Social and Problem Drinking: Relationships with Cognition, Motivation and Impulsivity

Thesis presented by Matthew John Mayhew

Supervised by Professor Jane Powell[1] and Dr. David Ball[2]

Submitted in accordance with the requirements of the degree of Doctor of Philosophy (PhD) in the field of Psychology

Goldsmiths College, University of London

[1] Goldsmiths College, University of London

[2] Institute of Psychiatry, King's College London

Declaration

I hereby declare that the work contained within this thesis is my own.

Matthew John Mayhew

Dedication

I dedicate this thesis to my parents. Without their unwavering support I could never have completed this PhD.

Acknowledgements

Firstly I would like to say a big thank you to my main supervisor, Professor Jane Powell, for her guidance throughout the course of the PhD. In particular I acknowledge the incredibly thorough, constructive and prompt feedback she has given me throughout the development of the thesis.

Thank you to my co-supervisor, Dr. David Ball, for his help in recruiting clinical participants (Chapter 4), reading through draft pieces of the thesis and his general encouragement.

I would also like to thank Dr. José van Velzen for her help and guidance concerning the running, analysis and write-up of the electrophysiological study (Chapter 3).

I would like to extend my gratitude to all the National Health Service staff working within the Croydon Integrated Drug and Alcohol Service at Lantern Hall, who helped me to identify potentially eligible clinical participants. Of course I would also like to say a very big thank you to all those who participated in the studies detailed within this thesis; I feel particularly indebted to those service users who were attending treatment sessions at Lantern Hall for taking the time to participate.

Finally I would like to thank Dr. Nigel Guenole for his advice regarding Confirmatory Factor Analysis (Chapter 2), and Maurice Douglas and Rob Davis for their technical support.

Abstract of Thesis

Background: *A growing body of research suggests that phenomena typically observed in alcohol dependence syndrome (ADS), which are believed to reflect dysfunctional activity within the mesocorticolimbic (MCL) dopamine (DA) system – notably, heightened cue-reactivity (CR) and disturbances of inhibitory control/impulsiveness – are present in non-physically-dependent drinkers.*

Aims: *The present thesis investigated these findings further via three empirical studies. The first developed and gathered preliminary validation data on a new self-report questionnaire measuring 'recent' impulsiveness – the Recent Impulsivity Scale (STIS). The second and third examined whether, and to what extent, CR and disturbances of inhibitory control were present in heavy social drinkers (HDs) and problem drinkers (PDs), respectively, compared to controls; and also whether these variables were related to SIS scores. Additionally, Study 3 also examined whether PDs demonstrated disturbed responsivity to non-alcohol-associated reward-related stimuli – another manifestation of dysfunction within MCL DA circuitry – compared to controls. A further aim of Study 3 was to explore whether in social drinkers (SDs) a small 'priming' dose of alcohol would increase impulsivity and CR. The possible contribution of familial predisposition to alcohol use disorders (AUDs) was also investigated.*

Principal findings:

- *The RIS comprised two factors: Cognitive Impulsivity (CI) and Motor Impulsivity (MI). The final version demonstrated good internal and test-retest reliability, and good construct validity. Across the three studies RIS scores correlated significantly with several – though not all – self-report measures of recent alcohol intake and behavioural indices of CR, non-alcohol-related reward responsiveness, impulsivity and decision-making.*

- *HDs in Study 2 showed elevated electrophysiological (but not subjective) CR – reflected in heightened P3 amplitudes – compared to light drinking controls.*

- *During acute abstinence, the PDs in Study 3 demonstrated evidence of (i) dysfunctional responsiveness to non-alcohol-associated reward-related stimuli and (ii) subjective CR, compared to socially drinking controls.*

- *The PDs of Study 3, but not the HDs in Study 2, demonstrated evidence of heightened impulsiveness, compared to controls.*

- *There was no indication that the respective abnormalities demonstrated by HDs and PDs reflected differential familial predisposition to AUDs.*

- *SDs in Study 3 did not show effects of alcohol priming.*

Conclusions: *There was considerable support for the thesis that cognitive and behavioural characteristics believed to reflect disturbances of brain reward pathways are manifest in non-dependent drinkers rather than being confined to those with alcohol dependence. They may develop as a consequence of cumulative alcohol consumption, though the cross-sectional nature of these studies cannot exclude the possibility that they precede and are possibly risk factors for heavy drinking. In general, the present data are consistent with contemporary neurobiological models of addiction and suggest a continuum along which abnormalities develop in parallel with cumulative alcohol consumption.*

Table of Contents

Title page **1**
Declaration **2**
Dedication **3**
Acknowledgements **4**
Abstract **5**

Chapter 1: General Introduction **15**

Overview 15
Individual, interpersonal and societal problems associated with alcohol misuse 15
Definitions and prevalence of alcohol use disorders 17
Alcohol consumption and mesocorticolimbic circuitry 23
Craving: Definitions and measurement 26
Behavioural and physiological reactivity to alcohol-related stimuli 28
Cue-reactivity: Theoretical explanations 32
Impulsiveness in alcohol-dependent individuals 34
Aetiology of mesocorticolimbic dysfunction in substance dependence 42
Evidence for biological and behavioural dysfunction in non-dependent 'social' drinkers 44
The present thesis 47

Chapter 2: The development of a self-report questionnaire to measure recent impulsiveness and an exploration of its association with recent alcohol consumption **49**

Abstract **49**
Introduction and rationale **50**
Hypotheses 58
Methods **59**
Design and procedure 59
Participants 59
Developing the new impulsivity scales 60
Results **69**
Discussion **94**

Chapter 3: Examining electrophysiological and subjective cue-reactivity and electrophysiological and behavioural impulsiveness in non-dependent heavy social drinkers 101

Abstract 101
Introduction and rationale 102
Hypotheses 118
Methods 119
Design 119
Participants 120
Assessments 120
Procedure 126
Results 129
Discussion 145

