where women were substantially impaired in the alcohol condition, but men were not.

6.3.4 Cognitive Correlates of Episodic Foresight

Correlations between *VW-Foresight* item acquisition and item use (conditionalized) and the other cognitive measures are reported in Table 6.5, separately for the two conditions. For the alcohol condition, item acquisition was significantly correlated with retrospective memory, as indexed by both immediate and delayed recall. Additionally, item use in the alcohol condition was significantly associated with inhibitory control and cognitive flexibility, with better performance on these measures associated with more items used. No significant correlations were found between episodic foresight and any of the other cognitive measures in the placebo condition[9].

Table 6. 5

Correlations Between Item Acquisition and Item Use (Conditionalized) and Measures of FSIQ, Retrospective Memory, Executive Function, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions.

	Alcohol condition *n* = 61		Placebo condition *n* = 63	
	Item acquisition	Item use	Item acquisition	Item use
FSIQ	.251	.193	- .005	.156
Retrospective memory				
Immediate recall	.530**	- .003	- .006	-.043
Delayed recall	.403**	.054	.106	-.150
Executive functions				
Cognitive initiation	.180	.176	.038	.053
Inhibitory control	.077	.373**	.067	.179
Cognitive flexibility	-.093	-.310*	-.174	-.107
Episodic future thinking	.116	.168	.002	.052

* $p < 0.025$, ** $p < 0.01$

[9] Correlations were also performed for item use (unconditionalized). See Appendix I.

6.3.5 Regression Analyses

Hierarchical multiple regressions were then conducted to test whether the associations identified in the correlational analyses reflected unique contributions to episodic foresight. These regression analyses were conducted for item acquisition and item use (conditionalized) separately for the alcohol and placebo conditions (see Table 6.6). FSIQ was entered in Step 1 in the analyses, retrospective memory and executive functions were entered in Step 2, and EFT in Step 3.

For item acquisition, the variables did not account for significant variance in performance in the placebo condition (total $R^2 = .07$, $F\,(7,55) = 0.61$, $p = .75$), but did in the alcohol condition (total $R^2 = .34$, $F\,(7,53) = 3.82$, $p = .002$). However, upon closer inspection, immediate recall was the only variable that significantly contributed to item acquisition in the alcohol condition. Similarly, for item use (conditionalized), the results showed that the variables did not predict significant variance in the placebo condition (total $R^2 = .12$, $F\,(7,55) = 1.03$, $p = .42$), but did predict significant variance in the alcohol condition (total $R^2 = .23$, $F\,(7,53) = 2.27$, $p = .04$). Inhibitory control was the only variable that significantly contributed to item use in the alcohol condition[10].

[10] Hierarchical multiple regression analyses were also performed for item use (unconditionalized). See Appendix J.

Table 6. 6

Hierarchical Multiple Regression Analyses Predicting Episodic Foresight from FSIQ, Retrospective Memory, Executive Functions, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	Alcohol condition $n = 61$						Placebo condition $n = 63$					
	Item acquisition			Item use			Item acquisition			Item use		
Predictor	ΔR^2	*B* (*SE*)	β	ΔR^2	*B* (*SE*)	β	ΔR^2	*B* (*SE*)	β	ΔR^2	*B* (*SE*)	β
Step 1	.06*			.04			<.01			.02		
FSIQ		.01 (.01)	.25*		.01 (.01)	.19		.00 (.00)	-.01		.01 (.01)	.16
Step 2	.27**			.19*			.07			.09		
FSIQ		.01 (.01)	.23		.02 (.01)	.22		-.00 (.00)	-.05		.01 (.01)	.19
Immediate recall		.03 (.01)	.57*		.01 (.01)	.07		-.01 (.01)	-.30		.01 (.01)	.17
Delayed recall		-.01 (.02)	-.08		-.04 (.03)	-.29		.02 (.01)	.30		-.04 (.02)	-.35
Inhibitory control		.01 (.03)	.02		.10 (.04)	.35*		.01 (.02)	.04		.05 (.03)	.19
Cognitive flexibility		.00 (.00)	.11		-.00 (.00)	-.21		-.00 (.00)	-.17		-.00 (.00)	-.12
Cognitive initiation		.00 (.00)	.09		.00 (.00)	.02		.00 (.00)	.07		-.00 (.00)	-.13
Step 3	<.01			.06			<.01			<.01		
FSIQ		.01 (.01)	.23		.02 (.01)	.23		-.00 (.00)	-.06		.01 (.01)	.19
Immediate recall		.03 (.01)	.56**		.00 (.01)	.04		-.01 (.01)	-.32		.01 (.01)	.16
Delayed recall		-.01 (.02)	-.08		-.03 (.02)	-.26		.02 (.01)	.32		-.04 (.03)	-.35
Inhibitory control		.00 (.03)	.02		.10 (.04)	.33*		.01 (.02)	.05		.04 (.03)	.20
Cognitive flexibility		.00 (.00)	.11		-.00 (.00)	-.20		-.00 (.00)	-.17		-.00 (.00)	-.12
Cognitive initiation		.00 (.00)	.09		.00 (.00)	.02		.00 (.00)	.06		-.00 (.00)	-.14
EFT		.00 (.00)	.01		.00 (.00)	.08		.00 (.00)	.06		.00 (.00)	.01
Total R^2	.34**			.23*			.07			.12		

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

6.4 Discussion

These data provide the first empirical assessment of episodic foresight capacity in the context of acute alcohol use and show that this fundamental human capacity is significantly disrupted by even moderate levels of alcohol consumption. Relative to participants in the placebo condition, acute alcohol use 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. Given the critical adaptive importance of episodic foresight, impairment may lead to suboptimal decision making, potentially contributing to many of the functional problems commonly associated with alcohol consumption, such as excess spending and increased risk taking (Field et al., 2010). The next critical step in this literature is now to directly test this possibility, and to establish the functional correlates of episodic foresight deficits associated with acute alcohol use.

The current study also provided novel 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. In relation to retrospective memory, consistent with past research, acute alcohol use was associated with significant impairment (Curran & Weingartner, 2002; Mintzer, 2007; Söderlund et al., 2005; White, 2003). However, additionally and more importantly, uniquely for participants in the alcohol condition, a significant positive association was found between one of the indices of episodic foresight (item acquisition) and both measures of retrospective memory, with immediate recall also a significant predictor of variance in item acquisition. These results therefore suggest that reductions in episodic foresight associated with acute alcohol consumption may, at least in part, be secondary consequences of 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 taking action accordingly. Interestingly

however, there was no evidence that either problems with executive function or EFT contributed to the problems with episodic foresight seen in the alcohol use group. With respect to executive functions, no group differences emerged, and thus do not explain the observed impairment in episodic foresight. For EFT, although participants in the alcohol condition did exhibit significant impairment in this capacity, these difficulties were unrelated to episodic foresight.

Taken together, these results raise the interesting possibility that episodic foresight may be more independent of other cognitive functions than has been assumed in the theoretical literature. While speculative, this suggestion gains support from the pattern of results also identified in the placebo group, which found no associations between episodic foresight and any of the other cognitive abilities assessed. Also consistent with this possibility is the fact that prior studies that have used *VW-Foresight* have failed to identify consistent cognitive correlates (Lyons et al., 2014; Lyons et al., 2016; Lyons et al., 2019; Terrett, Lyons, et al., 2016). Further research is now needed to explore this issue further.

The third key finding to emerge from this study 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. However, females in the alcohol condition acquired a similar number of items to males in the alcohol condition, and also did not differ from males in subsequent item use once initial item acquisition was accounted for. Thus, males and females' capacity for episodic foresight were comparably adversely affected by acute alcohol ingestion.

6.4.1 Strengths and Limitations

A notable strength of this study was the use of a well-powered design. Another key strength of the current study was the use of the *VW-Foresight* task, the only behavioural measure suitable for adult populations that meets the strict criteria for episodic foresight set out by Suddendorf and Corballis (2010). At the same time, while *VW-Foresig*ht attempts to reflect real-life activities in the laboratory, it would be beneficial for future studies to assess episodic foresight in the course of participants' actual daily lives. This would strengthen conclusions made regarding the potentially negative effects of moderate alcohol consumption on this critical cognitive capacity and could form the basis of public education programs to increase awareness of acute alcohol-related impairments in cognitive functioning. Additionally, another potential limitation of this study concerns the length of the testing sessions, which ranged from 2.5 to 3 hours in length, and may have potentially led to fatigue effects. However, this seems unlikely, as the testing protocol incorporated regular breaks and monitored participants' subjective mood states throughout the session using visual analogue scales, which did not show any major reduction in alertness across the entire testing duration.

In conclusion, these data provide the first empirical evidence that the ability to use episodic foresight is compromised in the context of a moderate dose of alcohol, and that the impairment is similar in males and females. While these deficits do appear to be associated with 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 clarify how these deficits manifest in daily life. These data have important implications for current understanding of how even acute moderate alcohol use may lead to suboptimal decision making and increased risk taking, as well as a range of well-documented functional problems.

Chapter 7: Study 3 - Prospective Memory Following Acute Alcohol Consumption

Preamble

In the previous chapters, empirical studies 1 and 2 investigated the effect of acute alcohol consumption on two forms of prospection; episodic future thinking (EFT) and episodic foresight. The current study, Study 3, investigated another form of prospection, namely prospective memory (PM), which refers to the ability to remember to carry out an intention at the appropriate time in the future, in order to further extend current understanding of the effects of acute alcohol consumption on cognitive impairment in relation to prospection. The primary aim of this study was to undertake a comprehensive investigation of PM ability by considering five types of PM tasks using a reliable measure of PM called *Virtual Week-Prospective Memory* (*VW-PM*; Rendell & Craik, 2000). In addition, this study also aimed to investigate whether any PM-related difficulties could be explained by impairment in retrospective memory, executive function, and/or EFT. As was the case for the previous two chapters, this chapter was also written as a standalone empirical paper for journal submission. The descriptions of measures in the Methods section have again been abbreviated and can be found in full in Chapter 4 (*Methodology for Empirical Studies*). However, participant characteristics and procedures have been repeated in full to facilitate comprehension.

7.1 Introduction

Acute alcohol consumption affects many brain regions known to play a key role in cognitive processing, including the frontal lobes, amygdala, and hippocampal regions (Charness, 1990; Jacob & Wang, 2020). In general, higher doses of alcohol are associated with greater cognitive impairment (Field et al., 2010; Fillmore, 2007). However, the impact of acute alcohol use is also affected by the complexity of the cognitive function, with alcohol consumption shown to selectively disrupt higher-order cognitive functions at relatively low doses of alcohol, while less demanding cognitive functions remain intact (Eckardt et al., 1998; Field et al., 2010; Fillmore, 2007).

The present study was interested in providing a clearer understanding of how acute alcohol consumption is related to a particularly important higher-level cognitive ability, namely PM. PM refers to the ability to remember to carry out an intended action at a specific point in the future and is therefore a critical predictor of health and safety-related behaviours involved in many important everyday activities, such as taking medication and attending appointments (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). PM impairment has also been argued to be a potentially important contributor to relapse in problem drinkers (Griffiths et al., 2012; Leitz et al., 2009; Smith-Spark et al., 2016). However, at present, current understanding of the effects of alcohol on PM function is surprisingly limited.

Specifically, to date, only five studies have objectively investigated the effect of acute alcohol consumption on PM, and their results have been mixed. While one study identified impairment across all types of PM tasks (Leitz et al., 2009), three studies reported PM impairment on some, but not all types of tasks (Montgomery et al., 2011; Paraskevaides et al., 2010; Smith-Spark et al., 2016), and one study did not identify a deficit in PM at all (Walter & Bayen, 2016). These discrepancies may be artefactual, reflecting differences in statistical power (sample sizes per group have ranged from 16 to 37 participants), or more substantive

method-specific differences, such as the dose of alcohol administered (which have ranged from 0.4 to 0.6 grams of alcohol per kilogram of body weight), and/or the tasks used to assess PM (which have ranged from extensively validated paradigms, such as *VW-PM* [Rendell & Craik, 2000]), to tasks for which relatively limited validation data exists, such as the *Jansari-Agnew-Akesson-Murphy* task [Jansari et al., 2004]). However, although differences in the exact nature and magnitude of impairment have been reported across these five studies, it is noteworthy that four of the five studies identified impairment in at least some aspects of PM, speaking to the potential detrimental effects of acute alcohol use on this critically important cognitive ability.

If acute alcohol intoxication does cause PM impairment, the next important question to address is why these difficulties arise. Again, current literature here is limited, but theoretically it seems likely that impaired retrospective memory (memory for past information and events) may contribute to problems with PM due to the well-documented effects of acute alcohol consumption on this cognitive ability (Mintzer, 2007; Ryback, 1971; White, 2003). This is because retrospective memory is important for PM, as the successful implementation of a PM task requires not only remembering that you have to complete a task (the prospective component), but also the recollection of task content (the retrospective component; Einstein & McDaniel, 1990; Kliegel et al., 2000). Consistent with this possibility, in the only study to date to look at this potential association in the context of alcohol use, Leitz et al. (2009) identified a significant association between retrospective memory and PM performance.

Acute alcohol-induced PM deficits might also be expected to arise because of the adverse impact of acute alcohol use on executive function (see Day et al., 2015 for a review). It has been argued that, in addition to heavily loading on retrospective memory, PM also imposes substantial demands on executive functions such as inhibitory control, cognitive flexibility, and strategic monitoring processes (Altgassen et al., 2014; Henry et al., 2014; van den Berg et al., 2004). Acute alcohol-induced deficits have been documented in executive function, although

the presence and degree of impairment appears to be largely influenced by the dose of alcohol administered, the executive function being assessed, and the specific measures used to assess each function (Day et al., 2015) Nevertheless, it is possible that acute alcohol-related executive dysfunction in abilities such as inhibitory control and cognitive flexibility may contribute to impairment in PM. However, no study to date has assessed whether acute alcohol-related executive dysfunction is related to difficulties with PM.

Finally, more recently, the relationship between PM and EFT has been the focus of considerable attention (Schacter et al., 2008; Szpunar, 2010). EFT refers to the ability to imagine oneself experiencing the future, and engagement in this type of mental simulation has been argued to potentially enhance encoding, thereby increasing the likelihood of successfully completing the PM task (Atance & O'Neill, 2001; Schacter et al., 2008; Szpunar, 2010). Consistent with the potential for a link between EFT and PM, EFT has shown to be an effective strategy for improving PM performance in clinical populations and nonclinical populations (Altgassen et al., 2015; Brewer & Marsh, 2010; Mioni et al., 2017; Neroni et al., 2014; Platt et al., 2016), and even when under the influence of alcohol (Paraskevaides et al., 2010). In addition, neuroimaging studies have identified overlap in the brain regions activated during EFT and PM (Burgess et al., 2003; Schacter et al., 2007; Weiler et al., 2010b), and behavioural studies have identified a positive association between PM and the ability to engage in EFT (Terrett et al., 2019; Terrett, Rose, et al., 2016). However, no study to date has directly assessed the effect of acute alcohol use on EFT, nor in turn, the extent to which problems with EFT may potentially contribute to acute alcohol-related impairment in PM.

The first aim of the current study was to extend prior literature testing the effects of acute alcohol use on PM function, but using the most methodologically rigorous design to date. Specifically, this relationship was tested using both a better powered design, as well as one of the most extensively validated measures of PM. It was hypothesised that acute alcohol use

would impair PM performance relative to the placebo condition. In addition, a novel, exploratory component of this study was to examine whether any sex differences emerged (and specifically, whether females may be disproportionately impacted), as sex differences in the pharmacokinetics of acute alcohol use have been identified (see Mumenthaler et al., 1999 for a review). The second aim of the current study was to provide the most comprehensive assessment to date of the cognitive abilities that underpin acute alcohol-related PM impairment. This was achieved by concurrently assessing retrospective memory, executive functions, and EFT. It was predicted that all three of these variables would be adversely affected by acute alcohol use. It was also anticipated that each of these abilities would be related to PM performance, but an open question (and of particular interest) was the relative strengths of these effects.

7.2 Method

This study was approved by the Australian Catholic University Human Research Ethics Committee (Project number: 2018-122H).

7.2.1 Participants and Design

One-hundred-and-twenty-four healthy adult social drinkers[11] aged 18 to 37 years (M = 24.4, SD = 4.2) participated in this study. Participants were randomly assigned to either the alcohol (n = 61; 30 males) or placebo (n = 63; 32 males) condition in a double-blind independent group design. As shown in Table 7.1, the groups were also similar in age, years of education, premorbid intelligence, as measured by the *Spot the Word* test (Baddeley et al., 1993), and negative affect, as indexed by the *Hospital Anxiety and Depression Scale* (Zigmond & Snaith, 1983).

[11] This sample of participants completed the full battery of cognitive measures required to conduct empirical studies 1, 2 and 3 (see Chapter 4 for details). However, only data from the *VW- PM*, *Autobiographical Interview*, executive functions and retrospective memory measures were included in the analyses for Study 3, as they were the measures relevant to answer the research questions in this study.

Table 7. 1

Participant Characteristics

	Alcohol condition $n = 61$	Placebo condition $n = 63$		
	M (*SD*)	*M* (*SD*)	*t* (122)	*p*
Age (in years)	24.3 (4.2)	24.5 (4.2)	0.29	.78
Years of education	16.1 (2.2)	16.2 (2.1)	0.21	.83
FSIQ	47.0 (4.3)	46.9 (4.5)	0.16	.87
Mental health				
Depression	3.0 (2.6)	2.3 (2.3)	1.61	.11
Anxiety	7.1 (3.6)	7.0 (4.1)	0.05	.96

Participants were recruited for the study via community advertisements and social networks. All participants provided written informed consent and were 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 2-25 standard units[12] of alcohol per week for females, and 2-36 standard units of alcohol per week for males.

Table 7.2 presents descriptive and inferential alcohol use statistics for males and females separately, as well as independent samples *t*-tests comparing the alcohol and placebo conditions total sample means for each of the variables. The alcohol and placebo 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

[12] One standard unit of alcohol in Australia contains 10 grams of alcohol.

times drinking until drink, as well as *Alcohol Use Questionnaire* (*AUQ*; Mehrabian & Russell, 1978) outcome scores including the *AUQ* score and *AUQ* binge score.

Exclusion criteria comprised 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 as a first language. Participants were asked to refrain from using alcohol or any other illicit substance in the 24 hours prior to testing and were reminded of this requirement 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.

Table 7. 2

Alcohol Use Demographics for the Total Sample and Separately for Males and Females

		Alcohol condition $n = 61$		Placebo condition $n = 63$			
		M	*SD*	*M*	*SD*	*t* (122) [a]	*p*
Age of first alcoholic drink	Total sample	15.2	2.0	15.1	1.9	0.15	.88
	Males	14.8	2.2	15.3	2.0		
	Females	15.6	1.8	15.0	1.7		
Alcohol units per week	Total sample	8.2	5.3	7.8	5.8	0.45	.65
	Males	9.9	5.7	8.7	6.1		
	Females	6.6	4.3	6.8	5.3		
Alcohol units per hour	Total sample	2.0	0.1	1.9	0.8	0.85	.40
	Males	2.5	1.2	1.9	0.7		
	Females	1.6	0.6	1.9	0.9		
Number of times drunk[b]	Total sample	12.1	13.4	11.0	17.7	0.39	.70
	Males	17.0	16.1	15.4	22.2		
	Females	7.3	7.8	6.4	9.6		
Percentage of times drinking until drunk[b]	Total sample	32.0	27.9	25.1	26.5	1.41	.16
	Males	37.8	28.5	31.7	31.1		
	Females	26.4	26.5	18.3	19.1		
AUQ score	Total sample	34.8	21.9	31.3	26.2	0.81	.42
	Males	44.3	24.3	38.0	31.6		
	Females	25.6	14.7	24.4	17.0		
AUQ binge score	Total sample	26.6	18.9	23.6	22.6	0.81	.42
	Males	34.4	21.6	29.4	27.7		
	Females	19.1	11.8	17.6	13.9		

[a] Independent samples *t*-tests comparing alcohol and placebo conditions total sample means.

[b] 'Drunk' is defined as loss of coordination, nausea, and/or inability to speak clearly.

7.2.2 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). For participants assigned to the alcohol condition, alcohol was administered at a dose of 0.6 grams of alcohol per kilogram of body weight, closely following the procedure outlined by Leitz et al. (2009). A moderate dose of alcohol (0.6g/kg) was chosen as research suggests that it produces a BAC level that is considered to be a good estimate of moderate alcohol intoxication and is an amount of alcohol that is commonly consumed by social drinkers, without perceiving themselves to be intoxicated.

Each participant in the alcohol condition was administered a total of 500mls of liquid containing 96% ethanol, tonic water, and lime cordial (which served to mask the taste of alcohol), which was divided equally into 10 cups of 50ml portions. Each participant assigned to the placebo condition was provided with 500mls of liquid equally divided into 10 cups of 50ml portions containing tonic water and lime cordial only. All participants were provided with their respective drinks by the research assistant and were required to consume one cup every three minutes in the presence of the researcher, until all 10 drinks were consumed. To maintain a stable BAC level over the entire testing session of up to 180 minutes, participants in the alcohol condition were given two sets of top-up drinks consisting of two 50ml portions each, administered at approximately 80- and 120-minutes into the testing session. Each top-up drink contained 0.1 grams of alcohol per kilogram 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, however they consisted of two 50ml 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 minutes after

consuming the drinks to ensure that residual alcohol within the mouth did not affect the BAC reading.

7.2.3 Measures[13]

7.2.3.1 Prospective Memory

PM was assessed using *VW-PM* (Rendell & Craik, 2000). *VW-PM* is a computerised board game that requires participants to remember to carry out tasks that closely resemble PM tasks in everyday life. *VW-PM* scores are calculated for each task type (regular event-based, regular time-based, irregular event-based, irregular time-based, and time-check) by dividing the number of tasks of that specific type completed correctly by the total number of tasks of that type administered. The five outcome variables of interest in the present study were the *proportion of correct regular and irregular event-based tasks*, the *proportion of correct regular and irregular time-based tasks* and the *proportion of correct time-check tasks*.