Chapter 4: Exploring the effects of a small dose of alcohol on sensitivity to non-alcohol-related and alcohol-related reinforcers, subjective cue-reactivity and inhibitory control and decision-making in healthy social drinkers and acutely abstinent non-dependent problem drinkers 157

Abstract 157
Introduction and rationale 158
Design and hypotheses of the present study 171
Methods 172
Participants 172
Drinks administered to participants 174
Assessments 175
Procedure 179
Results 182
Discussion 208

Chapter 5: General Discussion 224

Overview 224
Development and validation of the Recent Impulsivity Scale 224
Behavioural indices of appetitive responding and impulsivity in heavy / problem drinkers versus lighter social drinkers 227
Problems associated with low statistical power and small sample size 232
Summary and conclusion 235

References 237
Appendices 289

List of Tables

1.1: Diagnostic criteria for 'Alcohol and Drug Abuse' (DSM-IV) and 'Harmful Use of Alcohol and Drugs' (ICD-10) **.....19**

1.2: ICD-10 and DSM-IV diagnostic criteria for 'Alcohol and Drug Dependence' **.....20**

2.1: Number of items drawn from traditional impulsiveness instruments **.....63**

2.2: The preliminary set of 68 items taken from the traditional impulsiveness scales, grouped by their underlying theme, and the single state item which was produced in each case **.....64**

2.3: Schematic overview of design and order of assessments at Times 1 and 2 for Cohorts 1 (*n* = 145) and 2 (*n* = 132) **.....68**

2.4: Numbers (and percentages) of participants with data on each variable at Time 1 and Time 2 **.....70**

2.5: Demographic and alcohol-related characteristics of the whole sample of participants who completed the whole instrument battery at Time 1 (*N* = 277) **.....71**

2.6: Initial eigenvalues, percentages of variance and cumulative percentages of variance for first four factors **.....72**

2.7: Factor loadings, communalities (h^2) and percentages of variance and covariance explained for exploratory principal factors extraction and varimax rotation on the 17 TIS items at Time 1 (*N* = 262) **.....74**

2.8: Pearson's product-moment correlations (2-tailed) between each pair of component subscale scores at Time 1 (*N* = 262) **.....75**

2.9: Pearson's product-moment correlations (2-tailed) for the total TIS scale score and each component subscale score between Time 1 and Time 2 (*N* = 191) **.....75**

2.10: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 (*N* = 194) **.....77**

2.11: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on RIS items at Time 1 (*N* = 276) **.....79**

2.12: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 in females (*N* = 148)**.....80**

2.13: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 in males (*N* = 44)**82**

2.14: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 in females and males (*N* = 191) **.....84**

2.15: Personality characteristics of the whole sample of undergraduate participants who completed the whole instrument battery at Time 1 (*N* = 277) **.....85**

2.16: Personality characteristics of female and male undergraduate participants who completed the whole instrument battery at Time 1**.....86**

2.17: Mean (SE) skewness and kurtosis statistics for scores on the TIS and RIS for the whole sample of undergraduates at Time 1 (*N* = 277) **.....89**

2.18: Pearson's product-moment test-re-test correlations for trait and recent subscales and scales (*N* = 191) **.....91**

2.19: Pearson's product-moment correlations between recent alcohol intake and trait and recent impulsivity subscales and scales (*N* = 178)**.....92**

2.20: Correlations between TIS and RIS scales and subscales in participants with stable versus changing patterns of alcohol consumption**.....93**

3.1: Mean (standard deviations) characteristics of the final alcohol-related and household-related word stimuli **.....124**

3.2: Sociodemographic, personality and alcohol-related characteristics of heavy versus light drinkers **.....130**

3.3: Means and SDs (μV) for the peak amplitude and latency of the no-go P3 component, among heavy and light social drinkers, across frontal (FP1, FP2, AF3, AF4, Fz, F3, F4, F7, F8), central (FC1, FC2, FC5, FC6, Cz, C3, C4), parietal (CP1, CP2, Pz, P3, P4), temporal (T7, T8, CP5, CP6, P7, P8) and occipital (PO3, PO4, O1, O2) electrode regions **.....133**

3.4: Means and SDs (μV) for the peak amplitude and latency of the no-go N2 component, among heavy and light social drinkers, across frontal (FP1, FP2, AF3, AF4, Fz, F3, F4, F7, F8), central (FC1, FC2, FC5, FC6, Cz, C3, C4), parietal (CP1, CP2, Pz, P3, P4), temporal (T7, T8, CP5, CP6, P7, P8) and occipital (PO3, PO4, O1, O2) electrode regions **.....135**

3.5: Spearman correlations between RIS and TIS subscales and: i) subjective and electrophysiological CR and; ii) behavioural and ERP measures of impulsiveness in the CPT, in the combined sample of HDs and LDs**.....136**

3.6: Spearman correlations (*p* value; 1-tailed) between mean electrophysiological CR at all electrode locations and mean self-reported subjective CR and arousal ratings in the whole sample **.....138**

3.7: Means and SDs for arousal ratings of the AR and HR words in heavy drinkers, light drinkers and the whole sample**.....138**

3.8: Means and SDs for valence ratings of the AR and HR words in heavy drinkers, light drinkers and the whole sample**.....140**

3.9: Means and SDs for subjective alcohol desire in response to AR and HR words in heavy drinkers, light drinkers and the whole sample (*N* = 20) **.....140**

3.10: Mean amplitude and SDs (μV) in the P3 time window on the AR and HR stimuli among heavy and light social drinkers, across anterior (F1/2, F3/4, AF3/4), central (FC1/2, FC3/4, C1/2, C3/4, CP1/2, CP3/4) and posterior electrodes (P1/2, P3/4, P03/04) in each hemisphere **.....143**

4.1: Schematic overview of design and order of assessments in Study Parts 1 and 2**181**