7.2.3.2 Retrospective Memory and Executive Functions

Retrospective memory was measured using the *Hopkins Verbal Learning Test- Revised* (*HVLT-R* (Benedict et al., 1998). Cognitive initiation was measured using the validated *Verbal Fluency Task* (Tombaugh et al., 1999), while inhibitory control was assessed using the *Hayling Sentence Completion Test* (Burgess & Shallice, 1997a). Cognitive flexibility was measured using the *Trail Making Task* (Arbuthnott & Frank, 2000).

7.2.3.3 Episodic Future Thinking

EFT was assessed using an adapted version of the *Autobiographical Interview* (*AI*; Levine et al., 2002) developed by Addis et al. (2008). The primary measure of EFT was the total number of internal details generated across the three future trials.

---

[13] Description of measures have been abbreviated in this chapter to limit repetition. See Chapter 4 (Methodology for Empirical Studies) for a detailed description of the measures used in this study.

7.2.4 Procedure

Testing took place in a single individual testing session of up to 180 minutes, with breaks taken as needed. A baseline BAC measure was then taken to ensure that the participant had not consumed alcohol prior to testing. All participants were then weighed on a set of digital scales to allow calculation of the appropriate dose of alcohol to be administered to the participants assigned to the alcohol condition. Participants then completed measures listed in Table 7.3 (which included a number of measures not used in the current study).

Table 7. 3

Procedure: Tasks Performed with Corresponding Times (Mins), Including Average BAC of Participants Assigned to the Alcohol Condition (Total Sample and Separately for Males and Females)

Time	Tasks and measures
0 mins	Informed consent
	Baseline BAC= total *M* = 0.000
	Weigh participant
	Spot the word
	Initial drink administration (0.6g/kg alcohol OR placebo)
	Background questionnaire
	Hospital Anxiety and Depression Scale
	Alcohol Usage Questionnaire
45 mins	End of alcohol administration
	Hopkins Verbal Learning Test
	Verbal Fluency Task
	Hayling Sentence Completion Test
	Trail Making Test
75 mins	Alcohol group BAC Time 2 reading: total *M* = 0.064, *SD* = 0.014
	(Males *M* = 0.061 *SD* = 0.016; Females *M* = 0.067, *SD* = 0.011)
	Top up drink (0.1g/kg alcohol OR placebo)
	Administration of a cognitive measure not used in the current study
120 mins	Alcohol group BAC Time 3 reading: total *M* = 0.075, *SD* = 0.013
	(Males *M* = 0.070 *SD* = 0.014; Females *M* = 0.079, *SD* = 0.011)
	Top up drink (0.1g/kg alcohol OR placebo)
	Autobiographical interview
	Virtual Week- Prospective Memory
170 mins	Alcohol group BAC Time 4 reading: total *M* = 0.074, *SD* = 0.014
	(Males *M* = 0.068 *SD* = 0.013; Females *M* = 0.080, *SD* = 0.013)
	Debriefing, guess condition and payment

7.3 Results

All statistical tests were two-tailed and were conducted using IBM SPSS Statistics, version 26.0 (IBM Corp). An alpha level of $p < 0.05$ was considered significant, and effect sizes were estimated using partial eta squared (η^2_p), Cohen's *d* and Pearson *r* correlations. Cohen (1988) defines η^2_p effect sizes of .01 as small, .059 as medium and .138 as large, *d* effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large and *r* effect sizes of 0.1 as small, 0.3 as medium, and 0.5 as large. There were no missing values, however one case was identified as a univariate outlier in the *Verbal Fluency Task*, and two cases in the *TMT*, with z-scores of more than 3.29 (Tabachnick & Fidell, 2014). These outliers were replaced with scores $\pm$ 3SDs of the mean following the guidelines of Tabachnick and Fidell (2014).

7.3.1 Blood Alcohol Concentration

The mean (SD) BAC at baseline, 75-, 120- and 170-minutes testing are reported in Table 7.3, separately for males and females. Independent samples *t*-tests were conducted to compare sex differences in BAC across the four BAC measurements. All participants obtained a baseline BAC of zero. Males and females obtained a similar BAC on the second BAC measurement, t (59) = 1.67, p = .10. However, females obtained a significantly higher BAC level than males on the third, t (59) = 2.92, p = .005, and fourth BAC measurements, t (59) = 3.68, p = .001.

7.3.2 Cognitive Measures

Descriptive and inferential statistics for retrospective memory, executive functions, and EFT are reported in Table 7.4. Participants in the alcohol condition performed significantly worse on the measure of retrospective memory and EFT. However, there were no differences between the alcohol and placebo condition on any of the executive function measures.

Table 7. 4

Descriptive and Inferential Statistics for the Cognitive Function Measures for Participants in the Alcohol and Placebo Conditions

	Alcohol condition $n = 61$	Placebo condition $n = 63$		
	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
Episodic future thinking	160.7 (68.9)	184.4 (66.3)	1.95*	0.35

* $p < 0.05$, ** $p < 0.01$

7.3.3 Prospective Memory

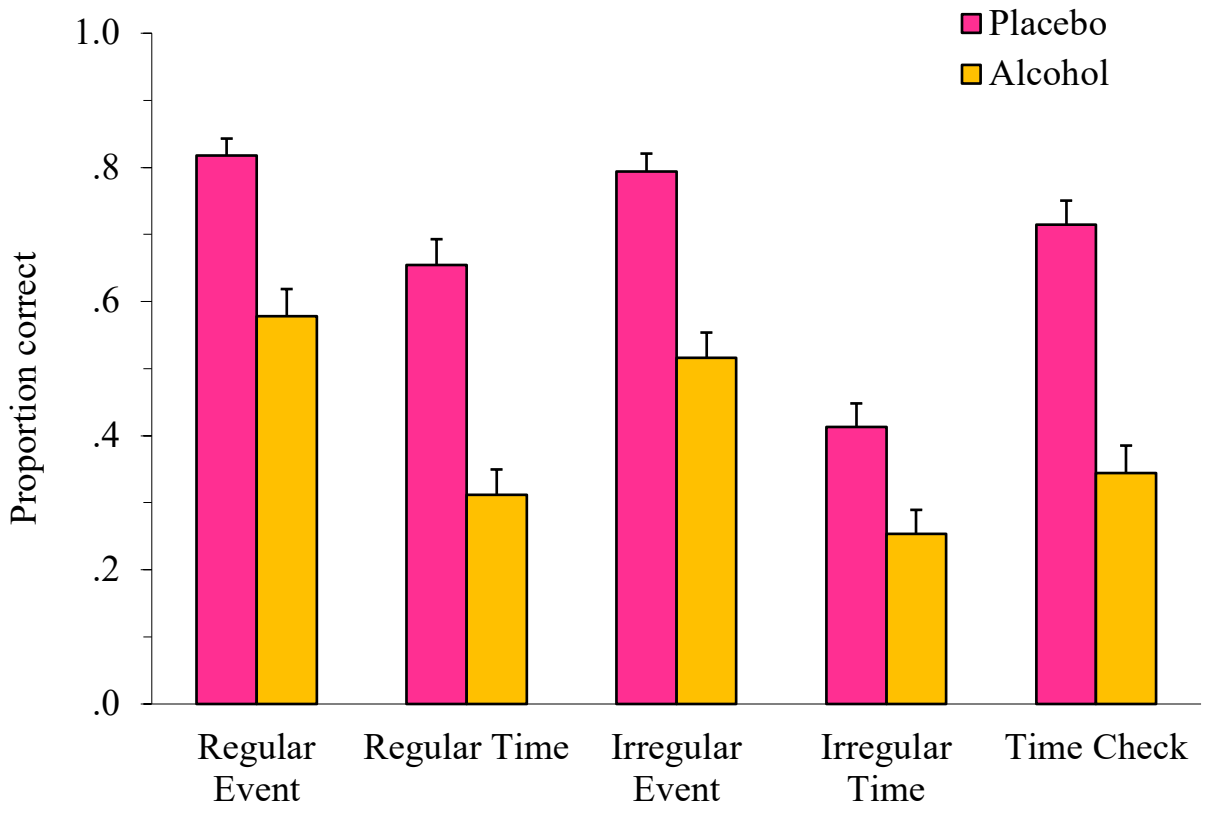
Figure 7.1 shows the mean proportion of correctly performed PM task responses for regular event, regular time, irregular event, irregular time and time-check tasks for both conditions (alcohol, placebo). To investigate whether there were differences in PM performance across different PM tasks as a function of sex and condition, a 2 x 2 x 5 mixed analysis of variance (ANOVA) was conducted. *Sex* (males, females) and *condition* (alcohol, placebo) were the between-groups variables, and the within-groups variable was *PM task* (regular event, regular time, irregular event, irregular time and time-check). The three-way interaction was not significant F (4,117) = 0.55, $p = .70$, $\eta^2_p < .01$, nor were there any two-way interactions between sex and PM task F (4,117) = 0.94, $p = .44$, $\eta^2_p < .01$, or sex and condition

F (1,120) = 0.72, p = .40, η^2_p < .01. However, there was a moderate main effect of sex F (1,120) = 5.04, p = .03, η^2_p = .04, with females' (M = .5, SD = .2) overall PM performance (proportion of correct PM responses) poorer than males' (M = .6, SD = .2).

There was an interaction between condition and PM task F (4,117) = 4.04, p = .003, η^2_p = .29. This interaction was investigated further with a test of simple effects which revealed that the alcohol condition performed significantly worse than the placebo condition on all PM tasks, with large effect sizes (all Fs > 25.02, ps < .001, η^2_p s > .17), except for irregular time-based tasks which showed a medium effect F (1,120) = 10.06, p = .002, η^2_p = .08. This interaction can be seen in Figure 7.1. Of secondary interest, there was a simple main effect of PM task within both the alcohol condition F (4,117) = 34.10, p < .001, η^2_p= .54, and placebo condition F (4, 117) = 22.14, p < .001, η^2_p = .43, with participants in both conditions performing worse on time-based tasks than event-based tasks. Furthermore, the placebo condition completed time-check tasks with similar accuracy to event-based tasks, whilst the alcohol condition completed time-check tasks with similar accuracy to time-based tasks. See Appendix K for detailed pairwise comparisons.

Figure 7. 1

Mean Proportion of Correct Prospective Memory Responses as a Function of Condition (Alcohol, n = 61; Placebo, n = 63) and PM Task (Regular Event; Regular Time; Irregular Event; Irregular Time; Time Check). Error Bars Represent Mean Standard Error.



To summarise, acute alcohol consumption substantially impaired PM performance relative to participants assigned to the placebo condition, with a large effect size across all PM tasks, except for irregular time tasks for which there was a medium effect. While sex was a significant main effect, with females slightly worse on overall PM performance than males, there was no interaction between sex and either condition or PM task. All participants performed worse on time-based PM tasks than event-based PM tasks.

7.3.4 Cognitive Correlates of Prospective Memory

Pearson product-moment correlations between PM performance and retrospective memory, executive functions, and EFT are reported in Table 7.5[14]. These analyses were performed for event-based, time-based, and time-check PM task types. It can be seen that for participants in the alcohol condition, all PM tasks were moderately associated with retrospective memory, while time-based PM tasks were also associated with cognitive initiation, and time-check tasks with cognitive flexibility. By contrast, no significant correlations were found between PM and any of the other cognitive measures in the placebo condition.

[14] The full correlations table is presented in Appendix L.

Table 7. 5

Correlations between Event-Based, Time-Based, and Time-Check PM Scores and Measures of FSIQ, Retrospective Memory, Executive Function, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	Alcohol condition *n* = 61			Placebo condition *n* = 63		
	Event-based tasks	Time-based tasks	Time-check tasks	Event-based tasks	Time-based tasks	Time-check tasks
FSIQ	.20	.29*	.15	-.01	.11	.05
Retrospective memory						
Immediate recall	.31*	.29*	.29*	.20	.22	-.03
Delayed recall	.31*	.31*	.35**	.10	.19	-.02
Executive functions						
Cognitive initiation	.18	.32*	.23	.17	.27	.19
Inhibitory control	.21	.11	.14	.15	.07	.18
Cognitive flexibility	-.20	-.27	-.37**	-.11	-.14	-.13
Episodic future thinking (future internal details)	.12	.16	.20	.14	.15	.08

* $p < 0.025$, ** $p < 0.01$

7.3.5 Regression Analyses

To test whether the associations identified in the correlational analyses reflected unique contributions to PM, hierarchical multiple regression analyses were then conducted. These regression analyses were conducted for event-based, time-based, and time-check PM task types separately for the alcohol and placebo conditions (see Table 7.6, Table 7.7, and Table 7.8). FSIQ was entered in Step 1 in the analyses, retrospective memory and executive functions were entered in Step 2, and EFT in Step 3.

For event-based PM, these variables did not account for significant variance in performance in the placebo condition (total $R^2 = .09$, F (7, 55) = 0.76, $p = .63$), nor in the alcohol condition (total $R^2 = .15$, F (7, 53) = 1.35, $p = .25$). For time-based PM, the variables did not predict performance in the placebo condition (total $R^2 = .12$, F (7, 55) = 1.09, $p = .38$), but did predict significant variance in the alcohol condition (total $R^2 = .23$, F (7, 53) = 2.26, $p = .04$). However, upon closer inspection, none of the variables significantly contributed to time-based PM performance in the final model. Finally, for time-check PM, the results showed that the variables did not predict significant variance in performance in the placebo condition (total $R^2 = .08$, F (7, 55) = 0.65, $p = .71$), nor the alcohol condition (total $R^2 = .20$, F (7, 57) = 1.94, $p = .08$).

Table 7. 6

Hierarchical Multiple Regression Analyses Predicting Event-Based Prospective Memory from FSIQ, Retrospective Memory, Executive Functions, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	Event-based PM tasks							
	Alcohol condition $n = 61$				Placebo condition $n = 63$			
Predictor	ΔR^2	*B* (SE)	β	*p*	ΔR^2	*B* (SE)	β	*p*
Step 1	.04				<.01			
FSIQ		.01 (.01)	.20	.13		.00 (.00)	-.01	.95
Step 2	.11				.08			
FSIQ		.01 (.01)	.17	.23		-.00 (.01)	-.11	.43
Immediate recall		.01 (.01)	.26	.20		.01 (.01)	.26	.25
Delayed recall		-.00 (.03)	-.01	.97		-.01 (.03)	-.12	.57
Inhibitory control		.04 (.04)	.14	.36		.02 (.00)	.09	.52
Cognitive flexibility		.00 (.00)	-.02	.90		-.00 (.00)	-.06	.67
Cognitive initiation		.00 (.00)	.05	.75		.00 (.00)	.13	.42
Step 3	<.01				.01			
FSIQ		.01 (.01)	.17	.23		-.00 (.01)	-.12	.42
Immediate recall		.01 (.01)	.25	.24		.01(.01)	.22	.33
Delayed recall		.00 (.03)	-.00	.99		-.01(.02)	-.09	.69
Inhibitory control		.03 (.04)	.13	.39		.02 (.03)	.10	.50
Cognitive flexibility		.00 (.00)	-.02	.92		-.00 (.00)	-.07	.64
Cognitive initiation		.00 (.00)	.05	.76		.00 (.00)	.10	.53
EFT		.00 (.00)	.03	.85		.00 (.00)	.09	.52
Total R^2	.15				.09			

* $p < 0.05$

Table 7. 7

Hierarchical Multiple Regression Analyses Predicting Time-Based Prospective Memory from FSIQ, Retrospective Memory, Executive Functions, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	Time-based PM tasks							
	Alcohol condition $n = 61$				Placebo condition $n = 63$			
Predictor	ΔR^2	*B* (SE)	β	*p*	ΔR^2	*B* (SE)	β	*p*
Step 1	.08*				.01			
FSIQ		.02 (.01)	.29	.02		.01 (.01)	.11	.37
Step 2	.14*				.10			
FSIQ		.01 (.01)	.23	.08		-.00 (.01)	-.04	.77
Immediate recall		.02 (.01)	.28	.15		.00 (.01)	.05	.81
Delayed recall		-.01 (.02)	-.11	.62		.02 (.03)	.12	.56
Inhibitory control		-.02 (.04)	-.06	.66		-.02 (.04)	-.06	.68
Cognitive flexibility		-.00 (.00)	-.13	.41		-.00 (.00)	-.07	.59
Cognitive initiation		.01 (.00)	.24	.09		.01 (.00)	.28	.08
Step 3	.01*				.01			
FSIQ		.01 (.01)	.24	.07		-.00 (.01)	-.05	.75
Immediate recall		.01 (.01)	.24	.24		.00 (.01)	.02	.94
Delayed recall		-.01 (.02)	-.08	.72		.02 (.03)	.16	.47
Inhibitory control		-.02 (.04)	-.09	.55		-.01 (.04)	-.05	.72
Cognitive flexibility		-.00 (.00)	-.12	.46		-.00 (.00)	-.08	.56
Cognitive initiation		.01 (.00)	.24	.09		.00 (.00)	-.08	.12
EFT		.00 (.00)	.11	.42		.00 (.00)	.10	.47
Total R^2	.23*				.12			

* $p < 0.05$

Table 7. 8

Hierarchical Multiple Regression Analyses Predicting Time-Check Prospective Memory from FSIQ, Retrospective Memory, Executive Functions, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	Time-check PM tasks							
	Alcohol condition $n = 61$				Placebo condition $n = 63$			
Predictor	ΔR^2	*B* (SE)	β	*p*	ΔR^2	*B* (SE)	β	*p*
Step 1	.02				<.01			
FSIQ		.01 (.01)	.15	.24		.00 (.01)	.05	.72
Step 2	.17				.07			
FSIQ		.00 (.01)	.03	.80		-.00 (.01)	-.05	.74
Immediate recall		.01 (.01)	.17	.38		-.01 (.02)	-.15	.49
Delayed recall		.01 (.03)	.05	.83		.01 (.03)	.05	.83
Inhibitory control		-.03 (.05)	-.08	.60		.04 (.05)	.12	.39
Cognitive flexibility		-.00 (.00)	-.30	.07		-.00 (.00)	-.13	.35
Cognitive initiation		.00 (.00)	.08	.56		.00 (.00)	.18	.26
Step 3	.01				.00			
FSIQ		.00 (.01)	.05	.73		-.00 (.01)	-.05	.73
Immediate recall		.01 (.12)	.12	.55		-.01 (.02)	-.17	.45
Delayed recall		.01 (.03)	.09	.71		.01 (.04)	.07	.75
Inhibitory control		-.04 (.05)	-.11	.47		.04 (.05)	.13	.38
Cognitive flexibility		-.00 (.00)	-.28	.09		-.00 (.00)	-.13	.34
Cognitive initiation		.00 (.00)	.08	.57		.00 (.00)	.17	.32
EFT		.00 (.00)	.13	.33		.00 (.00)	.06	.66
Total R^2	.20				.08			

* $p < 0.05$

7.4 Discussion

The present study provides the most complete and nuanced understanding to date of the effect of acute alcohol consumption on PM function, and the underlying cognitive mechanisms that contribute to these effects. The first aim was to simply clarify the nature and magnitude of PM impairment associated with a moderate dose of alcohol, using a methodologically stronger design than previous research studies in this area. This was achieved by recruiting a larger sample size than previous studies and using an extensively validated measure of PM that was also able to conceptually differentiate between multiple types of PM tasks. The results provided clear evidence that acute alcohol consumption impaired PM, with all task types indexed by *VW-PM* significantly disrupted relative to the placebo condition. Importantly, these effects were not only significant, but for all but one of the five PM task types, they were large in magnitude. These findings therefore indicate that participants assigned to the alcohol condition exhibited robust, consistent, and substantial difficulties remembering to carry out tasks at specific points in the future, irrespective of the specific features of the task.

As noted, a further exploratory component of this study was to also investigate potential sex differences in PM performance following acute alcohol use given previous literature showing that there are sex differences in the pharmacokinetics of alcohol (Erol & Karpyak, 2015; Mumenthaler et al., 1999). Consistent with past research, females in the alcohol condition obtained a higher BAC level than males even though they consumed an equivalent amount of alcohol that was adjusted to account for body weight. However, the results showed no sex differences in acute alcohol-related PM impairment, with females in the alcohol condition found to perform comparably to males in the alcohol condition.

In addition to quantifying the nature and magnitude of acute alcohol-related PM impairment, the second key aim was to better understand cognitive abilities that might underpin the observed deficit. In relation to retrospective memory, as expected, acute alcohol

ingestion adversely affected immediate and delayed recall, consistent with considerable past research (Curran & Weingartner, 2002; Mintzer, 2007; Söderlund et al., 2005; White, 2003). However, while an association between poorer retrospective memory and poorer PM was identified in the alcohol group, follow up analyses revealed that retrospective memory did not contribute significant unique variance to PM performance, indicating that acute alcohol-related impairment in PM is not driven by alcohol-related retrospective memory impairment. In relation to executive function, no group differences were observed between the alcohol and placebo conditions on any of the executive function measures, meaning that acute alcohol-related deficits in PM are also unlikely to be explained by alcohol-related executive dysfunction. Finally, in relation to EFT, although as expected, acute alcohol consumption adversely affected the ability to generate a personally relevant future scenario, EFT was unrelated to PM performance in the alcohol condition.

These findings were not anticipated, and run contrary to prior research which has argued that PM performance imposes considerable demands on retrospective memory and executive functions (see Kliegel et al., 2011 for a review), and more recently, EFT (Terrett, Rose, et al., 2016). Given that these findings were identified using a well-powered design and well-validated measures of all the constructs of interest, these data are important in suggesting that acute alcohol consumption has substantial effects on PM that are quite independent of its effects on other cognitive processes. While speculative, such a possibility suggests that, although often related to other cognitive abilities, PM is not merely a proxy for these abilities. This makes sense when one considers that, in addition to the recruitment of broader, secondary cognitive processes, PM also requires their integration, and so in the truest sense, this ability may be greater than the sum of its parts.

The identification of large-sized deficits on nearly all aspects of PM function assessed in this study is important, not only theoretically, but also practically. As noted earlier, PM

function is a critical predictor of functional capacity in everyday life. PM failures arising from moderate doses of alcohol may have consequences for health and safety-related behaviours whilst under the influence of alcohol. For example, a failure of PM following moderate alcohol consumption may decrease the likelihood of completing intended actions, such as remembering to lock the front door and turn off appliances when leaving home, or catch the last train home at 12am, all of which may have significant safety implications.

7.4.1 Strengths, Limitations and Future Directions

As noted, particular strengths of the current study included the use of well-validated measures and a well-powered design, meaningfully building on, but also extending, prior research investigating the effect of acute alcohol consumption on PM. However, limitations also need to be noted. In particular, it should be acknowledged that the lengthy nature of the testing session (typically 2.5-3 hours in duration) would have required considerable sustained concentration. To mitigate any potential fatigue effects, regular breaks were provided between measures and participants' subjective mood states were monitored via visual analogue scales, but it is nevertheless possible that the length of testing may have amplified any effects of alcohol consumption on cognitive performance. Future studies are needed to directly test this possibility. Further empirical investigation is also needed to understand the impact of acute moderate alcohol-related PM failures in daily life and would be a valuable avenue to pursue in future studies. Additionally, future research may endeavour to replicate the current study administering different doses of alcohol (e.g. 0.02g/kg, 0.04g/kg, 0.06g/kg and 0.08g/kg) to investigate a dose-response curve and to determine the point at which PM becomes significantly impaired by acute alcohol use.

In conclusion, the current study clarifies the nature and magnitude of PM impairment following a moderate dose of alcohol, with robust, consistent, and substantial deficits identified across five types of PM tasks. Additionally, the effect of acute alcohol consumption on PM

was similar for males and females. However, these data indicated that whilst acute alcohol-induced difficulties in retrospective memory and EFT were also found, these abilities did not contribute to PM performance, raising questions about what, if any abilities, underpin acute alcohol-related PM and the extent to which it may be an independent construct. As PM is critical for health and safety-related behaviours and has also been suggested to be a potential contributor to relapse in problem drinkers, these data have important implications for understanding the cognitive and behavioural difficulties experienced following even moderate alcohol consumption, and for the treatment of individuals with an alcohol use disorder.

Chapter 8: General Discussion

Preamble

This chapter concludes the thesis by integrating the findings of the three empirical studies presented in Chapters 5, 6, and 7. The chapter begins by reviewing the aims and results of each of the studies, and then provides a discussion of the contributions and implications of these findings, as well as directions for future research in the area of alcohol and prospection. This chapter also outlines the strengths and limitations of the overall research project.

8.1 Summary of Aims and Results of Empirical Studies

8.1.1 Study 1

This study was conducted to provide the first empirical investigation of the effect of a moderate dose of alcohol on episodic future thinking (EFT), and to examine the extent to which any observed deficits in EFT following acute alcohol consumption were contributed to by alcohol-induced impairment in retrospective episodic memory and/or executive functions. Additionally, Study 1 examined sex differences in EFT following acute alcohol consumption. The findings of Study 1 demonstrated that moderate alcohol consumption substantially impaired EFT as indexed by the generation of fewer episodic details by participants in the alcohol group compared to the placebo group when asked to imagine and describe themselves experiencing a novel future event. Furthermore, the results suggested a key role for retrospective episodic memory in EFT, given that it was also impaired by acute alcohol consumption, and was found to significantly contribute to EFT in both the alcohol and placebo conditions. However, the executive functions assessed in this study were not adversely affected by acute alcohol use, nor did they contribute to EFT performance. Finally, the results indicated that EFT was substantially impaired to a similar extent in both males and females assigned to the alcohol condition.

8.1.2 Study 2

Study 2 was conducted to provide the first empirical assessment of episodic foresight following a moderate dose of alcohol, and to examine the extent to which any observed deficits were underpinned by retrospective memory, executive functions, and/or EFT. Study 2 also examined sex differences in episodic foresight following acute alcohol consumption. The results of Study 2 showed that acute alcohol consumption adversely affected episodic foresight, as reflected in reduced ability to acquire the necessary items to resolve the presented problems sometime in the future and to subsequently use the acquired item to solve the

problem when it was re-presented. The results also identified a key role for retrospective memory in episodic foresight, as it was impaired by acute alcohol use and also significantly predicted item acquisition in the alcohol condition. However, acute alcohol-related episodic foresight impairment was not attributable to impaired EFT resulting from alcohol consumption, nor to executive dysfunction related to alcohol as no alcohol-induced impairment in executive function was observed. Finally, the results of Study 2 revealed an absence of sex differences, with the capacity for episodic foresight similarly and substantially impaired by acute alcohol consumption in both males and females.

8.1.3 Study 3

Study 3 was conducted to clarify the nature and magnitude of prospective memory (PM) impairment following a moderate dose of alcohol, and to investigate whether alcohol-related deficits in cognitive abilities that have been proposed to contribute to PM, including retrospective memory, executive functions, and EFT, might explain any observed impairment. This study also aimed to examine whether sex differences in PM performance emerged following acute alcohol consumption. The findings of Study 3 revealed that participants assigned to the alcohol condition exhibited pervasive deficits in PM, as reflected in their substantially reduced ability to remember to carry out all types of PM tasks when compared to the placebo condition. However, PM difficulties were not attributable to impairment in retrospective memory, executive functions, nor EFT. Finally, the results revealed no sex differences in acute alcohol-related PM impairment, with males and females in the alcohol condition found to perform comparably across all PM tasks.

8.2 Contributions of the Study Findings

8.2.1 Acute Alcohol Consumption and Cognition

This research project made an important contribution by supporting and extending current understanding of the effect of acute alcohol consumption on various forms of

cognition. More specifically, this research supports past studies that have identified acute alcohol-related impairment in retrospective memory (Curran & Hildebrandt, 1999; Söderlund et al., 2007; White et al., 2000), and adds to the mixed findings regarding the effect of moderate alcohol consumption on a range of executive functions (Day et al., 2015; Giancola, 2000). In addition, the current project addressed a significant gap in the literature by investigating the effect of acute alcohol consumption on prospection, an area of cognition that has been largely neglected in the alcohol literature. This was done by firstly undertaking the only empirical investigations to date of the effect of a moderate dose of alcohol on two key aspects of prospection, namely EFT and episodic foresight. Secondly, the current project extended limited past research investigating the effect of a moderate dose of alcohol on a third key aspect of prospection, i.e. PM, using a methodologically stronger design than previous studies in this area to more clearly delineate the nature and magnitude of acute alcohol-related PM impairment. Importantly, the results of the three empirical studies suggest that prospection may be highly sensitive to the adverse effects of alcohol ingestion, as indicated by the generally large effect sizes found. Understanding that acute alcohol consumption disrupts each of these abilities provides important insight into the effects of alcohol on cognition and has significant implications for understanding the difficulties associated with acute alcohol use.

Another key contribution of the current project in increasing understanding of the effect of moderate alcohol consumption on cognition was the novel investigation of sex differences in performance on the three forms of prospection following alcohol administration. This is a valuable addition to the literature as there is a dearth of research investigating sex differences in cognitive function following acute alcohol consumption, despite evidence suggesting that females cognitive functioning may be disproportionately impacted due to sex differences in the pharmacokinetics of acute alcohol use (Erol & Karpyak, 2015; Mumenthaler et al., 1999).

Importantly, the current study revealed that this was not the case with prospection, as females exhibited a similar level of impairment in EFT, episodic foresight, and PM, to males.

8.2.2 Prospection and its Cognitive Underpinnings

A novel contribution of this project was to provide not only the first empirical investigation of EFT following acute alcohol consumption, but to also investigate the cognitive abilities underpinning the identified EFT deficit. The finding that acute alcohol-induced retrospective episodic memory deficits were at least in part driving the EFT impairment in the alcohol group, but executive functions were not, makes an important theoretical contribution to the literature by increasing understanding of the mechanisms that explain EFT deficits in the context of moderate alcohol consumption. In addition, the exploration of the cognitive abilities underpinning deficits in EFT in the alcohol group, in combination with the results regarding cognitive contributors to EFT in the placebo group also makes an important contribution to the literature by helping develop a better theoretical understanding of EFT in general. For example, the finding that retrospective episodic memory was impaired by a moderate dose of alcohol, and significantly contributed to EFT in both the alcohol and placebo conditions, offers support for the *constructive episodic simulation hypothesis*, and the theoretical claim that memory of past personal events provides a foundation for the construction of novel future events in imagination (Addis et al., 2008; Buckner & Carroll, 2007; Hassabis et al., 2007; Schacter & Addis, 2007b; Schacter et al., 2017). Additionally, as noted, the findings of Study 1 showed that the executive functions assessed (cognitive initiation, inhibitory control, and cognitive flexibility) were not impaired by acute alcohol use and thus could not account for the alcohol-induced impairment in EFT. Furthermore, only one executive function was associated with EFT in each condition but was not consistent across the two conditions, and only cognitive initiation was found to predict EFT performance in the placebo group. Taken together, these findings contrast theoretical claims that executive functions play an important

role in EFT, and suggest that EFT may rely less on executive functions than proposed previously (Cole et al., 2013; Mercuri et al., 2018). However, given that the results add to the mixed empirical literature surrounding the contribution of executive functions to EFT (Addis et al., 2008; Brown et al., 2014; Irish & Piguet, 2013; Mercuri et al., 2015), the current findings do also indicate the need for ongoing investigation of the role of executive functions in EFT. In addition, the possibility should also be noted that executive functions not assessed in Study 1, such as working memory and planning, may be more pertinent to EFT, and should therefore be considered in future research to aid in the development of a comprehensive theoretical model of EFT.

Another important novel contribution of the current research project was the investigation of cognitive abilities that help to explain episodic foresight deficits associated with acute alcohol consumption. The finding that retrospective memory was impaired by acute alcohol consumption and also significantly predicted episodic foresight performance in participants in the alcohol condition, as reflected in the ability to acquire items necessary to solve the presented problems, suggests that difficulties in episodic foresight may be explained, at least in part, by deficits in retrospective memory. However, the executive functions assessed were not adversely affected by alcohol, and therefore could not explain the observed deficits in episodic foresight, thereby suggesting that executive functions do not appear to play a role in alcohol-induced difficulties in episodic foresight. These findings make an important theoretical contribution to the literature by not only identifying alcohol-related deficits, but by taking the additional step of providing novel insights into the mechanisms through which acute alcohol use adversely affects episodic foresight. Study 2 also makes a broader contribution to the field of episodic foresight theoretically through consideration of the results not only for the alcohol group, but also the placebo group. More specifically, contrary to predictions based on current theoretical arguments, Study 2 showed no evidence that either retrospective memory or

executive functions contributed to episodic foresight in the placebo group, and only inhibitory control was shown to contribute to episodic foresight in the alcohol group, reflected in the ability to use items to solve presented problems. Overall, these results support findings by Lyons et al. (2016) and Lyons et al. (2019) who also failed to identify a relationship between these abilities in individuals with schizophrenia, stroke patients, and healthy controls. The findings of the current project thus raise the possibility that episodic foresight may be a more independent cognitive ability than has been proposed theoretically (Schacter & Addis, 2007b; Suddendorf & Corballis, 2007; Suddendorf & Moore, 2011).

The current project also provided a valuable extension to the limited number of studies that have assessed PM and its potential contributors following acute moderate alcohol consumption. In addition to identifying acute alcohol-related impairment, the current study provided the most comprehensive investigation to date of the cognitive abilities underpinning the deficit, showing that it was not being driven by acute alcohol-induced deficits in retrospective memory or executive functions. Furthermore, as with the other empirical studies, the investigation of PM and its cognitive underpinnings in both the alcohol and placebo conditions allows for a broader contribution to the literature by increasing understanding of the nature of the cognitive abilities that support PM performance in normal adults. In this regard, the key findings were that Study 3 failed to identify a contribution of retrospective memory or executive functions to PM in both alcohol and placebo conditions. As outlined in Study 3, these data raise the possibility that PM may be an independent ability that is separate to other cognitive processes, and while speculative, this notion should be given further consideration in future studies. At the very least, Study 3 highlights the importance of directly assessing PM as a standalone construct in the context of acute alcohol consumption, as the findings suggest that the effect of acute alcohol use on PM cannot be inferred from its effect on other cognitive abilities. However, it is also acknowledged that further investigation is needed to replicate

these findings. Additionally, future research should consider the use of a retrospective memory task directly related to the recollection of PM task content.

One final contribution of this research project was to provide an important extension to current conceptual understanding of the interrelationships between the different forms of prospection. As noted in Chapter 1, prospection is an umbrella term for a group of future-oriented cognitive abilities that involve mentally representing future scenarios (Szpunar et al., 2014, 2016). The various forms of future thinking have recently been conceptualised as a taxonomy of interrelated abilities (Szpunar et al., 2014, 2016). To date, the majority of empirical studies have investigated these abilities in isolation, thus the interrelation of these abilities remains largely theoretical. However, the current study was able to address the issue of interrelationships by concurrently assessing three forms of prospection through the investigation of the contribution of EFT to episodic foresight and to PM. Interestingly, and contrary to theoretical predictions, EFT was not found to contribute to either episodic foresight or PM in the alcohol group, suggesting that acute alcohol-related deficits in the ability to imagine a personal future event did not underpin deficits in episodic foresight and PM. A lack of relationship between EFT and episodic foresight, and EFT and PM was also found in the placebo group, suggesting that a greater capacity to simulate detailed future events does not contribute to greater episodic foresight or PM. Taken together, the investigation of the interrelations between these various forms of future-oriented thinking in the current project provides a valuable extension to the taxonomy of prospection proposed by Szpunar and colleagues (Szpunar et al., 2014, 2016) and points to a clear conceptual distinction between these forms of prospection, despite a common theme of being future-oriented cognitive abilities.

8.3 Implications

Acute alcohol consumption presents a significant source of harm to the community, and has been linked with an increased risk of physical injury, compromised psychological functioning, violence, crime, sexual-risk taking, motor vehicle accidents, and financial strain (Brewer & Swahn, 2005; Chikritzhs et al., 2001; Field et al., 2010; Fillmore, 2007). Most people generally understand that *heavy* drinking leads to near global impairment in functioning. However, the effects of *moderate* alcohol consumption on cognition are often underestimated. As noted in Chapter 3, difficulties engaging in various forms of prospection following acute alcohol consumption may increase the likelihood of a person engaging in deleterious behaviours such as those listed above. Thus, the results of the current project have significant implications for understanding why individuals may engage in suboptimal decision making and increased risk taking under the influence of even moderate alcohol consumption. For example, in relation to EFT, a reduced capacity to imagine the potential adverse consequences of driving home following moderate alcohol consumption, such as having a motor vehicle accident or receiving a licence suspension if the person is found to be over the legal driving limit (BAC = 0.05% in Australia and 0.08% in the USA and England), could in turn increase the likelihood of making the decision to drink drive. On the other hand, a failure of PM when driving following moderate alcohol consumption could decrease the likelihood of completing intended actions such as remembering to put fuel in the car, remembering to indicate when changing directions/lanes, or remembering to take the correct exit off the freeway, all of which may have significant safety implications. In relation to episodic foresight, alcohol-induced deficits may adversely affect an individual's capacity to identify and consider the potential future negative consequences of behaviours, such that they are more likely to, for example, spend more money when socialising, and consequently may be unable to afford rent and bills the following week. Additionally, acute alcohol-related episodic

foresight difficulties may reduce the likelihood of taking steps in the present to avoid those adverse consequences, such as, for example, setting a spending limit prior to drinking. All of these examples highlight the functional importance of prospection in everyday living, and the potential for impairment in prospection to have harmful consequences following even a moderate dose of alcohol. Therefore, by understanding the factors underlying these problematic behaviours, individuals may be prompted to consider acute alcohol-related impairment in prospection prior to drinking and take steps to minimise harmful outcomes.

The results of the current project also have particularly important implications for public policy regarding acute alcohol consumption and could be used to inform and guide future policy development. The current National Alcohol Strategy (Commonwealth of Australia, 2019) aims to prevent and minimise alcohol-related harms using evidence-based and practice informed approaches. Thus, broader understanding and awareness of the cognitive abilities that may contribute to the occurrence of these harms, such as those presented in this research project, may in turn inform several of the priority areas of focus in this Strategy. For instance, these results could inform education programs and campaigns, such as the Plan B drink driving campaign, which focuses on the importance of planning how to get home safely and making alternative arrangements if people are going to be consuming alcohol. Given the current findings show that, as previously mentioned, the ability to imagine future events, the ability to take preparatory steps in the present in preparation for the future, and the ability to remember to complete actions in the future, are all impaired by moderate alcohol consumption, it is probable that the likelihood of making a Plan B and enforcing it will be lower once alcohol consumption has commenced. The Plan B campaign may therefore be more effective if it emphasises the need to make a Plan B *prior* to consuming alcohol. These education programs and campaigns ultimately assist in improving community safety and promoting healthier communities.

In addition to increasing understanding of the cognitive deficits and associated risks of acute alcohol use, the findings of the current thesis could also guide the development of strategies to compensate for deficits in these key areas of prospection. Research in this area to date is scarce, however there is some evidence of effective strategies used to support PM. For example, as mentioned in Chapter 2, there is preliminary evidence to suggest that future event simulation, which involves imagining yourself undertaking a task, is an effective strategy for improving acute alcohol-induced PM impairment (Paraskevaides et al., 2010) and PM impairment in heavy social drinkers (Platt et al., 2016). It has been suggested that this strategy works by strengthening the encoding of the link between the PM cue and the required action which increases the likelihood of automatic retrieval of the intended action, thus resulting in a greater chance of successfully performing the PM task (Foster et al., 2017). Another compensatory strategy that has been shown to support PM, which could potentially be adopted by individuals under the influence of a moderate dose of alcohol, is the use of audio-visual alerts on an electronic device, such as a smartphone, which provide an external prompt to perform the PM task (Dewar et al., 2018; Evald, 2015; Mahan et al., 2017; Raskin et al., 2018). As both PM and retrospective memory were shown to be impaired by acute alcohol use, future research investigating this compensatory strategy following acute alcohol consumption should seek to incorporate an external prompt that contains details regarding both the specific content of the task, and the circumstance in which the task is to be performed. Research investigating compensatory strategies that may be effective for EFT and episodic foresight, however, is currently lacking and should be a focus for future research. Episodic foresight is of particular note as it has been suggested to be an important factor in reducing the rate at which future rewards are discounted, which has implications for impulsivity and risk taking behaviour (Bulley & Gullo, 2017). Thus, strategies to compensate for deficits in episodic foresight may in turn reduce the incidence of people engaging in impulsive and risky behaviours under the

influence of alcohol. Overall, identifying effective compensatory strategies for impairment in EFT, episodic foresight, and PM may further inform policy and assist in the prevention and minimisation of acute alcohol-related harms.

Finally, the results of this research project also have significant implications for the treatment of individuals with an alcohol use disorder. This is because many psychological treatment techniques rely on some degree of future thought. For example, a common strategy employed in Cognitive Behavioural Therapy (CBT) for the treatment of alcohol use disorders involves identifying, imagining, and responding to high-risk situations and applying these techniques when these situations arise in real life (Blume et al., 2005; Curran & Drummond, 2007). Thus, deficits in prospection may hinder therapeutic progress by restricting a person's ability to imagine themselves experiencing future events and consider the future consequences of their actions, thus reducing their capacity to effectively engage in treatment. Indeed, it has been suggested that impairment in one of the key aspects of prospection (i.e. PM) may be a potential contributor to relapse in problem drinkers (Griffiths et al., 2012; Leitz et al., 2009; Smith-Spark et al., 2016), which may also apply to other forms of prospection. However, there is currently a dearth of research investigating prospection in alcohol use disorder.

8.4 Future Research Directions

Prospection is currently one of the most rapidly growing areas in cognitive neuroscience and psychological research, however as previously mentioned, much remains to be understood about the various forms of prospection, their cognitive underpinnings, and the interrelations between these abilities in both general and clinical populations. Research investigating prospection in the context of acute alcohol consumption is particularly scarce, which is surprising given the critical adaptive and functional importance of prospection in everyday life, and the potential for deleterious consequences should these abilities be interrupted. Whilst this project aimed to provide a comprehensive investigation of the effect of a moderate dose of

alcohol on three key forms of prospection, namely EFT, episodic foresight, and PM, in addition to their proposed cognitive underpinnings and interrelations, additional work is needed to replicate these findings, and to further deconstruct the potential cognitive abilities that may underlie these forms of prospection. This is especially important as the current research project was the first to examine a number of cognitive abilities that may contribute to acute alcohol-related deficits in EFT, episodic foresight, and PM. Furthermore, although this research project included measures that simulate everyday life, future research may also endeavour to directly examine the link between performance on these measures and real-life behaviours. This research would increase understanding of how deficits in these abilities translate to daily functioning.

Research also suggests that the effect of acute alcohol consumption on cognition occurs on a dose-related continuum, with higher doses of alcohol resulting in greater levels of impairment (Dry et al., 2012; Field et al., 2010; Fillmore, 2007; Ryback, 1971). Thus, a valuable extension of the current research project would be the implementation of a range of doses of alcohol to produce a dose-response curve. More specifically, this study utilised a cross-sectional design that demonstrated impairment in EFT, episodic foresight, and PM following the administration of a moderate dose of alcohol, which could be built upon by administering different doses of alcohol (e.g. 0.2g/kg, 0.4g/kg, 0.6g/kg and 0.8g/kg). This approach could be used to determine the point at which EFT, episodic foresight, and PM become impaired by acute alcohol use and would provide a more nuanced understanding of the effect of acute alcohol consumption on these specific forms of prospection.