4.2: Sociodemographic, personality, mood and alcohol-related characteristics of social drinkers **.....183**

4.3: Stroop colour-naming times and 'interference' scores in neutral, appetitive, aversive and alcohol-related word conditions in social drinkers after placebo and alcohol**.....184**

4.4: Stroop errors and 'interference' scores in neutral, appetitive, aversive and alcohol-related word conditions in social drinkers after placebo and alcohol **.....185**

4.5: Subjective desire for alcohol following presentation of a) participants' preferred alcoholic drink and b) a bottle of water in SDs after placebo and alcohol **.....186**

4.6: IGT score in each block, and net score, in SDs after placebo and alcohol drink administration **.....187**

4.7: Number of correct decisions, commission errors and motor errors in SDs under placebo and alcohol **188**

4.8: Spearman correlations (*p* value; 1-tailed) between habitual alcohol intake and difference scores for behavioural measures of non-alcohol-related and alcohol-related reward sensitivity and decision-making and inhibitory control in SDs **189**

4.9: Sociodemographic, personality, mood and alcohol-related characteristics of problem versus social drinkers **190**

4.10: Emotional stroop colour-naming times: Main and interaction effects **193**

4.11: Main and interaction effects for 2 (GROUP: SDs vs. PDs) x 2 ..... **194**

4.12: Emotional Stroop: Number of errors and interference effects in problem and social drinkers after placebo and alcohol **197**

4.13: Emotional stroop numbers of errors: Main and interaction effects **197**

4.14: Cue-elicited craving: means and standard deviations (s.d.s) SDs for craving following presentation of participants' preferred alcoholic drink and a bottle of water, in SDs and PDs, under placebo and alcohol **201**

4.15: Cue-elicited craving: main and interaction effects **201**

4.16: Means and s.d.s for IGT score by block, and net score, in PDs and SDs, after placebo and alcohol drink administration **205**

4.17: IGT performance: Main and interaction effects **205**

4.18: Means and s.d.s for number of correct detections, commission errors and motor errors, in PDs and SDs, under placebo and alcohol **206**

4.19: Spearman correlations for TIS and RIS subscale scores with experimental indices in the placebo condition, in the combined sample of SDs and PDs; and comparisons of the magnitude of RIS and TIS correlations with each index **207**

A1: Initial correlation matrix for pilot TIS items at Time 1 ..... **345**

A2: Means (standard deviations) of the final go and no-go word stimuli **352**

A3: Main effects of ELECTRODE REGION on no-go P3 and N2 amplitudes and latencies **353**

A4: Main and interaction effects of mean P3 amplitudes **354**

List of Figures

1.1: Neurochemical circuits implicated in drug reward **.....24**

2.1: Scree plot of the 17 items of the TIS at Time 1 (*N* = 262)**.....72**

2.2 i): Histograms showing normality of the TIS and RIS CI subscales at Time 1 **.....87**

2.2 ii): Histograms showing normality of the TIS and RIS MI subscales at Time 1 **....87**

2.2 iii): Histograms showing normality of the TIS and RIS CI total scales at Time 1 **..88**

2.3 i): Histograms of the TIS CI subscale in females (left) and males (right)**.....88**

2.3 ii): Histograms of the TIS MI subscale in females (left) and males (right)**.....88**

2.3 iii): Histograms of the TIS total scale in females (left) and males (right) **.....89**

2.4: Histogram demonstrating normality of the variable 'Alcohol intake within the previous two weeks compared to the previous twelve months'**.....96**

3.1: Diagram of an idealised ERP wave recorded over the posterior of the scalp elicited by a visual stimulus, showing the components P1, N1, P2, N2 and P3, and the times at which they each approximately tend to appear following stimulus presentation (image taken from Handy, 2005)**.....106**

3.2: ERPs elicited by nogo words at frontal electrodes (FP1, FP2, AF3, AF4, F3, F4, F7 and F8) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10)**.....134**

3.3: ERPs elicited by nogo words at central electrodes (FC1, FC2, FC5, FC6, Cz, C3 and C4) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10) **.....134**

3.4: ERPs elicited by nogo words at parietal electrodes (CP1, CP2, Pz, P3 and P4) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10) **.....134**

3.5: ERPs elicited by nogo words at temporal electrodes (T7, T8, CP5, CP6, P7 and P8) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10)**.....134**

3.6: ERPs elicited by nogo words at occipital electrodes (PO3, PO4, O1 and O2) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10) **.....134**

3.7: Mean (+/- 1 SE) arousal ratings in heavy and light drinkers **.....139**

3.8: ERPs elicited by AR and HR words at anterior electrodes (F1, F2, F3, F4, AF3 and AF4) in heavy drinkers (*n* = 12; left panel) and in light drinkers (*n* = 10; right panel) **142**

3.9: ERPs elicited by AR and HR words at central electrodes (FC1, FC2, FC3, FC4, C1, C2, C3, C4, CP1, CP2, CP3 and C4) in heavy drinkers (*n* = 12; left panel) and in light drinkers (*n* = 10; right panel) **.....142**

3.10: ERPs elicited by AR and HR words at posterior electrodes (P1, P2, P3, P4, PO3 and PO4) in heavy drinkers (*n* = 12; left panel) and in light drinkers (*n* = 10; right panel) **.....142**

3.11: Mean (+/- 1 SE) P3 amplitude in heavy and light drinkers **.....144**

4.1: Mean (+/- 1 SE) subjective craving in SDs following presentation of neutral and alcohol cues **.....186**

4.2: Interference effects for colour-naming times in the motivational word conditions of the Stroop task, under placebo and alcohol, for SDs (*n* = 21; left panel) and PDs (*n* = 10; right panel) **.....195**

4.3: Interference effects for numbers of errors in the motivational word conditions of the Stroop task, under placebo and alcohol, for SDs (*n* = 22; left panel) and PDs (*n* = 9; right panel)**.....199**