An additional and important target for future research would be to undertake a similar investigation of prospection following the use of other substances that are commonly used at a recreational level, such as cannabis. While there are very few acute cannabis studies largely due to ethical and legal considerations, there is some non-acute evidence to suggest that regular

cannabis use impairs EFT (Mercuri et al., 2018) and PM (see Platt et al., 2019 for a review). This research would have similarly important implications for understanding and informing individuals of the cognitive risks associated with acute use and the potential adverse impact on daily functioning.

Finally, given the limited research investigating prospection in the context of alcohol use disorder, and its potential treatment implications, future research should also seek to undertake a comprehensive investigation of prospection in individuals diagnosed with an alcohol use disorder. Such an understanding would further aid the development of more tailored treatment protocols and harm minimisation strategies for individuals with an alcohol use disorder. Additionally, given that impairment in PM may be a potential contributor to relapse (Griffiths et al., 2012; Leitz et al., 2009; Smith-Spark et al., 2016), a valuable avenue for future research would be to assess if deficits in PM and other key aspects of prospection may be predictors of relapse following treatment for alcohol use disorder.

8.5 Strengths and Limitations of the Overall Research Project

In addition to providing novel insights into prospection in the context of acute alcohol consumption, this research project contained a number of strengths. First and foremost, this project comprised a well-powered design. The large sample size of 124 participants allowed for strong conclusions regarding the effect of acute alcohol consumption on three key forms of prospection and was indeed designed to provide sufficient power (>.90) to detect moderate effect sizes for the group comparison statistical analyses, as outlined in the methodology chapter (Chapter 4). Furthermore, this sample size was substantially powered (.80) to conduct novel comparisons of sex differences in prospection following acute moderate alcohol consumption.

The second key strength of the current research project was the inclusion of an extensive battery of cognitive measures which facilitated an investigation of the relationships between a

wide range of cognitive abilities and prospection in a single sample of participants. Thus, this project provided a comprehensive understanding of the effect of a moderate dose of alcohol on three key aspects of prospection, their cognitive underpinnings, and their interrelations. Importantly, the battery of cognitive measures used in the current project comprised well-validated measures, which was another strength of this project. In particular, the current research included a novel behavioural measure of episodic foresight (*VW-Foresight*), which was designed in line with the strict criteria proposed by Suddendorf and Corballis (2010). The measure of PM (*VW-PM*) is also of note, as it is an extensively validated measure that enables the conceptual distinction between five different types of PM tasks (Rendell & Henry, 2009). Both measures simulate real-life situations and therefore increase confidence in conclusions regarding the impact of acute alcohol consumption on daily functioning.

Despite the use of a well-powered design and well-validated measures, possible limitations of the current project should also be acknowledged. One limitation of this project concerns the length of testing sessions, which were typically 2.5-3 hours in duration. It is therefore recognised that testing sessions would have required a considerable amount of sustained attention, particularly for participants assigned to the alcohol condition. However, to mitigate any potential effects of fatigue, regular breaks were provided between tasks and participants' subjective mood states were monitored via visual analogue scales, which revealed only a slight decline in participant alertness across the testing session. Nevertheless, it is possible that the length of the testing session may have amplified any effects of alcohol consumption on cognitive performance.

Another limitation relates to the results of the manipulation check, in which the researcher and each participant were asked at the conclusion of the testing session to guess which condition the participant had been assigned to (alcohol or placebo). The results showed that the majority (> 90%) of participants assigned to the alcohol condition correctly guessed

that they had received the alcoholic drinks, whereas just over half (59%) of the participants correctly guessed that they had received the placebo drinks. These findings thereby indicate that the administration of alcohol could not be effectively blinded from participants assigned to the alcohol condition but could be effectively blinded to those assigned to the placebo condition. Additionally, the results showed that the researcher correctly guessed the participants' assigned condition a majority (> 85%) of the time, although this is unsurprising given that a single researcher conducted all of the testing sessions and therefore would have become accustomed to the signs and symptoms of acute moderate alcohol consumption. Thus, although this research project comprised a double-blind design, the results support other studies (Bisby et al., 2010; Leitz et al., 2009; Walter & Bayen, 2016), by highlighting 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. 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.

8.6 Conclusions

Despite the prevalence of alcohol use in Australian society and many countries worldwide, and the abundance of research investigating its effect on various aspects of cognition, there has been a shortage of research investigating prospection in the context of acute moderate alcohol consumption. This thesis therefore extends current knowledge of the effects of acute alcohol consumption on cognition by providing a comprehensive picture of three key forms of prospection, namely EFT, episodic foresight, and PM, their cognitive underpinnings, and their interrelations. These data suggest that the area of prospection may be highly sensitive to acute alcohol use, revealing pervasive impairment in EFT, episodic foresight, and PM following a moderate dose of alcohol, with generally large effect sizes.

Additionally, these deficits were evident to a similar degree for males and females who consumed alcohol. However, much more remains to be understood regarding the cognitive abilities that may contribute to prospection. The results of this thesis provide a foundation for future research to explore other forms of prospection and indicate the value of replicating this study using various doses of alcohol to produce a dose-response curve. A greater understanding of the effects of acute alcohol use on cognition could in turn inform and guide future policy regarding alcohol consumption and form the basis of education campaigns and programs. In addition, this knowledge may assist in the development of more effective treatments for alcohol use disorder.

References

Abbey, A., Smith, M. J., & Scott, R. O. (1993). The relationship between reasons for drinking alcohol and alcohol consumption: An interactional approach. *Addictive Behaviors, 18*(6), 659-670. https://doi.org/10.1016/0306-4603(93)90019-6

Abroms, B. D., Fillmore, M. T., & Marczinski, C. A. (2003). Alcohol-induced impairment of behavioral control: Effects on the alteration and suppression of prepotent responses. *Journal of Studies on Alcohol, 64*(5), 687-695. https://doi.org/10.15288/jsa.2003.64.687

Abroms, B. D., Gottlob, L. R., & Fillmore, M. T. (2006). Alcohol effects on inhibitory control of attention: Distinguishing between intentional and automatic mechanisms. *Psychopharmacology, 188*(3), 324-334. https://doi.org/10.1007/s00213-006-0524-y

Acheson, S. K., Stein, R. M., & Swartzwelder, H. (1998). Impairment of semantic and figural memory by acute ethanol: Age-dependent effects. *Alcoholism: Clinical and Experimental Research, 22*(7), 1437-1442. https://doi.org/10.1111/j.1530-0277.1998.tb03932.x

Addis, D. R. (2018). Are episodic memories special? On the sameness of remembered and imagined event simulation. *Journal of the Royal Society of New Zealand, 48*(2-3), 64-88. https://doi.org/10.1080/03036758.2018.1439071

Addis, D. R. (2020). Mental Time Travel? A Neurocognitive Model of Event Simulation. *Review of Philosophy and Psychology, 11*(2), 233-259. https://doi.org/10.1007/s13164-020-00470-0

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: common and distinct neural substrates during event

construction and elaboration. *Neuropsychologia, 45*(7), 1363-1377. https://doi.org/10.1016/j.neuropsychologia.2006.10.016

Addis, D. R., Wong, A. T., & Schacter, D. L. (2008). Age-related changes in the episodic simulation of future events. *Psychological Science, 19*(1), 33-41. https://doi.org/10.1111/j.1467-9280.2008.02043.x

Altgassen, M., Rendell, P. G., Bernhard, A., Henry, J. D., Bailey, P. E., Phillips, L. H., & Kliegel, M. (2015). Future thinking improves prospective memory performance and plan enactment in older adults. *Quarterly Journal of Experimental Psychology, 68*(1), 192-204. https://doi.org/10.1080/17470218.2014.956127

Altgassen, M., Vetter, N. C., Phillips, L. H., Akgün, C., & Kliegel, M. (2014). Theory of mind and switching predict prospective memory performance in adolescents. *Journal of Experimental Child Psychology, 127*, 163-175. https://doi.org/10.1016/j.jecp.2014.03.009

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review, 16*(1), 17-42. https://doi.org/10.1007/s11065-006-9002-x

Ammon, E., Schäfer, C., Hofmann, U., & Klotz, U. (1996). Disposition and first-pass metabolism of ethanol in humans: Is it gastric or hepatic and does it depend on gender? *Clinical Pharmacology and Therapeutics, 59*(5), 503-513. https://doi.org/10.1016/S0009-9236(96)90178-2

Arbuthnott, K., & Frank, J. (2000). Trail making test, part B as a measure of executive control: Validation using a set-switching paradigm. *Journal of Clinical and Experimental Neuropsychology, 22*(4), 518-528. https://doi.org/10.1076/1380-3395(200008)22:4;1-0;FT518

Atance, C. M., & Meltzoff, A. N. (2005). My future self: Young children's ability to anticipate and explain future states. *Cognitive Development, 20*(3), 341-361. https://doi.org/10.1016/j.cogdev.2005.05.001

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences, 5*(12), 533-539. https://doi.org/10.1016/S1364-6613(00)01804-0

Atance, C. M., & O'Neill, D. K. (2005). The emergence of episodic future thinking in humans. *Learning and Motivation, 36*(2), 126-144. https://doi.org/10.1016/j.lmot.2005.02.003

Australian Institute of Health and Welfare. (2019). National Drug Strategy Household Survey 2019 - Alcohol. https://www.aihw.gov.au/getmedia/cd005d19-1ebc-47f5-a46e-1cefb97e74be/aihw-phe-270-Chapter3-Alcohol.pdf.aspx

Baddeley, A., Emslie, H., & Nimmo-Smith, I. (1993). The Spot-the-Word test: A robust estimate of verbal intelligence based on lexical decision. *British Journal of Clinical Psychology, 32*(1), 55-65. https://doi.org/10.1111/j.2044-8260.1993.tb01027.x

Bar, M. (2007). The continuum of “looking forward,” and paradoxical requirements from memory. *Behavioral and Brain Sciences, 30*(3), 315-316. https://doi.org/10.1017/S0140525X07002002

Baraona, E., Abittan, C. S., Dohmen, K., Moretti, M., Pozzato, G., Chayes, Z. W., Schaefer, C., & Lieber, C. S. (2001). Gender differences in pharmacokinetics of alcohol. *Alcoholism: Clinical and Experimental Research, 25*(4), 502-507. https://doi.org/10.1111/j.1530-0277.2001.tb02242.x

Barsics, C., Van der Linden, M., & D'Argembeau, A. (2016). Frequency, characteristics, and perceived functions of emotional future thinking in daily life.

Quarterly Journal of Experimental Psychology, 69(2), 217-233. https://doi.org/10.1080/17470218.2015.1051560

Bechara, A., Dolan, S., Denburg, N., Hindes, A., Anderson, S. W., & Nathan, P. E. (2001). Decision-making deficits, linked to a dysfunctional ventromedial prefrontal cortex, revealed in alcohol and stimulant abusers. *Neuropsychologia, 39*(4), 376-389. https://doi.org/10.1016/S0028-3932(00)00136-6

Benedict, R. H., Schretlen, D., Groninger, L., & Brandt, J. (1998). Hopkins Verbal Learning Test–Revised: Normative data and analysis of inter-form and test-retest reliability. *The Clinical Neuropsychologist, 12*(1), 43-55. https://doi.org/10.1076/clin.12.1.43.1726

Berntsen, D., & Jacobsen, A. S. (2008). Involuntary (spontaneous) mental time travel into the past and future. *Consciousness and Cognition, 17*(4), 1093-1104. https://doi.org/10.1016/j.concog.2008.03.001

Birnbaum, I. M., Parker, E. S., Hartley, J. T., & Noble, E. P. (1978). Alcohol and memory: Retrieval processes. *Journal of Verbal Learning and Verbal Behavior, 17*(3), 325-335. https://doi.org/10.1016/S0022-5371(78)90210-4

Bisby, J. A., Leitz, J. R., Morgan, C. J., & Curran, H. V. (2010). Decreases in recollective experience following acute alcohol: A dose–response study. *Psychopharmacology, 208*, 67-74. https://doi.org/10.1007/s00213-009-1709-y

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the Hospital Anxiety and Depression Scale: an updated literature review. *Journal of Psychosomatic Research, 52*(2), 69-77. https://doi.org/10.1016/S0022-3999(01)00296-3

Blume, A. W., Schmaling, K. B., & Marlatt, G. A. (2005). Memory, executive cognitive function, and readiness to change drinking behavior. *Addictive Behaviors, 30*(2), 301-314. https://doi.org/10.1016/j.addbeh.2004.05.019

Boha, R., Molnár, M., Gaál, Z. A., Czigler, B., Róna, K., Kass, K., & Klausz, G. (2009). The acute effect of low-dose alcohol on working memory during mental arithmetic: I. Behavioral measures and EEG theta band spectral characteristics. *International Journal of Psychophysiology, 73*(2), 133-137. https://doi.org/10.1016/j.ijpsycho.2009.02.006

Bradley, M. M., & Lang, P. J. (1999). Affective norms for English words (ANEW): Instruction manual and affective ratings.

Brewer, G. A., & Marsh, R. L. (2010). On the role of episodic future simulation in encoding of prospective memories. *Cognitive Neuroscience, 1*(2), 81-88. https://doi.org/10.1080/17588920903373960

Brewer, R. D., & Swahn, M. H. (2005). Binge drinking and violence. *Jama, 294*(5), 616-618. https://doi.org/10.1001/jama.294.5.616

Brown, A. D., Addis, D. R., Romano, T. A., Marmar, C. R., Bryant, R. A., Hirst, W., & Schacter, D. L. (2014). Episodic and semantic components of autobiographical memories and imagined future events in post-traumatic stress disorder. *Memory, 22*(6), 595-604. https://doi.org/10.1080/09658211.2013.807842

Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences, 11*(2), 49-57. https://doi.org/10.1016/j.tics.2006.11.004

Bulley, A., & Gullo, M. J. (2017). The influence of episodic foresight on delay discounting and demand for alcohol. *Addictive Behaviors, 66*, 1-6. https://doi.org/10.1016/j.addbeh.2016.11.003

Burgess, P. W., Scott, S. K., & Frith, C. D. (2003). The role of the rostral frontal cortex (area 10) in prospective memory: a lateral versus medial dissociation. *Neuropsychologia, 41*(8), 906-918. https://doi.org/10.1016/s0028-3932(02)00327-5

Burgess, P. W., & Shallice, T. (1997a). *The Hayling and Brixton Tests.* Bury St, Edmonds: Thames Valley Test Company.

Burgess, P. W., & Shallice, T. (1997b). The relationship between prospective and retrospective memory: Neuropsychological evidence. *Cognitive Models of Memory, 5*, 249-256.

Busby, J., & Suddendorf, T. (2005). Recalling yesterday and predicting tomorrow. *Cognitive Development, 20*(3), 362-372. https://doi.org/10.1016/j.cogdev.2005.05.002

Casbon, T. S., Curtin, J. J., Lang, A. R., & Patrick, C. J. (2003). Deleterious effects of alcohol intoxication: Diminished cognitive control and its behavioral consequences. *Journal of Abnormal Psychology, 112*(3), 476-487. https://doi.org/10.1037/0021-843X.112.3.476

Cavuoto, M. G., Ong, B., Pike, K. E., Nicholas, C. L., & Kinsella, G. J. (2017). Naturalistic prospective memory in older adults: Predictors of performance on a habitual task. *Neuropsychological Rehabilitation, 27*(5), 744-758. https://doi.org/10.1080/09602011.2015.1074590

Cederbaum, A. I. (2012). Alcohol metabolism. *Clinics in Liver Disease, 16*(4), 667-685. https://doi.org/10.1016/j.cld.2012.08.002

Charness, M. E. (1990). Alcohol and the brain. *Alcohol Health and Research World, 14*(2), 85-90.

Chikritzhs, T. N., Stockwell, T. R., Jonas, H. A., Heale, P. F., & Dietze, P. M. (2001). Mortality and life-years lost due to alcohol: a comparison of acute and chronic causes. *Medical Journal of Australia, 174*(6), 281-284. https://doi.org/10.5694/j.1326-5377.2001.tb143269.x

Cole, S. N., Morrison, C. M., & Conway, M. A. (2013). Episodic future thinking: Linking neuropsychological performance with episodic detail in young and old adults. *The Quarterly Journal of Experimental Psychology, 66*(9), 1687-1706. https://doi.org/10.1080/17470218.2012.758157

Cole-Harding, S., & Wilson, J. (1987). Ethanol metabolism in men and women. *Journal of Studies on Alcohol, 48*(4), 380-387. https://doi.org/10.15288/jsa.1987.48.380

Commonwealth of Australia, Department of Health. (2019). National Alcohol Strategy 2019-2028. https://www.health.gov.au/resources/publications/national-alcohol-strategy-2019-2028

Coughlin, C., Lyons, K. E., & Ghetti, S. (2014). Remembering the past to envision the future in middle childhood: Developmental linkages between prospection and episodic memory. *Cognitive Development, 30*, 96-110. https://doi.org/10.1016/j.cogdev.2014.02.001

Crews, F. T., Morrow, A. L., Criswell, H., & Breese, G. (1996). Effects of ethanol on ion channels. *International Review of Neurobiology, 39*, 283-367. https://doi.org/10.1016/S0074-7742(08)60670-4

Criswell, H., Simson, P., Duncan, G., McCown, T., Herbert, J., Morrow, A., & Breese, G. (1993). Molecular basis for regionally specific action of ethanol on gamma-aminobutyric acidA receptors: Generalization to other ligand-gated ion channels. *Journal of Pharmacology and Experimental Therapeutics, 267*(1), 522-537.

Cui, C., & Koob, G. F. (2017). Titrating tipsy targets: The neurobiology of low-dose alcohol. *Trends in Pharmacological Sciences, 38*(6), 556-568. https://doi.org/10.1016/j.tips.2017.03.002

Curran, H. V., & Hildebrandt, M. (1999). Dissociative effects of alcohol on recollective experience. *Consciousness and Cognition, 8*(4), 497-509. https://doi.org/10.1006/ccog.1999.0417

Curran, H. V., & Weingartner, H. (2002). Psychopharmacology of human memory. In A. Baddeley, M. Kopelman, & B. Wilson (Eds.), *Handbook of memory disorders* (Vol. 2, pp. 123-141). Wiley.

Curran, V., & Drummond, C. (2007). Psychological treatments of substance misuse and dependence. In *Drugs and the Future* (pp. 209-239). Elsevier.

Curtin, J. J., & Fairchild, B. A. (2003). Alcohol and cognitive control: Implications for regulation of behavior during response conflict. *Journal of Abnormal Psychology, 112*(3), 424-436. https://doi.org/10.1037/0021-843X.112.3.424

D'Argembeau, A., Raffard, S., & Van der Linden, M. (2008). Remembering the past and imagining the future in schizophrenia. *Journal of Abnormal Psychology, 117*(1), 247-251. https://doi.org/10.1037/0021-843X.117.1.247

D'Argembeau, A., Renaud, O., & Van der Linden, M. (2011). Frequency, characteristics and functions of future-oriented thoughts in daily life. *Applied Cognitive Psychology, 25*(1), 96-103. https://doi.org/10.1002/acp.1647

D'Argembeau, A., Ortoleva, C., Jumentier, S., & Van der Linden, M. (2010). Component processes underlying future thinking. *Memory and Cognition, 38*(6), 809-819. https://doi.org/10.3758/MC.38.6.809

Day, A. M., Celio, M. A., Lisman, S. A., & Spear, L. P. (2014). Gender, history of alcohol use and number of drinks consumed predict craving among drinkers in a

field setting. *Addictive Behaviors, 39*(1), 354-357. https://doi.org/10.1016/j.addbeh.2013.10.014

Day, A. M., Kahler, C. W., Ahern, D. C., & Clark, U. S. (2015). Executive functioning in alcohol use studies: A brief review of findings and challenges in assessment. *Current Drug Abuse Reviews, 8*(1), 26-40. https://doi.org/10.2174/1874473708666150416110515

De Pirro, S., Lush, P., Parkinson, J., Duka, T., Critchley, H. D., & Badiani, A. (2020). Effect of alcohol on the sense of agency in healthy humans. *Addiction Biology, 25*(4), e12796. https://doi.org/10.1111/adb.12796

de Vito, S., Gamboz, N., Brandimonte, M. A., Barone, P., Amboni, M., & Della Sala, S. (2012). Future thinking in Parkinson's disease: An executive function? Neuropsychologia, 50(7), 1494-1501. https://doi.org/10.1016/j.neuropsychologia.2012.03.001

Dettling, A., Skopp, G., Graw, M., & Haffner, H.-T. (2008). The influence of sex hormones on the elimination kinetics of ethanol. *Forensic Science International, 177*(2-3), 85-89. https://doi.org/10.1016/j.forsciint.2007.11.002

Dewar, B.-K., Kapur, N., & Kopelman, M. (2018). Do memory aids help everyday memory? A controlled trial of a Memory Aids Service. *Neuropsychological Rehabilitation, 28*(4), 614-632. https://doi.org/10.1080/09602011.2016.1189342

Dismukes, R. K. (2012). Prospective memory in workplace and everyday situations. *Current Directions in Psychological Science, 21*(4), 215-220. https://doi.org/10.1177/0963721412447621

Dougherty, D. M., Marsh, D. M., Moeller, F. G., Chokshi, R. V., & Rosen, V. C. (2000). Effects of moderate and high doses of alcohol on attention, impulsivity, discriminability, and response bias in immediate and delayed memory task

performance. *Alcoholism: Clinical and Experimental Research, 24*(11), 1702-1711. https://doi.org/10.1111/j.1530-0277.2000.tb01972.x

Dougherty, D. M., Marsh-Richard, D. M., Hatzis, E. S., Nouvion, S. O., & Mathias, C. W. (2008). A test of alcohol dose effects on multiple behavioral measures of impulsivity. *Drug and Alcohol Dependence, 96*(1-2), 111-120. https://doi.org/10.1016/j.drugalcdep.2008.02.002

Doyle, S. R., Donovan, D. M., & Simpson, T. L. (2011). Validation of a nine-dimensional measure of drinking motives for use in clinical applications: The desired effects of drinking scale. *Addictive Behaviors, 36*(11), 1052-1060. https://doi.org/10.1016/j.addbeh.2011.06.012

Dry, M. J., Burns, N. R., Nettelbeck, T., Farquharson, A. L., & White, J. M. (2012). Dose-related effects of alcohol on cognitive functioning. *PloS One, 7*(11), e50977. https://doi.org/10.1371/journal.pone.0050977

Duning, T., Kugel, H., Menke, R., & Knecht, S. (2008). Diffusion-weighted magnetic resonance imaging at 3.0 Tesla in alcohol intoxication. *Psychiatry Research: Neuroimaging, 163*(1), 52-60. https://doi.org/10.1016/j.pscychresns.2007.09.003

Eckardt, M. J., File, S. E., Gessa, G. L., Grant, K. A., Guerri, C., Hoffman, P. L., Kalant, H., Koob, G. F., Li, T. K., & Tabakoff, B. (1998). Effects of moderate alcohol consumption on the central nervous system. *Alcoholism: Clinical and Experimental Research, 22*(5), 998-1040. https://doi.org/10.1111/j.1530-0277.1998.tb03695.x

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*(4), 717-726. https://doi.org/10.1037/0278-7393.164.717

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. *Prospective memory: Theory and applications*, 115-141.

Ellis, J., & Kvavilashvili, L. (2000). Prospective memory in 2000: Past, present, and future directions. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition, 14*(7), S1-S9. https://doi.org/10.1002/acp.767.abs

Ellis, J. A., & Freeman, J. (2008). Ten years on: Realizing delayed intentions. In M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp. 1-27). Erlbaum.

Ely, M., Hardy, R., Longford, N. T., & Wadsworth, M. E. (1999). Gender differences in the relationship between alcohol consumption and drink problems are largely accounted for by body water. *Alcohol and Alcoholism, 34*(6), 894-902. https://doi.org/10.1093/alcalc/34.6.894

Erol, A., & Karpyak, V. M. (2015). Sex and gender-related differences in alcohol use and its consequences: Contemporary knowledge and future research considerations. *Drug and Alcohol Dependence, 156*, 1-13. https://doi.org/10.1016/j.drugalcdep.2015.08.023

Evald, L. (2015). Prospective memory rehabilitation using smartphones in patients with TBI: What do participants report? *Neuropsychological Rehabilitation, 25*(2), 283-297. https://doi.org/10.1080/09602011.2014.970557

Farber, P. D., Khavari, K. A., & Douglass, F. M. (1980). A factor analytic study of reasons for drinking: Empirical validation of positive and negative

reinforcement dimensions. *Journal of Consulting and Clinical Psychology, 48*(6), 780-781. https://doi.org/10.1037/0022-006X.48.6.780

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191. https://doi.org/10.3758/BF03193146

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics* (5th ed.). SAGE.

Field, D. T., & Groeger, J. A. (2004). Temporal interval production and short-term memory. *Perception and Psychophysics, 66*(5), 808-819. https://doi.org/10.3758/BF03194975

Field, M., Wiers, R. W., Christiansen, P., Fillmore, M. T., & Verster, J. C. (2010). Acute alcohol effects on inhibitory control and implicit cognition: Implications for loss of control over drinking. *Alcoholism: Clinical and Experimental Research, 34*(8), 1346-1352. https://doi.org/10.1111/j.1530-0277.2010.01218.x

Fillmore, M. T. (2007). Acute alcohol-induced impairment of cognitive functions: Past and present findings. *International Journal on Disability and Human Development, 6*(2), 115-126. https://doi.org/10.1515/IJDHD.2007.6.2.115

Fillmore, M. T., Dixon, M. J., & Schweizer, T. A. (2000). Differential effects of alcohol on responses to negatively and positively primed stimuli. *Journal of Studies on Alcohol, 61*(6), 872-880. https://doi.org/10.15288/jsa.2000.61.872

Fillmore, M. T., Ostling, E. W., Martin, C. A., & Kelly, T. H. (2009). Acute effects of alcohol on inhibitory control and information processing in high and low sensation-seekers. *Drug and Alcohol Dependence, 100*(1-2), 91-99. https://doi.org/10.1016/j.drugalcdep.2008.09.007

Finn, P. R., Justus, A., Mazas, C., & Steinmetz, J. E. (1999). Working memory, executive processes and the effects of alcohol on Go/No-Go learning: Testing a model of behavioral regulation and impulsivity. *Psychopharmacology, 146*(4), 465-472. https://doi.org/10.1007/PL00005492

Flower, R. J., Henderson, G., Loke, Y. K., MacEwan, D., & Rang, H. P. (2018). *Rang & Dale's Pharmacology E-Book*. Elsevier Health Sciences.

Foster, E. R., McDaniel, M. A., & Rendell, P. G. (2017). Improving prospective memory in persons with Parkinson disease: A randomized controlled trial. *Neurorehabilitation and Neural Repair, 31*(5), 451-461. https://doi.org/10.1177/1545968317690832

Foster, E. R., Rose, N. S., McDaniel, M. A., & Rendell, P. G. (2013). Prospective memory in Parkinson disease during a virtual week: Effects of both prospective and retrospective demands. *Neuropsychology, 27*(2), 170-181. https://doi.org/10.1037/a0031946

Frezza, M., di Padova, C., Pozzato, G., Terpin, M., Baraona, E., & Lieber, C. S. (1990). High blood alcohol levels in women: The role of decreased gastric alcohol dehydrogenase activity and first-pass metabolism. *New England Journal of Medicine, 322*(2), 95-99. https://doi.org/10.1056/NEJM199001113220205

Gaesser, B., Sacchetti, D. C., Addis, D. R., & Schacter, D. L. (2011). Characterizing age-related changes in remembering the past and imagining the future. *Psychology and Aging, 26*(1), 80-84. https://doi.org/10.1037/a0021054

Gan, G., Guevara, A., Marxen, M., Neumann, M., Jünger, E., Kobiella, A., Mennigen, E., Pilhatsch, M., Schwarz, D., & Zimmermann, U. S. (2014). Alcohol-induced impairment of inhibitory control is linked to attenuated brain responses in right

fronto-temporal cortex. *Biological Psychiatry, 76*(9), 698-707. https://doi.org/10.1016/j.biopsych.2013.12.017

George, S., Rogers, R. D., & Duka, T. (2005). The acute effect of alcohol on decision making in social drinkers. *Psychopharmacology, 182*(1), 160-169. https://doi.org/10.1007/s00213-005-0057-9

Giancola, P. R. (2000). Executive functioning: A conceptual framework for alcohol-related aggression. *Experimental and Clinical Psychopharmacology, 8*(4), 576-597. https://doi.org/10.1037/1064-1297.8.4.576

Gilbert, D. T., & Wilson, T. D. (2007). Prospection: Experiencing the future. *Science, 317*(5843), 1351-1354. https://doi.org/10.1126/science.1144161

Gollwitzer, P. M. (1993). Goal achievement: The role of intentions. *European Review of Social Psychology, 4*(1), 141-185. https://doi.org/10.1080/14792779343000059

Gollwitzer, P. M. (1999). Implementation intentions: strong effects of simple plans. *American Psychologist, 54*(7), 493-503. https://doi.org/10.1037/0003-066X.54.7.493

Gollwitzer, P. M., & Bargh, J. A. (1996). *The psychology of action: Linking cognition and motivation to behavior*. Guilford Press.

Gonneaud, J., Kalpouzos, G., Bon, L., Viader, F., Eustache, F., & Desgranges, B. (2011). Distinct and shared cognitive functions mediate event- and time-based prospective memory impairment in normal ageing. *Memory, 19*, 360-377. https://doi.org/10.1080/09658211.2011.570765

Goodwin, D. W., Powell, B., Bremer, D., Hoine, H., & Stern, J. (1969). Alcohol and recall: State-dependent effects in man. *Science, 163*(3873), 1358-1360. https://doi.org/10.1126/science.163.3873.1358

Gott, C., & Lah, S. (2014). Episodic future thinking in children compared to adolescents. *Child Neuropsychology, 20*(5), 625-640. https://doi.org/10.1080/09297049.2013.840362

Graf, P., & Uttl, B. (2001). Prospective memory: A new focus for research. *Consciousness and Cognition, 10*(4), 437-450. https://doi.org/https://doi.org/10.1006/ccog.2001.0504

Grant, S., Contoreggi, C., & London, E. D. (2000). Drug abusers show impaired performance in a laboratory test of decision making. *Neuropsychologia, 38*(8), 1180-1187. https://doi.org/10.1016/S0028-3932(99)00158-X

Grant, K. A., & Lovinger, D. M. (2018). *The Neuropharmacology of Alcohol*. Springer. https://doi.org/10.1007/978-3-319-96523-9

Griffiths, A., Hill, R., Morgan, C., Rendell, P. G., Karimi, K., Wanagaratne, S., & Curran, H. V. (2012). Prospective memory and future event simulation in individuals with alcohol dependence. *Addiction, 107*(10), 1809-1816. https://doi.org/10.1111/j.1360-0443.2012.03941.x

Guillot, C. R., Fanning, J. R., Bullock, J. S., McCloskey, M. S., & Berman, M. E. (2010). Effects of alcohol on tests of executive functioning in men and women: A dose response examination. *Experimental and Clinical Psychopharmacology, 18*(5), 409-417. https://doi.org/10.1037/a0021053

Hanson, L. K., Atance, C. M., & Paluck, S. W. (2014). Is thinking about the future related to theory of mind and executive function? Not in preschoolers. *Journal of Experimental Child Psychology, 128*, 120-137. https://doi.org/10.1016/j.jecp.2014.07.006

Harris, J. E. (1983). Remembering to do things: A forgotten topic. In J. E. Harris & P. E. Morris (Eds.), *Everyday memory, actions, and absent-mindedness* (pp. 71-92). Academic Press.

Hassabis, D., Kumaran, D., Vann, S. D., & Maguire, E. A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences, 104*(5), 1726-1731. https://doi.org/10.1073/pnas.0610561104

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences, 11*(7), 299-306. https://doi.org/10.1016/j.tics.2007.05.001

Haut, J. S., Beckwith, B. E., Petros, T. V., & Russell, S. (1989). Gender differences in retrieval from long-term memory following acute intoxication with ethanol. *Physiology and Behavior, 45*(6), 1161-1165. https://doi.org/10.1016/0031-9384(89)90103-0

Henry, J. D., Rendell, P. G., Kliegel, M., & Altgassen, M. (2007). Prospective memory in schizophrenia: Primary or secondary impairment? *Schizophrenia Research, 95*(1-3), 179-185. https://doi.org/10.1016/j.schres.2007.06.003

Henry, J. D., Terrett, G., Altgassen, M., Raponi-Saunders, S., Ballhausen, N., Schnitzspahn, K. M., & Rendell, P. G. (2014). A Virtual Week study of prospective memory function in autism spectrum disorders. *Journal of Experimental Child Psychology, 127*, 110-125. https://doi.org/10.1016/j.jecp.2014.01.011

Hering, A., Kliegel, M., Rendell, P. G., Craik, F. I., & Rose, N. S. (2018). Prospective memory is a key predictor of functional independence in older adults. *Journal of*

the International Neuropsychological Society, 24(6), 640-645. https://doi.org/10.1017/S1355617718000152

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences, 16*(3), 174-180. https://doi.org/10.1016/j.tics.2012.01.006

Holloway, F. A. (1994). *Low-dose alcohol effects on human behavior and performance: A review of post-1984 research*.

Hull, J. G., & Bond, C. F. (1986). Social and behavioral consequences of alcohol consumption and expectancy: A meta-analysis. *Psychological Bulletin, 99*(3), 347-360. https://doi.org/10.1037/0033-2909.99.3.347

IBM Corp. *IBM SPSS Statistics for Mac.* In (Version 26.0)

Irish, M. (2016). Semantic memory as the essential scaffold for future-oriented mental time travel. In M. Kourken, S. B. Klein, & K. K. Szpunar (Eds.), *Seeing the future: Theoretical perspectives on future-oriented mental time travel* (pp. 389-408). Oxford University Press.

Irish, M., Lawlor, B. A., O'Mara, S. M., & Coen, R. F. (2011). Impaired capacity for autonoetic reliving during autobiographical event recall in mild Alzheimer's disease. *Cortex, 47*(2), 236-249. https://doi.org/10.1016/j.cortex.2010.01.002

Irish, M., & Piguet, O. (2013). The pivotal role of semantic memory in remembering the past and imagining the future. *Frontiers in Behavioral Neuroscience, 7*, 1-11. https://doi.org/10.3389/fnbeh.2013.00027

Jacob, A., & Wang, P. (2020). Alcohol intoxication and cognition: Implications on mechanisms and therapeutic strategies. *Frontiers in Neuroscience, 14*(102), 1-10. https://doi.org/10.3389/fnins.2020.00102

Jansari, A., Agnew, R., Akesson, K., & Murphy, L. (2004). The use of virtual reality to assess and predict real-world executive dysfunction: Can VR help for work-placement rehabilitation? *Brain Impairment, 5*(1), 110.

Jones, B. M., & Jones, M. K. (1977). Alcohol and memory impairment in male and female social drinkers. In I. M. Birnbaum & E. S. Parker (Eds.), *Alcohol and Human Memory* (pp. 127-138). Lawrence Erlbaum Associates.

Klein, S. B., Loftus, J., & Kihlstrom, J. F. (2002). Memory and temporal experience: The effects of episodic memory loss on an amnesic patient's ability to remember the past and imagine the future. *Social Cognition, 20*(5), 353-379. https://doi.org/10.1521/soco.20.5.353.21125

Kliegel, M., Altgassen, M., Hering, A., & Rose, N. S. (2011). A process-model based approach to prospective memory impairment in Parkinson's disease. *Neuropsychologia, 49*(8), 2166-2177. https://doi.org/10.1016/j.neuropsychologia.2011.01.024

Kliegel, M., McDaniel, M. A., & Einstein, G. O. (2000). Plan formation, retention, and execution in prospective memory: A new approach and age-related effects. *Memory and Cognition, 28*(6), 1041-1049. https://doi.org/10.3758/BF03209352

Klinger, E., & Cox, W. M. (1987). Dimensions of thought flow in everyday life. *Imagination, Cognition and Personality, 7*(2), 105-128. https://doi.org/10.2190/7K24-G343-MTQW-115V

Kwo, P. Y., Ramchandani, V. A., O'Connor, S., Amann, D., Carr, L. G., Sandrasegaran, K., Kopecky, K. K., & Li, T.-K. (1998). Gender differences in alcohol metabolism: Relationship to liver volume and effect of adjusting for body mass. *Gastroenterology, 115*(6), 1552-1557. https://doi.org/10.1016/S0016-5085(98)70035-6

Lammers, S. M., Mainzer, D. E., & Breteler, M. H. (1995). Do alcohol pharmacokinetics in women vary due to the menstrual cycle? *Addiction, 90*(1), 23-30. https://doi.org/10.1111/j.1360-0443.1995.tb01006.x

Leitz, J. R., Morgan, C. J., Bisby, J. A., Rendell, P. G., & Curran, H. V. (2009). Global impairment of prospective memory following acute alcohol. *Psychopharmacology, 205*(3), 379-387. https://doi.org/10.1007/s00213-009-1546-z

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: dissociating episodic from semantic retrieval. *Psychology and Aging, 17*(4), 677-689. https://doi.org/10.1037//0882-7974.17.4.677

Lezak, M. D., Howieson, D. B., Loring, D. W., & Fischer, J. S. (2004). *Neuropsychological assessment*. Oxford University Press.

Lind, S. E., & Bowler, D. M. (2010). Episodic memory and episodic future thinking in adults with autism. *Journal of Abnormal Psychology, 119*(4), 896-905. https://doi.org/10.1037/a0020631

Lyons, A. D., Henry, J. D., Rendell, P. G., Corballis, M. C., & Suddendorf, T. (2014). Episodic foresight and aging. *Psychology and Aging, 29*(4), 873-884. https://doi.org/10.1037/a0038130

Lyons, A. D., Henry, J. D., Rendell, P. G., Robinson, G., & Suddendorf, T. (2016). Episodic foresight and schizophrenia. *British Journal of Clinical Psychology, 55*(2), 107-122. https://doi.org/10.1111/bjc.12092

Lyons, A. D., Henry, J. D., Robinson, G., Rendell, P. G., & Suddendorf, T. (2019). Episodic foresight and stroke. *Neuropsychology, 33*(1), 93-102. https://doi.org/10.1037/neu0000495

Magrys, S., & Olmstead, M. (2014). Alcohol intoxication alters cognitive skills mediated by frontal and temporal brain regions. *Brain and Cognition, 85*, 271-276. https://doi.org/10.1016/j.bandc.2013.12.010

Mahan, S., Rous, R., & Adlam, A. (2017). A Systematic Review of Neuropsychological Rehabilitation for Prospective Memory Deficits as a Consequence of Acquired Brain Injury. *Journal of the International Neuropsychological Society, 23*, 254-265. https://doi.org/10.1017/S1355617716001065

Mahy, C. E., Mazachowsky, T. R., & Pagobo, J. R. (2018). Do verbal reminders improve preschoolers' prospective memory performance? it depends on age and individual differences. *Cognitive Development, 47*, 158-167. https://doi.org/10.1016/j.cogdev.2018.06.004

Mäntylä, T., Carelli, M. G., & Forman, H. (2007). Time monitoring and executive functioning in children and adults. *Journal of Experimental Child Psychology, 96*(1), 1-19. https://doi.org/10.1016/j.jecp.2006.08.003

Marco, C. A., & Kelen, G. D. (1990). Acute intoxication. *Emergency Medicine Clinics of North America, 8*(4), 731-748.

Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*(2), 336-349. https://doi.org/10.1037/0278-7393.24.2.336

Martin, M., Kliegel, M., & McDaniel, M. A. (2003). The involvement of executive functions in prospective memory performance of adults. *International Journal of Psychology, 38*(4), 195-206. https://doi.org/10.1080/00207590344000123

Mattli, F., Schnitzspahn, K. M., Studerus-Germann, A., Brehmer, Y., & Zöllig, J. (2014). Prospective memory across the lifespan: Investigating the contribution

of retrospective and prospective processes. *Aging, Neuropsychology, and Cognition, 21*(5), 515-543. https://doi.org/10.1080/13825585.2013.837860

McDaniel, M. A., & Einstein, G. O. (2007). Prospective memory: A new research enterprise. In *Prospective memory: An overview and synthesis of an emerging field* (pp. 1-16). Sage Publications. https://doi.org/10.4135/9781452225913.n1

Mehrabian, A., & Russell, J. A. (1978). A questionnaire measure of habitual alcohol use. *Psychological Reports, 43*(3), 803-806. https://doi.org/10.2466/pr0.1978.43.3.803

Mercuri, K., Terrett, G., Henry, J. D., Bailey, P. E., Curran, H. V., & Rendell, P. G. (2015). Episodic foresight deficits in long-term opiate users. *Psychopharmacology, 232*(7), 1337-1345. https://doi.org/10.1007/s00213-014-3772-2

Mercuri, K., Terrett, G., Henry, J. D., Curran, H. V., Elliott, M., & Rendell, P. G. (2018). Episodic foresight deficits in regular, but not recreational, cannabis users. *Journal of Psychopharmacology, 32*(8), 876-882. https://doi.org/10.1177/0269881118776672

Miloyan, B., McFarlane, K. A., & Suddendorf, T. (2019). Measuring mental time travel: Is the hippocampus really critical for episodic memory and episodic foresight? *Cortex, 117*, 371-384. https://doi.org/10.1016/j.cortex.2019.01.020

Mintzer, M. Z. (2007). The acute effects of alcohol on memory: A review of laboratory studies in healthy adults. *International Journal on Disability and Human Development, 6*(4), 397-404. https://doi.org/10.1515/IJDHD.2007.6.4.397

Mioni, G., Bertucci, E., Rosato, A., Terrett, G., Rendell, P. G., Zamuner, M., & Stablum, F. (2017). Improving prospective memory performance with future

event simulation in traumatic brain injury patients. *British Journal of Clinical Psychology, 56*(2), 130-148. https://doi.org/10.1111/bjc.12126

Mioni, G., Rendell, P. G., Henry, J. D., Cantagallo, A., & Stablum, F. (2013). An investigation of prospective memory functions in people with traumatic brain injury using Virtual Week. *Journal of Clinical and Experimental Neuropsychology, 35*(6), 617-630. https://doi.org/10.1080/13803395.2013.804036

Monsell, S. (1996). Control of mental processes. In *Unsolved mysteries of the mind: Tutorial essays in cognition* (pp. 93-148).