4.4: Mean (+/- 1 SE) subjective craving in response to water and alcohol stimuli**..202**

4.5: Mean (+/- 1 SE) subjective craving in response to water and alcohol stimuli, under placebo and alcohol, in PDs (*n* = 11; left panel) and SDs (*n* = 22; right panel) **203**

Chapter 1: General Introduction

Overview

The misuse of alcohol poses diverse problems for society. It is therefore important that research investigates factors involved in Alcohol Use Disorders (AUDs) in order that future treatment strategies can be developed accordingly. It is of particular relevance to contemporary theories of addiction that people with AUDs tend to demonstrate two key phenomena: i) characteristic responses to stimuli associated with alcohol ('cue-reactivity' (CR)); and ii) heightened impulsiveness. Several major theories (e.g. Robinson & Berridge, 1993, 2000; Jentsch & Taylor, 1999) explain these phenomena in terms of underlying dysfunctions within the mesocorticolimbic (MCL) dopamine (DA) system. A growing body of research suggests that social drinkers who do not have an AUD may also demonstrate CR and heightened impulsiveness. The present thesis extends this research by testing predictions from current models of alcohol addiction in non-alcohol-dependent drinking groups.

Section I of this chapter illustrates the extent to which alcohol misuse incurs physical, psychoemotional and financial burdens for the alcohol misuser, their families and broader society. Sections II and III define and describe psychological features of the two recognised alcohol use disorders (AUDs): alcohol abuse and alcohol dependence syndrome (ADS).

Section IV reviews recent evidence of psychological dysfunction in other, non-dependent drinker groups. If such individuals show signs of underlying biological disturbance, this may illuminate factors associated with the initial development of AUDs. Section V then sets out the principal research aims of this thesis.

1) Individual, interpersonal and societal problems associated with alcohol misuse

Maladaptive patterns of alcohol consumption pose enormously complex and wide-ranging physical, emotional and financial problems, which are not confined only to the individual drinkers themselves, but which place a considerable burden upon their families and loved ones as well as wider society.

In broad terms, increasing levels of alcohol consumption are detrimental to health, both directly and indirectly. Alcohol consumption increases risk for major illnesses, including various forms of cancer, unipolar depression, ischaemic heart disease, epilepsy, hypertension, stroke and cirrhosis of the liver, as well, of course, as alcohol use disorders (AUDs) (Rehm *et al*., 2003; Balakrishnan *et al*., 2009). Heavy drinkers are also at elevated risk of traffic accidents, drowning, falls, violence and suicide (Balakrishnan *et al*., 2009; Grønbæk, 2011). Interestingly, however, moderate levels of alcohol consumption may actually reduce the risks of coronary heart disease (CHD), stroke and diabetes mellitus (Rehm *et al*., 2003).

Alcohol misuse also has emotional, physical and medical implications for others. In a recent review, Navarro, Doran and Shakeshaft (2011) report that family members often suffer domestic violence, neglect, abuse and poverty, which frequently culminates in separation/family breakdown. Maternal drinking can harm the developing foetus. Thus Fetal Alcohol Spectrum Disorder (FASD) may manifest in birth defects, including characteristic abnormalities of the upper lip and eyes, and neurodevelopmental disorders; the risk of miscarriage, stillbirths and underweight births are all elevated. Alcohol-related aggression also has overt consequences in the forms, for example, of interpersonal violence, traffic accidents and fire destruction.

In terms of financial impact, Balakrishnan *et al*. (2009) have estimated that in 2005-2006 illnesses related to alcohol consumption cost the National Health Service (NHS) £3 billion, or 3.2% of total NHS expenditure. However, substantial additional indirect costs arise from work absenteeism, informal care, non-fatal alcohol-related injuries and crime. Thus, the Cabinet Office (2003) estimated that in the years 2001-2002, alcohol-related crime cost England and Wales around £11.7 billion, and alcohol-related lost productivity was estimated at £6.4 billion.

Given the physical, social and financial burdens associated with alcohol misuse, Lee and Forsythe (2011) are among others who argue that alcohol is more dangerous than heroin. It is likely that these burdens will worsen as the number of people reporting harmful alcohol consumption increases. Whereas in 1988 around a

quarter of men and 10% of women reported drinking above weekly recommendations, in 2006 these figures had risen to around a third of men and a fifth of women (Office for National Statistics, 2001; The NHS Information Centre, 2008). Correspondingly, the per capita consumption of alcohol in the UK increased from 6.61 units per week per head in 1973 to 9.11 in 2003 (British Beer and Pub Association, 2004). It is therefore of vital importance to increase our understanding of the factors associated with maladaptive patterns of alcohol consumption.

2) Definitions and prevalence of alcohol use disorders

The latest versions of the World Health Organisation (WHO) International Classification of Diseases (ICD-10; 1992) and the American Psychiatric Association (APA) Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; 1995) each identify two forms of diagnosable alcohol use disorder (AUD) (see Tables 1.1 and 1.2 on pages 19 and 20, respectively). In the ICD-10, these are termed 'harmful alcohol use' and 'alcohol dependence'. Harmful alcohol use is defined as

> "*A pattern of psychoactive substance use that is causing damage to health. The damage may be physical (e.g. hepatitis) or mental (e.g. depressive episodes secondary to heavy alcohol intake). Harmful use commonly, but not invariably, has adverse social consequences: social consequences in themselves, however, are not sufficient to justify a diagnosis of harmful use*".

Individuals do not demonstrate evidence of physical dependence (i.e. 'tolerance' and a withdrawal syndrome upon cessation of drinking). The DSM-IV equivalent is 'alcohol abuse'. Though not a diagnosable condition in either ICD-10 or DSM-IV, the term 'problem drinker' is often used in research contexts and is broadly equivalent to harmful alcohol use and alcohol abuse.