Montgomery, C., Ashmore, K. V., & Jansari, A. (2011). The effects of a modest dose of alcohol on executive functioning and prospective memory. *Human Psychopharmacology: Clinical and Experimental, 26*(3), 208-215. https://doi.org/10.1002/hup.1194

Moore, S. C., & Cusens, B. (2010). Delay discounting predicts increase in blood alcohol level in social drinkers. *Psychiatry Research, 179*(3), 324-327. https://doi.org/10.1016/j.psychres.2008.07.024

Mumenthaler, M. S., Taylor, J. L., O'Hara, R., & Yesavage, J. A. (1999). Gender differences in moderate drinking effects. *Alcohol Research and Health, 23*(1), 55-64. https://doi.org/10.1111/j.1530-0277.1999.tb04107.x

Neroni, M. A., Gamboz, N., & Brandimonte, M. A. (2014). Does episodic future thinking improve prospective remembering? *Consciousness and Cognition, 23*, 53-62. https://doi.org/10.1016/j.concog.2013.12.001

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., Suzuki, K., Kawashima, R., Fukuda, H., Itoh, M., & Yamadori, A. (2003). Thinking of the future and past:

The roles of the frontal pole and the medial temporal lobes. *Neuroimage, 19*(4), 1369-1380. https://doi.org/10.1016/S1053-8119(03)00179-4

Oscar-Berman, M., & Marinković, K. (2007). Alcohol: Effects on neurobehavioral functions and the brain. *Neuropsychology Review, 17*(3), 239-257. https://doi.org/10.1007/s11065-007-9038-6

Paraskevaides, T., Morgan, C. J., Leitz, J. R., Bisby, J. A., Rendell, P. G., & Curran, H. V. (2010). Drinking and future thinking: Acute effects of alcohol on prospective memory and future simulation. *Psychopharmacology, 208*(2), 301-308. https://doi.org/10.1007/s00213-009-1731-0

Petersen, R. C. (1977). Retrieval failures in alcohol state-dependent learning. *Psychopharmacology, 55*(2), 141-146. https://doi.org/10.1007/BF01457849

Phillips, N. L., Shum, D. H., Mandalis, A., Parry, L., Benson, S., Morrow, A., Epps, A., & Lah, S. (2018). Time-based prospective memory in children and adolescents with traumatic brain injury: Impact of working memory demands. *Neuropsychology, 32*(5), 575-585. https://doi.org/10.1037/neu0000468

Platt, B., Kamboj, S. K., Italiano, T., Rendell, P. G., & Curran, H. V. (2016). Prospective memory impairments in heavy social drinkers are partially overcome by future event simulation. *Psychopharmacology, 233*(3), 499-506. https://doi.org/10.1007/s00213-015-4145-1

Platt, B., O'Driscoll, C., Curran, V. H., Rendell, P. G., & Kamboj, S. K. (2019). The effects of licit and illicit recreational drugs on prospective memory: a meta-analytic review. *Psychopharmacology*, 1-13. https://doi.org/10.1007/s00213-019-05245-9

Ramchandani, V., Bosron, W., & Li, T. (2001). Research advances in ethanol metabolism. *Pathologie Biologie, 49*(9), 676-682. https://doi.org/10.1016/S0369-8114(01)00232-2

Raskin, S., & Buckheit, C. (2010). *Memory for intentions test (MIsT)*. Psychological Assessment Resources Inc.

Raskin, S. A. (2018). Prospective memory in clinical populations. *Clinical Neuropsychologist, 32*, 741-747. https://doi.org/10.1080/13854046.2018.1484519

Raskin, S. A., Williams, J., & Aiken, E. M. (2018). A review of prospective memory in individuals with acquired brain injury. *The Clinical Neuropsychologist, 32*(5), 891-921. https://doi.org/10.1080/13854046.2018.1455898

Redshaw, J., & Suddendorf, T. (2013). Foresight beyond the very next event: Four-year-olds can link past and deferred future episodes. *Frontiers in Psychology, 4*, 1-6. https://doi.org/10.3389/fpsyg.2013.00404

Rehm, J., & Shield, K. D. (2019). Global burden of alcohol use disorders and alcohol liver disease. *Biomedicines, 7*(4), 99. https://doi.org/10.3390/biomedicines7040099

Rendell, P. G., & Craik, F. I. M. (2000). Virtual week and actual week: Age-related differences in prospective memory. *Applied Cognitive Psychology, 14*(7), S43-S62. https://doi.org/10.1002/acp.770

Rendell, P. G., Gray, T. J., Henry, J. D., & Tolan, A. (2007). Prospective memory impairment in "ecstasy"(MDMA) users. *Psychopharmacology, 194*(4), 497-504. https://doi.org/10.1007/s00213-007-0859-z

Rendell, P. G., & Henry, J. D. (2009). A review of Virtual Week for prospective memory assessment: Clinical implications. *Brain Impairment, 10*(1), 14-22. https://doi.org/10.1375/brim.10.1.14

Rendell, P. G., Henry, J. D., Phillips, L. H., De la Piedad Garcia, X., Booth, P., Phillips, P., & Kliegel, M. (2012). Prospective memory, emotional valence, and multiple sclerosis. *Journal of Clinical and Experimental Neuropsychology, 34*(7), 738-749. https://doi.org/10.1080/13803395.2012.670388

Rendell, P. G., Mazur, M., & Henry, J. D. (2009). Prospective memory impairment in former users of methamphetamine. *Psychopharmacology, 203*(3), 609-616. https://doi.org/10.1007/s00213-008-1408-0

Rickenbacher, E., Greve, D. N., Azma, S., Pfeuffer, J., & Marinkovic, K. (2011). Effects of alcohol intoxication and gender on cerebral perfusion: An arterial spin labeling study. *Alcohol, 45*(8), 725-737. https://doi.org/10.1016/j.alcohol.2011.04.002

Roberto, M., & Varodayan, F. P. (2017). Synaptic targets: chronic alcohol actions. *Neuropharmacology, 122*, 85-99. https://doi.org/10.1016/j.neuropharm.2017.01.013

Roberts, R. P., Schacter, D. L., & Addis, D. R. (2018). Scene construction and relational processing: Separable constructs? *Cerebral Cortex, 28*(5), 1729-1732. https://doi.org/10.1093/cercor/bhx081

Rose, N. S., Rendell, P. G., McDaniel, M. A., Aberle, I., & Kliegel, M. (2010). Age and individual differences in prospective memory during a" Virtual Week": The roles of working memory, vigilance, task regularity, and cue focality. *Psychology and Aging, 25*(3), 595-605. https://doi.org/10.1037/a0019771

Rosenbaum, R. S., Köhler, S., Schacter, D. L., Moscovitch, M., Westmacott, R., Black, S. E., Gao, F., & Tulving, E. (2005). The case of KC: Contributions of a memory-impaired person to memory theory. *Neuropsychologia, 43*(7), 989-1021. https://doi.org/10.1016/j.neuropsychologia.2004.10.007

Ryback, R. S. (1971). The continuum and specificity of the effects of alcohol on memory: A review. *Quarterly Journal of Studies on Alcohol, 32*, 995-1016. https://doi.org/10.15288/qjsa.1971.32.995

Saults, J. S., Cowan, N., Sher, K. J., & Moreno, M. V. (2007). Differential effects of alcohol on working memory: Distinguishing multiple processes. *Experimental and Clinical Psychopharmacology, 15*(6), 576-587. https://doi.org/10.1037/1064-1297.15.6.576

Schacter, D. L. (2012). Adaptive constructive processes and the future of memory. *American Psychologist, 67*(8), 603-613. https://doi.org/10.1037/a0029869

Schacter, D. L., & Addis, D. R. (2007a). The cognitive neuroscience of constructive memory: remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences, 362*(1481), 773-786. https://doi.org/10.1098/rstb.2007.2087

Schacter, D. L., & Addis, D. R. (2007b). On the constructive episodic simulation of past and future events. *Behavioral and Brain Sciences, 30*(3), 331-332. https://doi.org/10.1017/S0140525X07002178

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: The prospective brain. *Nature Reviews Neuroscience, 8*(9), 657-661. https://doi.org/10.1038/nrn2213

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic simulation of future events: Concepts, data, and applications. *Annals of the New York Academy of Sciences, 1124*, 39-60. https://doi.org/10.1196/annals.1440.001

Schacter, D. L., Addis, D. R., Hassabis, D., Martin, V. C., Spreng, R. N., & Szpunar, K. K. (2012). The future of memory: Remembering, imagining, and the brain. *Neuron, 76*(4), 677-694. https://doi.org/10.1016/j.neuron.2012.11.001

Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: Mechanisms and functions. *Current Opinion in Behavioral Sciences, 17*, 41-50. https://doi.org/10.1016/j.cobeha.2017.06.002

Schnitzspahn, K. M., Stahl, C., Zeintl, M., Kaller, C. P., & Kliegel, M. (2013). The role of shifting, updating, and inhibition in prospective memory performance in young and older adults. *Developmental Psychology, 49*(8), 1544-1553. https://doi.org/10.1037/a0030579

Schweizer, T. A., Vogel-Sprott, M., Danckert, J., Roy, E. A., Skakum, A., & Broderick, C. E. (2006). Neuropsychological profile of acute alcohol intoxication during ascending and descending blood alcohol concentrations. *Neuropsychopharmacology, 31*(6), 1301-1309. https://doi.org/10.1038/sj.npp.1300941

Seligman, M. E., Railton, P., Baumeister, R. F., & Sripada, C. (2013). Navigating into the future or driven by the past. *Perspectives on Psychological Science, 8*(2), 119-141. https://doi.org/10.1177/1745691612474317

Singer, J. L., & Antrobus, J. S. (1963). A factor-analytic study of daydreaming and conceptually-related cognitive and personality variables. *Perceptual and Motor Skills, 17*(1), 187-209. https://doi.org/10.2466/pms.1963.17.1.187

Singer, J. L., & Antrobus, J. S. (1972). Daydreaming, imaginal processes, and personality: A normative study. In *The function and nature of imagery* (pp. 175-202).

Smith, R. E., Persyn, D., & Butler, P. (2015). Prospective memory, personality, and working memory. *Zeitschrift für Psychologie*.

Smith-Spark, J. H., Moss, A. C., & Dyer, K. R. (2016). Do baseline executive functions mediate prospective memory performance under a moderate dose of alcohol? *Frontiers in Psychology, 7*(1325), 1-12. https://doi.org/10.3389/fpsyg.2016.01325

Söderlund, H., Grady, C. L., Easdon, C., & Tulving, E. (2007). Acute effects of alcohol on neural correlates of episodic memory encoding. *Neuroimage, 35*(2), 928-939. https://doi.org/10.1016/j.neuroimage.2006.12.024

Söderlund, H., Parker, E. S., Schwartz, B. L., & Tulving, E. (2005). Memory encoding and retrieval on the ascending and descending limbs of the blood alcohol concentration curve. *Psychopharmacology, 182*(2), 305-317. https://doi.org/10.1007/s00213-005-0096-2

Spinola, S., Maisto, S. A., White, C. N., & Huddleson, T. (2017). Effects of acute alcohol intoxication on executive functions controlling self-regulated behavior. *Alcohol, 61*, 1-8. https://doi.org/10.1016/j.alcohol.2017.02.177

Spreng, R. N., & Levine, B. (2006). The temporal distribution of past and future autobiographical events across the lifespan. *Memory and Cognition, 34*(8), 1644-1651. https://doi.org/10.3758/BF03195927

Squire, L. R., Stark, C. E., & Clark, R. E. (2004). The medial temporal lobe. *Annual Review of Neuroscience, 27*, 279-306. https://doi.org/10.1146/annurev.neuro.27.070203.144130

Strauss, E., Sherman, E. M., & Spreen, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary*. Oxford University Press.

Suddendorf, T. (2010a). Episodic memory versus episodic foresight: Similarities and differences. *Wiley Interdisciplinary Reviews: Cognitive Science, 1*(1), 99-107. https://doi.org/10.1002/wcs.23

Suddendorf, T. (2010b). Linking yesterday and tomorrow: Preschoolers' ability to report temporally displaced events. *British Journal of Developmental Psychology, 28*(2), 491-498. https://doi.org/10.1348/026151009X479169

Suddendorf, T. (2017). The emergence of episodic foresight and its consequences. *Child Development Perspectives, 11*(3), 191-195. https://doi.org/10.1111/cdep.12233

Suddendorf, T., Addis, D. R., & Corballis, M. C. (2009). Mental time travel and shaping of the human mind. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1521), 1317-1324. https://doi.org/10.1093/acprof:oso/9780195395518.003.0121

Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: What is mental time travel, and is it unique to humans? *Behavioral and Brain Sciences, 30*(3), 299-313. https://doi.org/10.1017/S0140525X07001975

Suddendorf, T., & Corballis, M. C. (2010). Behavioural evidence for mental time travel in nonhuman animals. *Behavioural Brain Research, 215*(2), 292-298. https://doi.org/10.1016/j.bbr.2009.11.044

Suddendorf, T., & Henry, J. (2013). Proximate and ultimate perspectives on memory. *Journal of Applied Research in Memory and Cognition, 2*, 246-247. https://doi.org/10.1016/j.jarmac.2013.10.005

Suddendorf, T., & Moore, C. (2011). The development of episodic foresight [Special issue]. *Cognitive Development, 26*, 295-298. https://doi.org/10.1016/j.cogdev.2011.09.001

Suddendorf, T., Nielsen, M., & Von Gehlen, R. (2011). Children's capacity to remember a novel problem and to secure its future solution. *Developmental Science, 14*(1), 26-33. https://doi.org/10.1111/j.14677687.2010.00950.x

Suddendorf, T., & Redshaw, J. (2013). The development of mental scenario building and episodic foresight. *Annals of the New York Academy of Sciences, 1296*(1), 135-153. https://doi.org/10.1111/nyas.12189

Szpunar, K. K. (2010). Episodic future thought: An emerging concept. *Perspectives on Psychological Science, 5*(2), 142-162. https://doi.org/10.1177/1745691610362350

Szpunar, K. K., Spreng, R. N., & Schacter, D. L. (2014). A taxonomy of prospection: Introducing an organizational framework for future-oriented cognition. *Proceedings of the National Academy of Sciences, 111*(52), 18414-18421. https://doi.org/10.1073/pnas.1417144111

Szpunar, K. K., Spreng, R. N., & Schacter, D. L. (2016). Toward a taxonomy of future thinking. In K. Michaelian, S. B. Klein, & K. K. Szpunar (Eds.), *Seeing the future: Theoretical perspectives on future-oriented mental time travel* (pp. 21-35). Oxford University Press.

Tabachnick, B., & Fidell, L. (2014). *Using multivariate statistics* (6th ed.). Pearson.

Taylor, J. L., Dolhert, N., Friedman, L., Mumenthaler, M., & Yesavage, J. A. (1996). Alcohol elimination and simulator performance of male and female aviators: A preliminary report. *Aviation, Space, and Environmental Medicine, 67*(5), 407-413.

Terrett, G., Horner, K., White, R., Henry, J. D., Kliegel, M., Labuschagne, I., & Rendell, P. G. (2019). The relationship between episodic future thinking and prospective memory in middle childhood: Mechanisms depend on task type. *Journal of Experimental Child Psychology, 178*, 198-213. https://doi.org/10.1016/j.jecp.2018.10.003

Terrett, G., Lyons, A., Henry, J. D., Ryrie, C., Suddendorf, T., & Rendell, P. G. (2016). Acting with the future in mind is impaired in long-term opiate users. *Psychopharmacology, 234*(1), 99-108. https://doi.org/10.1007/s00213-016-4442-3

Terrett, G., McLennan, S. N., Henry, J. D., Biernacki, K., Mercuri, K., Curran, H. V., & Rendell, P. G. (2014). Prospective memory impairment in long-term opiate users. *Psychopharmacology, 231*(13), 2623-2632. https://doi.org/10.1007/s00213-014-3432-6

Terrett, G., Rendell, P. G., Raponi-Saunders, S., Henry, J. D., Bailey, P. E., & Altgassen, M. (2013). Episodic future thinking in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 43*(11), 2558-2568. https://doi.org/10.1007/s10803-013-1806-y

Terrett, G., Rose, N. S., Henry, J. D., Bailey, P. E., Altgassen, M., Phillips, L. H., Kliegel, M., & Rendell, P. G. (2016). The relationship between prospective memory and episodic future thinking in younger and older adulthood. *The Quarterly Journal of Experimental Psychology, 69*(2), 310-323. https://doi.org/10.1080/17470218.2015.1054294

Thomasson, H. R. (2002). Gender differences in alcohol metabolism. *Recent Developments in Alcoholism*, 163-179. https://doi.org/10.1007/0-306-47138-8_9

Tombaugh, T. N., Kozak, J., & Rees, L. (1999). Normative data stratified by age and education for two measures of verbal fluency: FAS and animal naming. *Archives of Clinical Neuropsychology, 14*(2), 167-177. https://doi.org/10.1016/S0887-6177(97)00095-4

Townshend, J., & Duka, T. (2002). Patterns of alcohol drinking in a population of young social drinkers: a comparison of questionnaire and diary measures. *Alcohol and Alcoholism, 37*(2), 187-192. https://doi.org/10.1093/alcalc/37.2.187

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology, 26*(1), 1-12. https://doi.org/10.1037/h0080017

Tulving, E. (2001). Episodic memory and common sense: how far apart? *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 356*(1413), 1505-1515. https://doi.org/10.1098/rstb.2001.0937

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53*(1), 1-25. https://doi.org/10.1146/annurev.psych.53.100901.135114

Tulving, E., Schacter, D. L., McLachlan, D. R., & Moscovitch, M. (1988). Priming of semantic autobiographical knowledge: a case study of retrograde amnesia. *Brain and Cognition, 8*(1), 3-20. https://doi.org/10.1016/0278-2626(88)90035-8

Ünal, G., & Hohenberger, A. (2017). The cognitive bases of the development of past and future episodic cognition in preschoolers. *Journal of Experimental Child Psychology, 162*, 242-258. https://doi.org/10.1016/j.jecp.2017.05.014

Urban, N. B., Kegeles, L. S., Slifstein, M., Xu, X., Martinez, D., Sakr, E., Castillo, F., Moadel, T., O'Malley, S. S., & Krystal, J. H. (2010). Sex differences in striatal dopamine release in young adults after oral alcohol challenge: A positron

emission tomography imaging study with [11C] raclopride. *Biological Psychiatry, 68*(8), 689-696. https://doi.org/10.1016/j.biopsych.2010.06.005

van den Berg, S., Aarts, H., Midden, C., & Verplanken, B. (2004). The role of executive processes in prospective memory tasks. *European Journal of Cognitive Psychology, 16*(4), 511-533. https://doi.org/10.1080/095414400340000240

Van Skike, C. E., Goodlett, C., & Matthews, D. B. (2019). Acute alcohol and cognition: Remembering what it causes us to forget. *Alcohol, 79*, 105-125. https://doi.org/10.1016/j.alcohol.2019.03.006

Volkow, N. D., Wang, G.-J., Franceschi, D., Fowler, J. S., Thanos, P. P. K., Maynard, L., Gatley, S. J., Wong, C., Veech, R. L., & Kunos, G. (2006). Low doses of alcohol substantially decrease glucose metabolism in the human brain. *Neuroimage, 29*(1), 295-301. https://doi.org/10.1016/j.neuroimage.2005.07.004

Vonghia, L., Leggio, L., Ferrulli, A., Bertini, M., Gasbarrini, G., & G, A. (2008). Acute alcohol intoxication. *European Journal of Internal Medicine, 19*(8), 561-567. https://doi.org/10.1016/j.ejim.2007.06.033

Wagner, S., Helmreich, I., Dahmen, N., Lieb, K., & Tadić, A. (2011). Reliability of three alternate forms of the trail making tests A and B. *Archives of Clinical Neuropsychology, 26*(4), 314-321. https://doi.org/10.1093/arclin/acr024

Wallace, G. B. (1932). The pharmacological actions of alcohol. In *Alcohol and man* (pp. 24-65). The MacMillan Company.

Walter, N. T., & Bayen, U. J. (2016). Selective effects of acute alcohol intake on the prospective and retrospective components of a prospective-memory task with emotional targets. *Psychopharmacology, 233*(2), 325-339. https://doi.org/10.1007/s00213-015-4110-z

Wang, L., Kliegel, M., Liu, W., & Yang, Z. (2008). Prospective memory performance in preschoolers: Inhibitory control matters. *European Journal of Developmental Psychology, 5*(3), 289-302. https://doi.org/10.1080/17405620600778161

Weiler, J. A., Suchan, B., & Daum, I. (2010a). Foreseeing the future: occurrence probability of imagined future events modulates hippocampal activation. *Hippocampus, 20*(6), 685-690. https://doi.org/10.1002/hipo.20695

Weiler, J. A., Suchan, B., & Daum, I. (2010b). When the future becomes the past: Differences in brain activation patterns for episodic memory and episodic future thinking. *Behavioural Brain Research, 212*(2), 196-203. https://doi.org/10.1016/j.bbr.2010.04.013

Weissenborn, R., & Duka, T. (2003). Acute alcohol effects on cognitive function in social drinkers: Their relationship to drinking habits. *Psychopharmacology, 165*(3), 306-312. https://doi.org/10.1007/s00213-002-1281-1

West, R., & Bowry, R. (2005). Effects of aging and working memory demands on prospective memory. *Psychophysiology, 42*(6), 698-712. https://doi.org/10.1111/j.1469-8986.2005.00361.x

Wetherill, R. R., & Fromme, K. (2011). Acute alcohol effects on narrative recall and contextual memory: An examination of fragmentary blackouts. *Addictive Behaviors, 36*(8), 886-889. https://doi.org/10.1016/j.addbeh.2011.03.012

White, A. M. (2003). What happened? Alcohol, memory blackouts, and the brain. *Alcohol Research and Health, 27*(2), 186-196.

White, A. M., Matthews, D. B., & Best, P. J. (2000). Ethanol, memory, and hippocampal function: a review of recent findings. *Hippocampus, 10*(1), 88-93. https://doi.org/10.1002/(SICI)1098-1063(2000)10:1<88::AID-HIPO10>3.0.CO;2-L

Wiebels, K., Addis, D. R., Moreau, D., van Mulukom, V., Onderdijk, K. E., & Roberts, R. P. (2020). Relational processing demands and the role of spatial context in the construction of episodic simulations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 1-18. https://doi.org/10.1037/xlm0000831

Wiese, J. G., Shlipak, M. G., & Browner, W. S. (2000). The alcohol hangover. *Annals of Internal Medicine, 132*(11), 897-902. https://doi.org/10.7326/0003-4819-132-11-200006060-00008

Williams, D. M., Jarrold, C., Grainger, C., & Lind, S. E. (2014). Diminished time-based, but undiminished event-based, prospective memory among intellectually high-functioning adults with autism spectrum disorder: relation to working memory ability. *Neuropsychology, 28*(1), 30-42. https://doi.org/10.1037/neu0000008

Williams, J. M., & Broadbent, K. (1986). Autobiographical memory in suicide attempters. *Journal of Abnormal Psychology, 95*(2), 144-149. https://doi.org/10.1037/0021-843X.95.2.144

Williams, J. M. G., Ellis, N. C., Tyers, C., Healy, H., Rose, G., & Macleod, A. K. (1996). The specificity of autobiographical memory and imageability of the future. *Memory and Cognition, 24*(1), 116-125. https://doi.org/10.3758/BF03197278

Zakhari, S. (2006). Overview: how is alcohol metabolized by the body? *Alcohol Research and Health, 29*(4), 245-254. https://doi.org/10.1159/000095013

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica, 67*(6), 361-370. https://doi.org/10.1111/j.1600-0447.1983.tb09716.x

Zimmermann, T. D., & Meier, B. (2006). The rise and decline of prospective memory performance across the lifespan. *Quarterly Journal of Experimental Psychology, 59*(12), 2040-2046. https://doi.org/10.1080/17470210600917835

Zinke, K., Altgassen, M., Mackinlay, R. J., Rizzo, P., Drechsler, R., & Kliegel, M. (2010). Time-based prospective memory performance and time-monitoring in children with ADHD. *Child Neuropsychology, 16*(4), 338-349. https://doi.org/10.1080/09297041003631451

Zöllig, J., Martin, M., & Kliegel, M. (2010). Forming intentions successfully: Differential compensational mechanisms of adolescents and old adults. *Cortex, 46*(4), 575-589. https://doi.org/10.1016/j.cortex.2009.09.010

Zorumski, C. F., Mennerick, S., & Izumi, Y. (2014). Acute and chronic effects of ethanol on learning-related synaptic plasticity. *Alcohol, 48*(1), 1-17. https://doi.org/10.1016/j.alcohol.2013.09.045

Appendices

Appendix A. Recruitment Flyer

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

ARE YOU ARE SOCIAL DRINKER?