Alcohol dependence, on the other hand, is defined in the ICD-10 as:

> "*A cluster of behavioural, cognitive and physiological phenomena that develop following repeated substance use and that typically include a strong desire to take the drug, difficulties in controlling its use, persisting in its use despite harmful consequences, a higher priority given to alcohol use than to other activities and obligations, increased tolerance and sometimes a physical withdrawal state*".

Alcohol dependence is likewise a category in DSM-IV although, as indicated in Table 1.2, the criteria differ slightly from those used by ICD-10 (e.g. a strong desire or compulsion to use substances is not included in DSM-IV). In everyday language and in earlier versions of these classification systems, this has been referred to as 'alcoholism'. The term alcohol dependence, however, is preferable as it is more precise and more reliably defined and measured using ICD-10 and DSM-IV criteria.

Table 1.1: Diagnostic criteria for 'Alcohol and Drug Abuse' (DSM-IV) and 'Harmful Use of Alcohol and Drugs' (ICD-10)

DSM-IV Alcohol and Drug Abuse	ICD-10 Harmful Use of Alcohol and Drugs
A. A maladaptive pattern of substance use leading to clinically significant impairment or distress, as manifested by one (or more) of the following occurring within a 12-month period: 1. Recurrent substance use resulting in a failure to fulfil major role obligations at work, school or home; 2. Recurrent substance use in situations in which use is physically hazardous; 3. Recurrent substance-related legal problems; 4. Continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the drug. B. The symptoms have never met the criteria for substance dependence for the same class of substance.	A. A pattern of substance use that is causing damage to health. The damage may be physical or mental. The diagnosis requires that actual damage should have been caused to the mental or physical health of the user. B. No concurrent diagnosis of the substance dependence syndrome for the same class of substance.

Table 1.2: ICD-10 and DSM-IV diagnostic criteria for 'Alcohol and Drug Dependence'

Symptoms	DSM-IV Definitions	ICD-10 Definitions
Clustering Criterion	Three or more of the following have been experienced or exhibited at some time during the previous year:	A maladaptive pattern of substance use, leading to clinically significant impairment or distress as manifested by three or more of the following occurring at any time in the same 12-month period:
Tolerance	Evidence of tolerance, such that increased doses are required in order to achieve effects originally produced by lower doses; or markedly diminished effect with continued use of the same amount of the substance;	Need for markedly increased amounts of a substance to achieve intoxication or desired effect;
Withdrawal	The characteristic withdrawal syndrome for a substance or use of a substance (or a closely related substance) to relieve or avoid withdrawal symptoms;	A physiological withdrawal state when substance use has ceased or been reduced as evidenced by the characteristic substance withdrawal syndrome, or use of the substance (or a closely related substance) to relieve or avoid withdrawal symptoms;
Impaired Control	Persistent desire or one or more unsuccessful efforts to cut down or control substance use; Substance used in larger amounts or over a longer period than the person intended;	Difficulties in controlling substance use in terms of onset, termination, or levels of use;

Table 1.2 continues over the page

Table 1.2 continued

Neglect of Activities	Important social, occupational, or recreational activities given up or reduced because of substance use;	Progressive neglect of alternative pleasures or interests in favour of substance use; or A great deal of time spent in activities necessary to obtain, to use, or to recover from the effects of substance used;
Time Spent	A great deal of time spent in activities necessary to obtain, to use, or to recover from the effects of the substance used;	
Continued use despite problems	Continued substance use despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to be caused or exacerbated by use;	Continued substance use despite clear evidence of overtly harmful physical or psychological consequences;
Compulsive use	None.	A strong desire or sense of compulsion to use substance.
Duration criterion	No duration criterion separately specified. However, several dependence criteria must occur repeatedly as specified by duration qualifiers associated with criteria (e.g. 'often', 'persistent', 'continued').	A. No duration criterion separately specified.
Criterion for subtyping dependence	*With physiological dependence:* Evidence of tolerance or withdrawal (i.e., any of items A-1 or A-2 above are present); *Without physiological dependence:* No evidence of tolerance or withdrawal (i.e., none of items A-1 or A-2 above are present).	None.

For the pragmatic purposes of diagnosis, ICD-10 and DSM-IV criteria define the disorders of alcohol abuse and alcohol dependence categorically, as either present or absent. However, in reality, these disorders exist along a continuum of severity. Thus the National Institute for Health and Clinical Excellence (NICE; 2011) refers to mild, moderate and severe dependence, the latter group consuming a litre or more of spirits per day.

In the UK, one unit of alcohol is defined as 8 g (or 10 ml) of pure ethanol. Department of Health guidelines (Department of Health, 1995) recommend that men should not regularly consume more than four units of alcohol per day, and women no more than 3 units; similarly, the Royal College of Psychiatrists (RCP; 1986) advises that men should drink less than 21 units of alcohol per week, and women less than 14. Those consuming below these recommended limits are considered to be at low risk of health or social harm. Individuals who regularly consume alcohol above these levels, but who have not as yet experienced alcohol-related harm, can be termed 'hazardous drinkers': that is, they are at increased risk for harm in the future (NICE, 2011). Research studies, however, tend to use the alternative yet broadly operationally synonymous terms 'heavy social drinkers' or 'heavy drinkers' in reference to such individuals. For example, Cox, Yeates and Regan (1999) defined their heavy drinkers as females consuming more than 16 units per week and males consuming more than 26 units per week. The RCP (1986) defines 'harmful' drinking as the consumption of more than 50 units per week by men, and more than 35 units by women. 'Binge' drinking is defined as men consuming more than 8 units, and women drinking more than six, in a single day (Prime Minister's Strategy Unit, 2004). Thus, there are several patterns of non-dependent yet dysfunctional alcohol consumption.