This research study may interest you:

Does alcohol effect our ability to plan ahead?

We are looking for people who meet these criteria:

- Aged 18-40 years.
- Social drinker (i.e. you drink 2 or more standard alcoholic drinks each week).
- No history of alcohol or drug dependence.
- Never needed support for alcohol or drug use.
- Not using medication for mental health or sleep.
- No medical condition that requires alcohol abstinence.
- Not pregnant.
- No diagnosis of acquired or traumatic brain injury.
- No history of head injury that has led to hospitalisation.
- No formal psychiatric diagnosis.
- Fluent in English.

What's involved?

One testing session (approx.3hrs) involving:

- A brief interview about your background, alcohol and substance use.
- Drinking either alcoholic or non-alcoholic drinks.
- Having breathalyser tests to monitor your BAC.
- Completing computerised games & thinking tasks.
- Financial reimbursed for your time.

Testing Location:

Australian Catholic University

115 Victoria St, Fitzroy.

For further information:

Phone our dedicated research number: **0448 671 676**

Email: **morgan.elliott@myacu.edu.au**

This research has been approved by the Australian Catholic University Human Research Ethics Committee (HREC 2018-122H).

Appendix B. Recruitment Script

PARTICIPANT RECRUITMENT TELEPHONE SCRIPT

"Hi, this is ……. from the Australian Catholic University, Cognition and Emotion Research Lab. Thank you for your interest in my research study."

"Firstly, I would like to make sure that you meet the inclusion criteria and then I will give you some more information about the study. If you are still interested in participating, we can arrange a mutual time for the testing session."

"To participate in this study, I have some questions I need to ask. Is that okay?"

- Are you over the age of 18?
- Do you consume between 2 to 25 units of alcohol per week (women) or between 2 to 36 units of alcohol per week (men) and are familiar with the effects of alcohol?
- Can you ensure you are abstinent from alcohol and other drugs for at least 24 hours prior to the testing session?
- Are you pregnant?
- Do you have a diagnosed mental health or psychiatric condition (such as depression or anxiety disorder; bi-polar disorders or borderline personality disorder)?"
- Are you currently taking any prescription medications for mental health or sleep issues, such as anti-psychotics, anti-depressants, anti-anxiety or sleeping medications?
- Do you have a diagnosis of acquired or traumatic brain injury?
- Have you ever had a diagnosis of alcohol dependence or other substance dependence?
- Have you ever sought support services or attended a rehabilitation program or service for alcohol or other substance use?
- Do you have any medical conditions such as diabetes that requires you to eat regularly? (**Note: i**f participant answers 'yes' to this question advise them to follow their usual eating regime).

- Do you have a medical condition and/or are you taking medication that requires alcohol abstinence?

If inclusion criteria are **not** met.

"Unfortunately, we have a particular set of inclusion criteria for this study which does not allow everyone to participate. Thank you for your time. We appreciate your call."

If inclusion criteria **are** met, continue.

"Great. To give you some more information about the study…"

Study description:

"The study will involve one testing session, at the ACU Melbourne Campus, at a mutually convenient date/time for you and the researcher. It is advised that you do not drive to the testing session given you may be consuming alcohol, and so you will need to make alternative transport arrangements to get you to and from your testing session (eg. get picked up by a friend or take public transport). You must agree that you will not use any recreational drug/s or drink any alcohol for 24 hours prior to the testing session. This will be confirmed with an alcohol breath test prior to the session. We also ask that you avoid eating a heavy meal for at least two hours prior to the session, and that if you do need to eat anything in the two hours leading up to your booked session, that you eat only light non-fatty food, such as fruit/vegetable snacks, unless you have a medical condition, such as diabetes, that requires you to eat regularly (in which case you should follow your usual eating regime).

At the start of the session you will be asked some background questions about yourself and your past and present alcohol consumption and use of any other substances. You will be weighed on a set of digital scales (without shoes on) so that we can determine the appropriate dose of alcohol to give you. You will then be given 10 small drinks containing either alcohol or a non-alcoholic drink to consume over a 30-

minute time interval. The alcoholic drink will be diluted with tonic water and lime cordial. The non-alcoholic drink will also contain tonic water and lime cordial but will contain no alcohol. You will receive either the non-alcoholic or the alcoholic drink throughout the entire session. Neither you nor the researcher will know which drink you will receive on the day.

After you have consumed the drinks, you will complete two computerised tasks; some short questionnaires about your general mental health and cognitive function; and an interview-type task to assess future thinking ability which will be audio-taped for scoring. Most people find these tasks quite straight forward to do.

Throughout the session, you will also be asked to complete multiple alcohol breath tests to assess your Blood Alcohol Concentration (BAC) level. You will be given top ups drinks during the session to maintain a stable BAC of 0.05%. At the end of the session, you will be required to remain in the test lab with the researcher until you have a BAC reading below 0.05.

As you may be consuming alcohol, all participants are advised not to drive upon leaving the session and pre-arrange alternate transport (e.g. get driven by a friend/family; take public transport or taxi/uber). This is important as drink driving in Australia is a federal offence. Drivers caught with a Blood Alcohol Concentration of 0.05% risk facing fines and loss of licence and those with a Learners Permit, Probationary Licence or Z conditioned licence must have a zero BAC or face the same penalty.

As part of the consent process of the study, you will be asked to sign a consent form, and on that form, you will notice a section that asks you to indicate whether you have a Learners, Probationary or z-conditioned licence. You only need to tick yes or no to that question; the form does not ask you to specify which one of those licence types

you have. If you tick yes, at the start of your booked session, you will be required to indicate and sign off on the non-driving transport arrangements you have made for leaving the session. At the end of the session, the researcher will reconfirm these arrangements with you and can assist you with your arrangements for example, calling you a taxi, checking you have your myki card or waiting with you for your accompanying friend/family member.

The session will take approximately two and half to three hours to complete. As compensation for your time, you will receive a $60 Coles/Myer Voucher. Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate and have signed the consent form, you can still withdraw from the study at any time without adverse consequences."

"Do you have any questions?"

"Are you interested in participating in this study?"

If no. "Thank you for your time."

If yes, continue.

"Great, I will need to email or post you a copy of the information and consent form. Once you receive these you will need to read them, and then sign both copies of the consent form, keeping one copy for yourself and bringing the other copy to me on the day of the session. Once you give me the consent form, we can start the session. Do you have an email address and a printer so I can send these to you to print, read and sign?

If no. "No problem, I can send them to you in the post. What is your postal address?"

Are you happy to book in a suitable time for the session now?"

Confirm session time, day and location.

“I will send you a text message the day prior to the session to give you a friendly reminder of your booking. Is the mobile number I called you on today, the best number to send it to? “

“Thank you for your time. Have a nice day.”

Appendix C. Background Questionnaire

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

Background Information Questionnaire

Administered in Interview Format

(Introductory Page for Empirical Studies - Social Drinkers)

Before you participate in this study, could you please answer the following questions:

1.	Are you over the age of 18 years old?	Yes	No
2.	Do you consume between 2 and 14 units of alcohol on average per week?	Yes	No
3.	Do you have a history of alcohol or drug dependence?	Yes	No
4.	Do you have a history of head injury that led to hospitalisation?	Yes	No
5.	Have you ever had a formal diagnosis of Traumatic Brain Injury (TBI) or Acquired Brain injury (ABI)?	Yes	No
6.	Have you used alcohol or any other illicit drug within the last 24 hours?	Yes	No
7.	Is English your first language?	Yes	No

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

Date: ____/____/_____ ID: _____

Section 1: Demographics

Age: _____ years **Date of Birth:** ____/____/_____

Gender (*please circle*): Male Female Other (please specify)_____

Relationship Status (tick one)**:**

- ○ Married
- ○ Living together/defacto
- ○ Partnered but not living together
- ○ Separated/divorced
- ○ Single

Employment Status:

- ○ Full-time
- ○ Part-time
- ○ Casual
- ○ Unemployed

Highest level of education completed:

- ○ Up to Year 10
- ○ Up to Year 12
- ○ TAFE
- ○ Undergraduate degree
- ○ Postgraduate degree
- ○ Other, please specify:_____

Section 2: English Language Skills

Is English your first language: Yes ____ No ____ If NO, how many years have you spoken English? _____ years

How do you rate your level of spoken English?

1. Poor
2. Not very good
3. Very good
4. Excellent

Section 3: Health

Using the following as a guide please answer the questions below. Please circle the answer that best describes you.

Excellent: No problems

Very good: No major problems

Good: Occasional bad days

Not very good: A number of problems

Poor: Persistent serious problems

How would you describe your state of health over the last month or so?

4. Excellent 3. Very good 2. Good 1. Not very good

How would you describe your state of health today?

4. Excellent 3. Very good 2. Good 1. Not very good

How would you describe how you have been sleeping over the last few weeks?

4. Excellent 3. Very good 2. Good 1. Not very good

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

Section 4: Psychiatric History

Are you aware of any formal psychiatric diagnoses? Yes No
If **YES**, please specify:

_____
_____
_____
_____
_____
_____
_____
_____
_____

Section 5a: Substance use

The following section asks about current and past use of alcohol and drugs. For each drug please indicate whether you are a ***current user, have used in the past,*** **or** ***have never used*** the substance.

If you are a **current user** or **have used this substance in the past** you will be asked to indicate:

- Your age when you first used it
- Your age when you started using it regularly (if applicable)
- How many days do you use this drug in a typical week?
- How long you have used the drug for? years/ months
- Your age when you stopped using the drug (if applicable- years/ months)

For any substance that you have never used, please tick NEVER, and continue to the next drug. If you have **never used any type of drugs including prescription medication** you do not have to complete this section.

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

Alcohol

Have you ever used alcohol? Yes No

Do you currently use alcohol? Yes No

Have you previously used alcohol? Yes No

How old were you when you first used alcohol: ____ years

How old were you when you started using alcohol regularly: ____ years

How long have you used alcohol for: ____ years ____ months

How much alcohol do you drink in a typical session: ____ drinks

How often do you drink alcohol: ____ days/ week ____ days/ month ____ other

When did you stop using alcohol: ____ years ____ months

When did you last drink alcohol? _____

Cigarettes

Have you ever smoked a cigarette? Yes No

Do you currently smoke cigarettes? Yes No

Have you previously smoked cigarettes? Yes No

How old were you when you first smoked cigarettes: ____ years

How old were you when you started using cigarettes regularly: ____ years

How long have you smoked cigarettes for: ____ years ____ months

How many cigarettes do you smoke in a typical day: ____ cigarettes

How often do you smoke cigarettes: ____ days/ week ____ days/ month ____ other

When did you stop using cigarettes: ____ years ____ months

When did you last smoke a cigarette? _____

Cannabis

Have you ever used cannabis? Yes No

Do you currently use cannabis? Yes No

Have you previously used cannabis? Yes No

How old were you when you first used cannabis: ____ years

How old were you when you started using cannabis regularly: ____ years

How long have you used cannabis for: ____ years ____ months

How much cannabis do you use in a typical session: ____ cigarettes

How often do you use cannabis: ____ days/ week ____ days/ month ____ other

When did you stop using cannabis: ____ years ____ months

When did you last use cannabis? _____

Amphetamines (e.g. speed, ecstasy, ice, MDMA)

Please specify _____

Have you ever used amphetamines? Yes No

Do you currently use amphetamines? Yes No

Have you previously used amphetamines? Yes No

How old were you when you first used amphetamines: ____ years

How old were you when you started using amphetamines regularly: ____ years

How long have you used amphetamines for: ____ years ____ months

How many pills would you use in a typical session: ____ pills

How often do you use amphetamines: ____ days/ week ____ days/ month ____ other

When did you stop using amphetamines: ____ years ____ months

When did you last use amphetamines? _____

Heroin

Have you ever used heroin Yes No

Do you currently use heroin? Yes No

Have you previously used heroin? Yes No

How old were you when you first used heroin: ____ years

How old were you when you started using heroin regularly: ____ years

How long have you used heroin for: ____ years ____ months

How many hits would you have in a typical session: ____ hits

How often do you use heroin: ____ days/ week ____ days/ month ____ other

When did you stop using heroin: ____ years ____ months

When did you last use heroin? _____

Cocaine

Have you ever used cocaine? Yes No

Do you currently use cocaine? Yes No

Have you previously used cocaine? Yes No

How old were you when you first used cocaine: ____ years

How old were you when you started using cocaine regularly: ____ years

How long have you used cocaine for: ____ years ____ months

How many lines would you use in a typical session: ____ lines

How often do you use cocaine: ____ days/ week ____ days/ month ____ other

When did you stop using cocaine: ____ years ____ months

When did you last use cocaine? _____

Cognition & Emotion
Research Centre

Psychedelic drugs (e.g. LSD/ Acid)

Please specify _____

Have you ever used psychedelic drugs? Yes No

Do you currently use psychedelic drugs? Yes No

Have you previously used psychedelic drugs? Yes No

How old were you when you first used psychedelic drugs: ____ years

How old were you when you started using psychedelic drugs regularly: ____ years

How long have you used psychedelic drugs for: ____ years ____ months

How many tabs would you use in a typical session: ____ tabs

How often do you use psychedelic drugs: ____ days/ week ____ days/ month ____ other

When did you stop using psychedelic drugs: ____ years ____ months

When did you last use psychedelic drugs? _____

Prescription medications

Please specify _____

Have you ever used prescription medication? Yes No

Do you currently use prescription medication? Yes No

Have you previously used prescription medication? Yes No

How old were you when you first used prescription medication: ____ years

How long have you used prescription medication for: ____ years ____ months

When did you stop using prescription medication: ____ years ____ months

When did you last use prescription medication? _____

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

Section 5b: Substance use

Is there any other drug/s you have used that have not already been specified?

Other drug _____

Do you currently use this drug? Yes No

Have you previously used this drug? Yes No

How old were you when you first used this drug: ____ years

How old were you when you started using this drug regularly: ____ years

How long have you used this drug for: ____ years ____ months

How much of this drug would you use in a typical session: ____ pills

How often do you use this drug: ____ days/ week ____ days/ month ____ other

When did you stop using this drug: ____ years ____ months

When did you last use this drug? _____

Appendix D. Visual Analogue Scales

Date: ___/___/___ ID:_____

VISUAL ANALOGUE SCALES

For each item, please circle the number that describe how you feel **RIGHT NOW**

Alert

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Anxious

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Mentally impaired

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Tipsy

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Want to drink alcohol

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Want to see friends

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Feel effect of alcohol

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Like the alcohol effect

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

ID:_____

Energized

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Excited

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Sedated

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Slow thoughts

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Sluggish

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Up

Not at all	0	1	2	3	4	5	6	7	8	9	10	Extremely

Appendix E. Study Ethics Approval Email

2018-122H Ethics application approved!

Kylie Pashley <Kylie.Pashley@acu.edu.au>
on behalf of
Res Ethics <Res.Ethics@acu.edu.au>
Fri 6/07/2018 10:43 AM

To: Gill Terrett <Gill.Terrett@acu.edu.au>; Natalie De Bono <Natalie.DeBono@acu.edu.au>; Morgan Elliott <morgan.elliott3@myacu.edu.au>
Cc: Res Ethics <Res.Ethics@acu.edu.au>

Dear Applicant,

Principal Investigator: Assoc. Prof. Gill Terrett
Student Researcher: Morgan Elliott (Doctoral Student)
Ethics Register Number: 2018-122H
Project Title: Future-Oriented Cognition in the context of Acute and Dependent Alcohol Use.
Date Approved: 06/07/2018
Ethics Clearance End Date: 31/12/2020

This is to certify that the above application has been reviewed by the Australian Catholic University Human Research Ethics Committee (ACU HREC). The application has been approved for the period given above.

Researchers are responsible for ensuring that all conditions of approval are adhered to, that they seek prior approval for any modifications and that they notify the HREC of any incidents or unexpected issues impacting on participants that arise in the course of their research. Researchers are also responsible for ensuring that they adhere to the requirements of the National Statement on Ethical Conduct in Human Research, the Australian Code for the Responsible Conduct of Research and the University's Code of Conduct.

Any queries relating to this application should be directed to the Ethics Secretariat (res.ethics@acu.edu.au). It is helpful if quote your ethics approval number in all communications with us.

If you require a formal approval certificate in addition to this email, please respond via reply email and one will be issued.

We wish you every success with your research.

Kind regards,

Kylie Pashley
on behalf of ACU HREC Chair, Assoc Prof. Michael Baker

Senior Research Ethics Officer | Office of the Deputy Vice Chancellor (Research)
Australian Catholic University
T: +61 2 9739 2646 E: res.ethics@acu.edu.au

THIS IS AN AUTOMATICALLY GENERATED RESEARCHMASTER EMAIL

Appendix F. Information Letter

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

PARTICIPANT INFORMATION LETTER

PROJECT TITLE: Does alcohol affect future-oriented thinking *(Study 1)*
APPLICATION NUMBER: (2018-122H)
PRINCIPAL INVESTIGATOR: Associate Professor Gill Terrett
CO-INVESTIGATOR: Professor Peter Rendell
STUDENT RESEARCHER: Morgan Elliott
STUDENT'S DEGREE: Research Higher Degree, Doctor of Philosophy (PhD)

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?
This research project aims to increase our understanding of how alcohol affects people's memory and future thinking processes. This study is a controlled laboratory study of alcohol.

Who is undertaking the project?
This project is being conducted by Morgan Elliott and researchers from the Cognitive and Emotion Research Centre, and will form the basis of Morgan's higher research degree (Doctor of Philosophy (PhD) at the Australian Catholic University, Melbourne. Morgan will undertake this research under the supervision of Associate Professor Gill Terrett, who is an expert in the field of future thinking and cognitive processes in clinical and healthy populations and Professor Peter Rendell, Director of the CERC and internationally recognised researcher in the field of Prospective Memory. This research study follows well-established procedures published by Professor Valerie Curran, an internationally renowned researcher in psychopharmacology, and a Professorial Research Fellow at the CERC who will also be advising on this project.

Are there any risks associated with participating in this project?
Part of the selection criteria to participate in this study is that you must be 18 years or older, and have previous experience as a social drinker of alcohol. You must therefore be the Australian legal age to drink alcohol and be familiar with and/or aware of the side effects of alcohol such as 'tipsy' feelings, drowsiness, nausea, unsteadiness and headache. No risks are expected from the administration of alcohol, as the dose administered will be a similar quantity to that typically consumed socially. If you feel any adverse effects during the study, please inform the researcher.

At the end of the testing session, once you have completed all tasks, you will be asked to complete an alcohol breath test. For your safety, the researcher will ask you to stay in the testing room until your blood alcohol level has dropped below the Australian legal driving alcohol limit of 0.05 Blood Alcohol Concentration (BAC). We advise that you do not drive to and from the session and arrange alternate transport.

What will I be asked to do?

- The study will involve one testing session, at the ACU Melbourne Campus, at a mutually convenient date/time for you and the researcher.
- You will be asked not use any recreational drug/s or drink any alcohol for 24 hours prior to the testing session. This will be confirmed with an alcohol breath test at the start of this session.
- You need to agree that you will not eat a heavy meal for at least two hours prior to the session, and that if you do need to eat anything in the two hours leading up to your booked session, that you will eat only light (non-fatty) food (such as fruit/vegetables snacks), unless you have a medical condition, such as diabetes, that requires you to eat regularly (in which case you should follow your usual eating regime).
- At the start of the session you will be asked to remove your shoes and if applicable, heavy jacket/coat so that you can be weighed on a set of digital scales. This is so we can determine the dosage of your drinks.
- You will then be asked some background questions about yourself and your past and present alcohol consumption and use of any other substances.
- Over a 30 minute time interval, you will be given 10 small drinks containing alcohol or an inactive non-alcoholic drink to consume. The alcoholic drink will be diluted with tonic water and lime cordial. The inactive drink will also contain tonic water and lime cordial, but will contain no alcohol. You will receive either the inactive (non-alcoholic) or the alcoholic drink throughout the session. Neither you nor the researcher will know which drink you will receive on the day.
- After you have consumed the drinks, you will complete two computerised memory and future thinking tasks. These two tasks have a board game format which people generally find engaging to do. You will also complete some short questionnaires about your general mental health and cognitive function; and an interview-type task to assess future thinking ability which will be audio-taped for scoring. Most people find these tasks quite straight forward to do.
- Throughout the session, you will also be asked to complete multiple alcohol breath tests to assess your blood alcohol concentration (BAC) level. You will also be given top up drinks during the session to maintain a stable BAC of 0.05%.
- At the end of the session, you will complete another breathalyser test, and will be asked to stay in the test lab with the researcher until you have a Blood Alcohol Concentration (BAC) reading below 0.05. (Additional breath tests will be administered if necessary).
- Given you may be consuming alcohol during the session, all participants are advised not to drive upon leaving the session and to pre-arrange alternate transport (e.g. get driven by a friend/family; take public transport or taxi).