Prevalence of alcohol use disorders

Reliable data concerning the prevalence of alcohol dependence and alcohol abuse are difficult to obtain given that UK population-wide surveys do not tend to include self-report diagnostic instruments. Some surveys, however, have included the Alcohol Use Disorders Identification Test (AUDIT; Saunders *et al*., 1993). Using this

measure, the Alcohol Needs Assessment Research Project (ANARP) found the prevalence of alcohol dependence to be 6% in men and 2% in women aged 16-64 (Drummond *et al*., 2005). This translates to approximately 1.1 million alcohol-dependent people in England in 2000; a similar survey suggested this figure had increased to 1.6 million by 2007 (McManus *et al*., 2009).

Unhealthy albeit non-dependent levels of alcohol consumption are even more prevalent, as revealed for example by the General Household Survey (Robinson & Bulger, 2010), the Health Survey for England (Craig, Mindell & Hirani, 2009) and the Psychiatric Morbidity Survey (McManus *et al*., 2009). Thus in 2008, 21% of men and 15% of women were drinking at 'hazardous' levels. A further 7% of men and 5% of women were identified as harmful drinkers and 21% of men and 14% of women as binge drinkers. In all, McManus *et al*. (2009) report that 24% of English adults (33% of men and 16% of women) consume alcohol in a manner which is either potentially or actually harmful.

3) Alcohol consumption and mesocorticolimbic dopaminergic circuitry

A large and growing body of research literature documents the psychological features demonstrated by people with alcohol use disorders, and especially those with alcohol dependence. Numerous empirical studies (e.g. Goldstein & Volkow, 2002; Volkow *et al.*, 2002; Jentsch & Taylor, 1999; Robinson & Berridge, 1993, 2000) have revealed alcohol and substance users to show pathology or dysfunction in brain 'reward' circuitry comprising dopaminergic (DAergic) projections from the ventral tegmental area (VTA) to the nucleus accumbens (NAcc), amygdala, anterior cingulate gyrus (ACG) and prefrontal cortex (PFC) (see Figure 1.1).

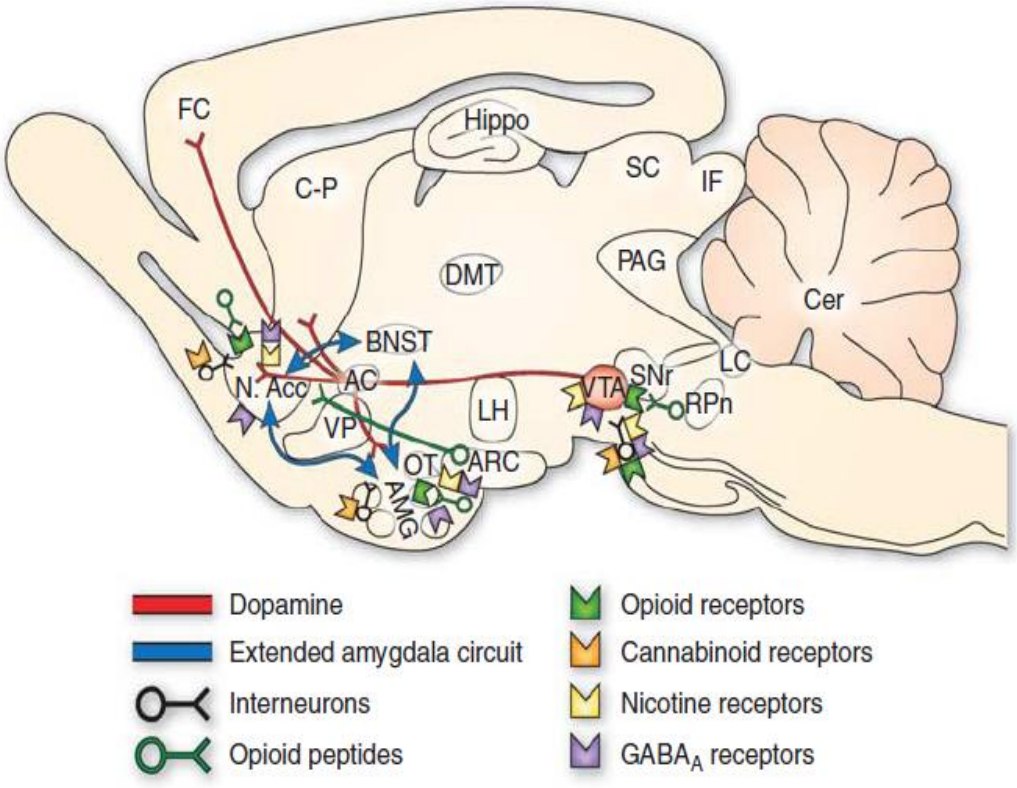

Figure 1.1: Neurochemical neurocircuits implicated in drug reward (image taken with permission from Koob & LeMoal, 2006). The figure depicts a sagittal section through a representative rodent brain showing the pathways and receptor systems implicated in the reinforcing actions of drugs of abuse. Alcohol activates γ-aminobutyric acid-A ($GABA_A$) receptors in the VTA, N Acc and AMG by either direct actions at the $GABA_A$ receptor or through indirect release of GABA. Alcohol is hypothesised to facilitate the release of opioid peptides in the VTA, N Acc and central nucleus of the AMG. Alcohol facilitates the release of dopamine in the N Acc through an action either in the VTA or the N Acc. The blue arrows represent the interactions within the extended amygdala system hypothesised to have a key function in drug reinforcement. AC, anterior commissure; AMG, amygdala; ARC, arcuate nucleus; BNST, bed nucleus of the stria terminalis; Cer, cerebellum; C-P, caudate-putamen; DMT, dorsomedial thalamus; FC, frontal cortex; Hippo, hippocampus; IF, inferior colliculus; LC, locus coeruleus; LH, lateral hypothalamus; N Acc., nucleus accumbens; OT, olfactory tract; PAG, periaqueductal gray; RPn, reticular pontine nucleus; SC, superior colliculus; SNr, substantia nigra pars reticulata; VP, ventral pallidum; VTA, ventral tegmental area.

Collectively termed the mesocorticolimbic (MCL) system, it is believed that these tracts have evolved to direct appropriate responses towards 'natural' rewards such as food or sex (Kelley & Berridge, 2002). Exposure to an appetitive stimulus phasically increases dopamine (DA) transmission in the VTA, signalling the availability of reward and influencing attention, decision-making and behaviour via DAergic projections to the NAcc, striatum, anterior cingulate cortex (ACC) and other prefrontal regions (Schultz, Dayan & Montague, 1997). DA release likewise occurs in response to stimuli with other forms of motivational salience, such as aversion and novelty (Gray, Young & Joseph, 1997; Salamone, 1994; Volkow *et al*., 2004a).

Chronic drug use is associated with attenuation of tonic or resting activity in this circuitry (reviews by Grace, 2000, Diana *et al*., 2003, Volkow *et al*., 2004b, and Weiss & Porrino, 2002). Alcohol dependence is associated with reduced DA D_2/D_3 receptor availability in the striatum as well as reduced striatal DA release, as indicated by positron emission tomography (PET) and single photon emission computed tomography (SPECT) (e.g. Heinz *et al.*, 2004; Volkow & Li, 2004; Shen, Choong & Thompson, 2007; Volkow *et al*., 2007) and by post-mortem studies (Tupala *et al.*, 2001, 2003).

Crucially, even in dependent individuals drugs of abuse directly increase DA transmission in the VTA in the MCL circuitry with a potency, immediacy and reliability that exceed the effects of almost every natural reward (Hyman & Malenka, 2001). For example, Martinez *et al*. (2005) employed PET and the D_2 receptor radiotracer [^{11}C]raclopride to measure DA D_2 receptors and DA release in fifteen alcohol-dependent (AD) and 15 healthy control participants. Participants underwent scans at baseline and following administration of 0.3 mg/kg of amphetamine, which produces acute reductions in [^{11}C]raclopride binding and corresponding changes in extracellular DA (Breier *et al*., 1997). At baseline, [^{11}C]raclopride binding was significantly lower in ADs than in controls in the limbic striatum, associative striatum, and sensorimotor striatum. Following amphetamine administration, however, this was the case only in the limbic striatum. Similar findings have been reported in people addicted to nicotine, cocaine, methamphetamine and heroin (Martinez *et al*., 2004, 2007; Volkow *et al*., 1997).

It has been argued that they 'hijack' the MCL system (Lubman, Yücel & Pantelis, 2004). A psychological manifestation of this so-called 'hijacking' is likely to be the user's enduring preoccupation with the procurement and consumption of alcohol; in other words, craving.

4) Craving: Definitions and measurement

'Craving' can be defined as 'a subjective feeling of a strong urge to do something' (West, 2006, p. 11). Craving for alcohol is considered to be a fundamental element in the maintenance of AUDs (Kozlowski & Wilkinson, 1987). In spite of its importance, however, definitions and conceptualisations of craving are highly varied; differing approaches have been identified, for example, by Kozlowski & Wilkinson (1987), Drobes & Thomas (1999), Sayette *et al.* (2000), Tiffany, Carter & Singleton (2000), Flannery *et al.* (2001) and Grüsser, Mörsen & Flor (2006). The term 'craving' is often used to refer both to self-reported desires and/or urges to ingest alcohol, and to 'wanting' or 'needing' to drink alcohol (Grüsser *et al.*, 2006). Verheul, Van den Brink and Geerlings (1999) have proposed three distinct forms of craving – reward craving, relief craving and compulsive craving – each with different underlying mechanisms. Tiffany and Drobes (1991) have postulated four principal sub-types: desire to take the drug, anticipation of positive outcomes, avoidance/relief of withdrawal and/or negative affect and intention to take the drug (see also Tiffany *et al*., 2000). There are, accordingly, varied approaches to the measurement of craving; some are based on self-report, others on behavioural/physiological responses.

Self-report measures of craving may be either single- or multi-item instruments; some ask about the respondent's craving over the course of the preceding day, week, month or even longer periods, whereas 'state' versions are concerned with the respondent's craving *at that moment*. The former ('global') measures index craving in the 'natural' context of the respondent's daily life, whereas state measures can be used to tap fluctuations in craving in response to experimental manipulations.

Multi-item questionnaires are constructed to offer rich measures of the subjective craving experience. The Alcohol Craving Scale (ACQ; Singleton, Tiffany & Henningfield, 1994) for example, contains 47 items related to five domains: desire to drink alcohol; intention to drink alcohol; lack of control over the use of alcohol; anticipation of positive effects from drinking; and expectancy of relief from withdrawal or other negative states. However, such instruments are often time-consuming to administer, limiting their use in experimental studies. The Yale-Brown Obsessive Compulsive Scale for heavy drinkers (Y-BOCS-hd; Modell *et al.*, 1992), for example, is a clinical interview taking between 15 and 30 minutes (Drobes & Thomas, 1999).

Single-item instruments take the form of questions such as 'How strong is your craving for alcohol?' or 'How strong is your urge to drink?' with anchor responses like 'The most I've ever felt' and 'Not at all'. Respondents typically either select the most appropriate choice on a 7- or 10-point Likert-type scale or use a Visual Analog Scale (VAS), marking a line connecting the two anchor statements; the distance between the 'no craving' end of the line and the respondent's mark serves as the craving index.