  NB: Drink driving in Australia is a federal offence and drivers caught with a Blood Alcohol Concentration (BAC) of 0.05% or over, risk facing fines and loss of licence. Drivers with a Learner Permit (L Plate), Probationary (P Plate) or Z Conditioned Driver Licence have further restrictions, requiring a zero BAC or face the same penalty.
- As part of your agreement to participant in this study, you will be required to indicate on the consent form whether you currently hold a valid Learner Driver Permit, Probationary Driver Licence or Z Conditioned Driver Licence (a yes/no response is only required – you do not have to specify which type). If you do have one of these licence types, on the day of the session, you will be required to document and sign off, on the non-driving transport

arrangements you have made to use upon leaving the session. At the end of the session, the researcher will reconfirm this with you, and will assist you with your travel arrangements (e.g. call you a taxi; check you have your myki card, or wait with you for your accompanying family/friend).

How much time will the project take?
You will participate in one testing session which will take approximately two and half to three hours to complete. As compensation for your time, you will receive a $60 Coles/Myer Voucher.

What are the benefits of the research project?
There are no direct benefits to you by participating in this study however you will have contributed to our understanding of the effects of alcohol on cognition.

Can I withdraw from the study?
Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate and have signed the consent form you can still withdraw from the study at any time without adverse consequences. Unless otherwise requested by you, data collected prior to you withdrawing, will be included in the group dataset for aggregated data analysis. If you withdraw after the completion of data analysis your data will be retained within the dataset.

Will anyone else know the results of the project?
To maintain confidentiality your data from this study will be stored electronically using a numeric code so that your information cannot be personally identified. Only researchers directly involved in the study will have access to the data. The background questionnaire includes questions regarding use of substances other than alcohol, some of which are unlawful. This information is collected for the purposes of describing sample characteristics. Given illicit substance use is unlawful, the researchers cannot guarantee that a third party could not use some legal process to gain access to the data. All hardcopy and electronic data will be securely stored with restricted access at the ACU, Melbourne Campus and consent forms will be stored separately from data files. Only results of group (aggregated) data will be reported and may be published in refereed psychological or medical journals and presented at research conferences. No individual data will be reported or published.

Will I be able to find out the results of the project?
If you are interested in finding out the results of the study, please tick the relevant box on your consent form. You will then receive a summary of the outcomes at the end of the study.

Who do I contact if I have questions about the project?

If you have any questions or concerns regarding this project, before or after participating, please contact the researcher, Morgan Elliott via email: morgan.elliott@myacu.edu.au or telephone our dedicated research line, 0448671676. If leaving a voice message, please provide your name, telephone number and/or email address and a convenient time to return your call. Alternatively, you can contact the Principal Supervisor, Associate Professor Gill Terrett on 03 9953 3121, in the School of Psychology at the Australian Catholic University, to discuss your participation or the project in general.

What if I have a complaint or any concerns?

The study has been reviewed by the Human Research Ethics Committee at Australian Catholic University (review number 2018-122H). If you have any complaints or concerns about the conduct of the project, you may write to the Manager of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Manager, Ethics
c/o Office of the Deputy Vice Chancellor (Research)
Australian Catholic University
North Sydney Campus
PO Box 968
NORTH SYDNEY, NSW 2059
Ph.: 02 9739 2519
Fax: 02 9739 2870
Email: resethics.manager@acu.edu.au

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

I want to participate! How do I sign up?

If you are willing to participate please sign the attached informed consent form. You should sign both copies of the consent form and retain one copy for your records and then contact me on our dedicated research phone on 0448671676 or email me at morgan.elliott@myacu.edu.au to book a session. You will need to bring the researcher's copy of the signed consent form to the session before we can start.

Your support for the research project will be most appreciated.

Yours sincerely,

Gill Terrett & Peter Rendell
Principal and Co-Investigators
Cognition and Emotion Research Centre
School of Psychology
Australian Catholic University
115 Victoria Pde, Fitzroy, VIC, 3065
E: gill.terrett@acu.edu.au

Morgan Elliott
Provisional Psychologist
Student Researcher
MPsych/PhD (Clinical) Candidate
Australian Catholic University
115 Victoria Pde, Fitzroy, VIC, 3065
E: morgan.elliott@acu.edu.au

Appendix G. Consent Forms

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

CONSENT FORM

Copy for Researcher

TITLE OF PROJECT: **Does alcohol affect future-oriented thinking?** *(Study 1)*

APPLICATION NUMBER: (2018-122H)

(NAME OF) PRINCIPAL INVESTIGATOR (or SUPERVISOR): Associate Professor Gill Terrett

(NAME OF) CO-INVESTIGATOR (or SUPERVISOR): Professor Peter Rendell

(NAME OF) STUDENT RESEARCHER (if applicable): Morgan Elliott

I ..... *(the participant)* have read (*or, where appropriate, have had read to me)* and understood the information provided in the Letter to Participants. Any questions I have asked have been answered to my satisfaction.

I agree to participate in the activities as outlined in the information letter that involve participating in a testing session at ACU, which may take up to 3 hours to complete. I understand that the session will involve: questions about my background, past and present alcohol consumption and use of any other substances; being weighed on a set of digital scales; completing two computerised tasks, some short questionnaires about my general mental health and cognitive function, and an interview-type task to assess future thinking which will be audio-taped for scoring.

Additionally, I understand that the study will involve two groups: a control group and an experimental group. During the experimental session, the control group will consume a non-alcoholic drink – containing tonic water and lime cordial, whilst the experimental group will consume an active drink – containing tonic water, lime cordial and measured amounts of alcohol. I understand that I will be randomly allocated to one of these two groups and that neither I nor the researcher will know which group I have been allocated to. Given this study involves the consumption of alcohol, I have been advised by the researchers not to drive to or from the session and agree to make alternate transport arrangements.

Section A (TO BE COMPLETED BY ALL PARITICPANTS)

Do you currently hold a valid Learners Driving Permit, Probationary Driver Licence or Z-Conditioned Driver Licence?

☐ YES ☐ NO *(Please proceed to Section C, page 2 of this form)*

Section B (TO BE COMPLETED BY ALL PARTICIPANTS WHO TICKED YES TO SECTION A ABOVE)

As a holder of any of the above permit/licence types, I understand that I require a blood alcohol concentration of 0.00% to legally drive a vehicle in Australia. I have therefore made one of the following non-driving travel arrangements to use upon leaving the research session as indicated below:

☐	Accompanying adult	☐	Taxi/Uber	☐	Public Transport
☐	Other, please specify:				

To be completed on the day of the session (before testing commences):

I, _____ confirm that I have made the above documented non-driving arrangements to use upon leaving the research session today?

Participant's Signature:		Date:
Participant's Name (Print):		
Researcher's Signature (witness):		Date:

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

SECTION C (TO BE COMPLETED BY ALL PARTICIPANTS)

I realise that I can withdraw my consent at any time (without adverse consequences). I agree that research data collected for the study may be published or may be provided to other researchers in a form that does not identify me in any way.

NAME OF PARTICIPANT:.....

SIGNATURE: ..... DATE: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR (or SUPERVISOR):..... DATE: .....

SIGNATURE OF STUDENT RESEARCHER:..... DATE: .....

Would you like to hear about the outcomes of this study?	*Please tick:*	Yes		No	
Are you interested in hearing about future research projects conducted by the Cognition and Emotion Research Centre at ACU?	*Please tick:*	Yes		No	
If you have ticked YES to either of the above, please provide your contact details below: Email:					
Phone:					
Date of birth:					
Handedness (left, right, ambidextrous):					

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

CONSENT FORM

Copy for Participant

TITLE OF PROJECT: **Does alcohol affect future-oriented thinking?** *(Study 1)*

APPLICATION NUMBER: (2018-122H)

(NAME OF) PRINCIPAL INVESTIGATOR (or SUPERVISOR): Associate Professor Gill Terrett

(NAME OF) CO-INVESTIGATOR (or SUPERVISOR): Professor Peter Rendell

(NAME OF) STUDENT RESEARCHER (if applicable): Morgan Elliott

I ..... *(the participant)* have read (*or, where appropriate, have had read to me)* and understood the information provided in the Letter to Participants. Any questions I have asked have been answered to my satisfaction.

I agree to participate in the activities as outlined in the information letter that involve participating in a testing session at ACU, which may take up to 3 hours to complete. I understand that the session will involve: questions about my background, past and present alcohol consumption and use of any other substances; being weighed on a set of digital scales; completing two computerised tasks, some short questionnaires about my general mental health and cognitive function, and an interview-type task to assess future thinking which will be audio-taped for scoring.

Additionally, I understand that the study will involve two groups: a control group and an experimental group. During the experimental session, the control group will consume a non-alcoholic drink – containing tonic water and lime cordial, whilst the experimental group will consume an active drink – containing tonic water, lime cordial and measured amounts of alcohol. I understand that I will be randomly allocated to one of these two groups and that neither I nor the researcher will know which group I have been allocated to. Given this study involves the consumption of alcohol, I have been advised by the researchers not to drive to or from the session and agree to make alternate transport arrangements.

Section A: (TO BE COMPLETED BY ALL PARITICPANTS)

Do you currently hold a valid Learners Driving Permit, Probationary Driver Licence or Z-Conditioned Driver Licence?

☐ YES ☐ NO *(Please proceed to Section C, page 2 of this form)*

Section B: (TO BE COMPLETED BY ALL PARTICIPANTS WHO TICKED YES TO SECTION A ABOVE)

As a holder of any of the above permit/licence types, I understand that I require a blood alcohol concentration of 0.00% to legally drive a vehicle in Australia. I have therefore made one of the following non-driving travel arrangements to use upon leaving the research session as indicated below:

☐	Accompanying adult	☐	Taxi/Uber	☐	Public Transport
☐	Other, please specify:				

To be completed on the day of the session (before testing commences):

I, _____ confirm that I have made the above documented non-driving arrangements to use upon leaving the research session today?

Participant's Signature:		Date:
Participant's Name (Print):		
Researcher's Signature (witness):		Date:

Cognition & Emotion Research Centre

ACU AUSTRALIAN CATHOLIC UNIVERSITY

SECTION C (TO BE COMPLETED BY ALL PARTICIPANTS)

I realise that I can withdraw my consent at any time (without adverse consequences). I agree that research data collected for the study may be published or may be provided to other researchers in a form that does not identify me in any way.

NAME OF PARTICIPANT:.....

SIGNATURE: ..... DATE: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR (or SUPERVISOR):..... DATE: .....

SIGNATURE OF STUDENT RESEARCHER:.....DATE: .....

Would you like to hear about the outcomes of this study?	*Please tick:*	Yes		No	
Are you interested in hearing about future research projects conducted by the Cognition and Emotion Research Centre at ACU?	*Please tick:*	Yes		No	
If you have ticked YES to either of the above, please provide your contact details below: Email:					
Phone:					
Date of birth:					
Handedness (left, right, ambidextrous):					

Appendix H. Study 2 Analysis for Items Used (Unconditionalized)

A mixed 2 × 2 × 2 ANOVA was conducted with the between-subjects factors of assigned *treatment condition* (alcohol, placebo) and *sex* (males, females), and within-subjects factor of *foresight task* (items acquired, items used). For this analysis, the number of items acquired was expressed as a proportion of the total of the seven items that it was possible to acquire. Similarly, the total number of items used was expressed as a proportion of the total of seven items it was possible to use (i.e. not first conditionalized on number of items acquired).

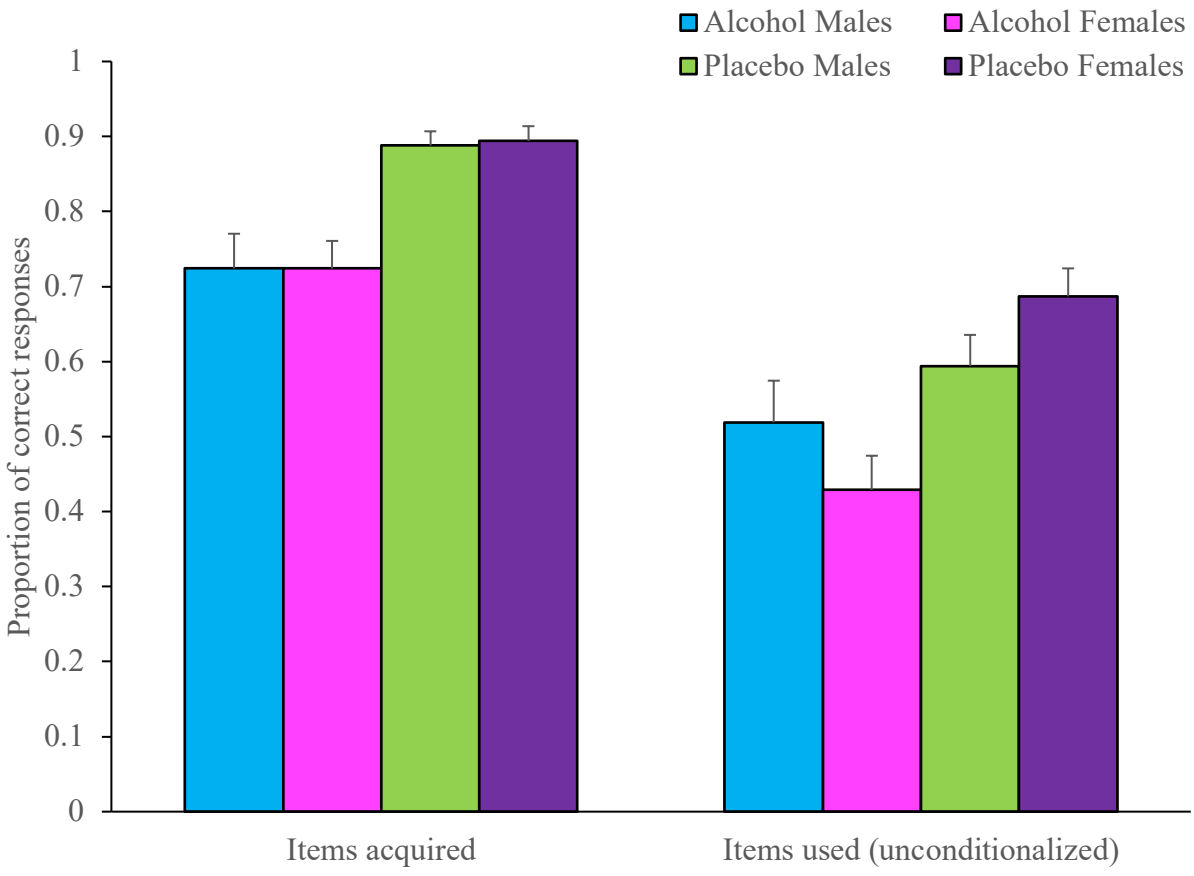
The results revealed a significant three-way interaction between condition, sex and foresight task, F (1, 120) = 4.93, p = .03, η^2_p = .04, for which the descriptive statistics are shown in Figure 1. This three-way interaction was further investigated with two separate two-way ANOVAs, conducted separately for items acquired and items used, with the between-subjects factors of assigned *treatment condition* (alcohol, placebo) and *sex* (males, females). For items acquired, sex was not an interaction effect, F (1, 120) < 0.01 p = .93, η^2_p < .01, nor a main effect F (1, 120) < 0.01 p = .93, η^2_p < .01, however, there was a main effect of condition, F (1, 120) = 27.04, p < .001, η^2_p = .18. This main effect revealed that participants in the alcohol condition (M = 0.7, SD = 0.1) acquired significantly fewer items than participants in the placebo condition (M = 0.9, SD = 0.1).

For items used, the results revealed a two-way interaction between condition and sex, F (1, 120) = 4.12, p = .05, η^2_p = .03, and a main effect of condition, F (1, 120) = 13.56, p < .001, η^2_p = .10, while sex was not a main effect, F (1, 120) < 0.01, p = .98, η^2_p < .01. The interaction (shown in Figure 1) was analysed with tests of simple effects, firstly analysing the effect of condition within males and females separately. The results revealed a large simple main effect of condition for females, F (1, 120) = 16.3, p < .001,

η^2_p = .12, but not for males, F (1, 120) = 1.37, p = .25, η^2_p = .01, with females in the alcohol condition using significantly fewer items than females in the placebo condition, but males' use of items was not significantly impaired by alcohol. Further tests of simple effects analysing the effect of sex within each condition revealed no simple effects of sex for the alcohol condition, F (1,120) = 1.97, p = .16, η^2_p = .02, or the placebo condition, F (1,120) = 2.15, p = .15, η^2_p = .02. Figure 1 shows the sex interaction with item use, and the absence of this sex interaction for item acquisition.

Figure 1

Performance on VW-Foresight as a Function of Condition (Alcohol, Placebo) and Sex (Males, Females). Items Acquired and Items Used (Unconditionalised) are Both Expressed as a Proportion of Seven Possible Items. Error Bars Represent One Standard Error.



Appendix I. Study 2 Correlation Analyses for Item Use (Unconditionalized)

Table 1

Correlations Between Item Use (Unconditionalized) and Measures of FSIQ, Executive Function, Retrospective Memory, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	Item use (unconditionalized)	
	Alcohol condition *n* = 61	Placebo condition *n* = 63
FSIQ	.30*	.03
Executive functions		
Cognitive initiation	.23	-.04
Inhibitory control	.28*	.18
Cognitive flexibility	-.29*	-.06
Retrospective memory		
Immediate recall	.25*	-.02
Delayed recall	.25	-.03
Episodic future thinking	.20	-.04

* $p < 0.05$

Appendix J. Study 2 Hierarchical Regression Analyses for Item Use (Unconditionalized)

Table 1

Hierarchical Multiple Regression Analyses Predicting Item Use (Unconditionalized) from FSIQ, Retrospective Memory, Executive Functions, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	Item use (unconditionalised)					
	Alcohol condition n = 61			Placebo condition n = 63		
Predictor	ΔR^2	B (SE)	β	ΔR^2	B (SE)	β
Step 1	.09*			<.01		
FSIQ		.02 (.01)	.30*		.00 (.01)	.03
Step 2	.13*			.05		
FSIQ		.02 (.01)	.31*		.00 (.01)	.07
Immediate recall		.02 (.01)	.31		.00 (.01)	.03
Delayed recall		-.03 (.03)	-.24		-.01 (.03)	-.09
Inhibitory control		.06 (.04)	.22		.06 (.04)	.23
Cognitive flexibility		-.00 (.00)	-.12		-.00 (.00)	-.06
Cognitive initiation		.00 (.00)	.08		-.00 (.00)	-.16
Step 3	.01*			<.01		
FSIQ		.02 (.01)	.32*		.00 (.01)	.08
Immediate recall		.02 (.01)	.27		.00 (.01)	.04
Delayed recall		-.03 (.03)	-.21		-.01 (.03)	-.10
Inhibitory control		.06 (.04)	.20		.06 (.04)	.23
Cognitive flexibility		-.00 (.00)	-.11		-.00 (.00)	-.05
Cognitive initiation		.00 (.00)	.08		-.00 (.00)	-.16
EFT		.00 (.00)	.10		-.00 (.00)	-.02
Total R^2	.23*			.06		

* $p < 0.05$

Appendix K. Study 3 Pairwise Comparisons Between PM Tasks

Table 1

Pairwise Comparisons Between PM Tasks Separately for Alcohol and Placebo Conditions

		Alcohol condition n = 61			Placebo condition n = 63		
		Mean difference	p	*d*	Mean difference	p	*d*
Regular event	Regular time	.27	.00	0.86	.16	.00	0.63
	Irregular event	.06	.11	0.20	.02	.55	0.12
	Irregular time	.32	.00	1.09	.40	.00	1.65
	Time check	.23	.00	0.73	.10	.02	0.42
Regular time	Irregular event	.21	.00	0.70	.14	.00	0.53
	Irregular time	.06	.18	0.20	.24	.00	0.83
	Time check	.03	.43	0.11	.06	.15	0.20
Irregular event	Irregular time	.26	.00	0.92	.38	.00	1.53
	Time check	.17	.00	0.56	.08	.06	0.31
Irregular time	Time check	.09	.05	0.30	.30	.00	1.06

Appendix L. Study 3 Full Correlations Table

Table 1

Correlations between Event-Based, Time-Based, and Time-Check PM Scores and Measures of FSIQ, Retrospective Memory, Executive Function, and Episodic Future Thinking, Separately for the Alcohol and Placebo Conditions

	EBT	TBT	TCT	FSIQ	IR	DR	CI	IC	CF	EFT
Event-based PM tasks (EBT)		.27*	.19	-.01	.20	.10	.17	.15	-.11	.14
Time-based PM tasks (TBT)	.54**		.28	.11	.22	.19	.27	.07	-.14	.15
Time-check PM tasks (TCT)	.47**	.57**		.05	-.03	-.02	.19	.18	-.13	.08
FSIQ	.20	.29*	.15		.18	.15	.45**	.14	-.13	.16
Immediate recall (IR)	.31*	.29*	.29*	.10		.79**	.25	.16	-.26	.11
Delayed recall (DR)	.31*	.31*	.35**	.30*	.75**		.09	.11	-.25	-.08
Cognitive initiation (CI)	.18	.32*	.23	.11	.22	.38**		.36**	-.13	.30*
Inhibitory control (IC)	.21	.11	.14	-.02	.17	.31*	.40**		-.13	.03
Cognitive flexibility (CF)	-.20	-.27	-.37**	-.25	-.24	-.50**	-.40**	-.47**		.04
Episodic Future Thinking (EFT)	.12	.16	.20	-.10	.26	.14	.14	.29*	-.19	

* $p < 0.025$, ** $p < 0.01$

Note: Correlations for the placebo condition are above the diagonal line and correlations for the alcohol condition are below the diagonal line.