Compared to healthy controls, alcohol dependent patients consistently demonstrate increases in self-reported craving, as recorded via Likert-type and visual analog scales, following presentation of alcohol-related compared to neutral cues in CR designs (e.g. Pomerleau *et al.*, 1983; McCusker & Brown, 1995; Cooney *et al.*, 1987; Reid *et al.*, 2006). Such manipulations generally adopt the following procedure. In one condition, the participant is presented with a stimulus considered 'neutral' (i.e. of no particular significance to the participant), whilst in another they are presented with alcohol or an alcohol-associated stimulus. The latter types of stimuli have included: the sight, smell and taste of alcohol (often the respondent's preferred beverage); words, pictures or videos representing alcohol or alcohol-related scenarios; the expectation that alcohol will be consumed; and mental imagery of alcohol-related contexts (Drobes & Thomas, 1999). The participant self-reports their craving during or immediately following exposure to each stimulus (or 'cue'). 'Cue-reactivity' is calculated by subtracting their craving in the neutral

condition from that in the alcohol-associated condition. Such studies experimentally explore and replicate earlier anecdotal observations (e.g. Wikler, 1973) that when exposed to drugs or associated stimuli, dependent individuals demonstrate characteristic subjective, behavioural and physiological responses (Drummond *et al.*, 1995). In most CR studies, craving is indexed via a single item rating; however, a few have used multi-item questionnaires. For example, Sobell *et al.* (1993) presented videotapes of a popular prime-time television program with and without alcohol-related advertisements to severely dependent alcohol abusers who then completed a modified version of the Situational Confidence Questionnaire (SCQ; Annis, 1982) which asked them to rate their perceived ability to resist the urge to drink heavily in various situations. The most highly dependent participants reported a significant decrease in confidence after exposure to the alcohol-related cues.

All self-report measures, whether single- or multi-items, may of course be subject to either conscious or unconscious biases; for this reason many studies have additionally (or alternatively) utilised behavioural and/or physiological indices.

5) Behavioural and physiological reactivity to alcohol-related stimuli

Behavioural and physiological responses are often investigated via CR designs. A number of studies have reported alcoholics to demonstrate cue-elicited increases in indices of autonomic arousal, such as salivation (Pomerleau *et al.*, 1983), skin temperature, respiration, blood pressure, heart rate (Kaplan *et al.*, 1985; Turkkan, McCaul & Stitzer, 1989; Payne *et al*., 1992) and skin conductance[3] (Kaplan *et al*., 1985; Turkkan *et al*., 1989). Changes in brain activity have also been recorded. Functional magnetic resonance imaging (fMRI) has demonstrated that when presented with alcohol-related cues, alcoholics show increased activity within anterior cingulate cortex (ACC), adjacent prefrontal areas, the OFC and the ventral striatum including the NAcc, dorsal striatum, amygdala and thalamus (e.g. see reviews by Wrase *et al*., 2002; Heinz *et al*., 2009; George *et al*., 2001). Numerous

[3] The term 'skin conductance' refers to the skin's ability to conduct weak electrical currents. This ability varies as a function of the amount of moisture on the surface of the skin, and is therefore used as an index of sweat gland activity (Drobes & Thomas, 1999).

studies have also documented changes as recorded by event-related potentials (ERPs); these are discussed in detail in Chapter 3.

Subjective, physiological and electrophysiological changes may be desynchronised and patterns of physiological activity to alcohol cues are not consistent (Niaura *et al*., 1988). However, some studies have reported different indices to co-vary. For instance, Sayette *et al.* (1994) required male alcoholics to respond to computer-generated tones as quickly as possible during exposure to alcohol or control cues. Not only did their reaction time increase during exposure to alcohol cues but there was also a significant correlation between reaction time and self-reported urge to drink. Similar findings have been reported in smokers (Sayette & Hufford, 1994; Mogg & Bradley, 2002), cocaine addicts (Franken, Kroon & Hendriks, 2000; Copersino *et al.*, 2004) and recreational users of cannabis (Field, Mogg & Bradley, 2004).

Many behavioural measures tap the extent to which the participant's attention is 'captured' by alcohol-related cues. This 'attentional bias' is often indexed via the visual probe (or dot probe) task or a modified Stroop task. In the visual probe procedure, participants sit in front of a computer screen, in the centre of which a fixation cross is presented for a short period (e.g. 500 msec). This is then replaced by a pair of pictures, one to the left of the screen, the other to the right. One is alcohol-related, the other a matched neutral image. These appear briefly (e.g. 50 msec), and immediately following picture offset, a 'dot probe' appears in one of the two locations and remains until the participant presses a response key to indicate its position. Shorter response latencies when the dot appears in the locations formerly occupied by the alcohol-related images indicate that the participant had oriented towards these stimuli. Participants with AUDs have been found to show such attentional bias (Noël *et al.*, 2006; Vollstädt-Klein *et al.*, 2011).

The Stroop colour-naming task (Stroop, 1935) is the most widely-used measure of attentional bias, in which participants must name the colour of the ink in which conflicting colour words are printed. Performance in this condition is compared with another in which the words are not colour names. The differences between

conditions in the times taken to name the colours, and the number of errors made, indicate the extent to which the semantic content of the words has been processed and has interfered with the naming of the conflicting ink colour. The 'modified' or 'emotional' Stroop task (Williams, Mathews & MacLeod, 1996) is a variation of the above procedure which examines the effect of varying the semantic content of the words. Differential interference by words with different semantic connotations is a function of their salience to the individual. Thus, for example, some studies have reported that anxious patients are more susceptible than non-anxious controls to interference in response to threat-related words (e.g. Martin, Williams & Clark, 1991).

The modified Stroop task has similarly been used in a number of studies to determine whether people with alcohol use disorders (AUDs) show attentional bias towards alcohol-related words. Thus, both Johnsen *et al.* (1994) and Stetter *et al.* (1995) reported that problem drinkers demonstrated greater interference from such words than did social drinkers. This has since been replicated in numerous studies (e.g. Cox, Blount & Rozak, 2000; Stormark *et al.*, 1997, 2000; Sharma, Albery & Cook, 2001; Franken, 2003; & Lusher *et al.*, 2004). However, some studies have reported no significant difference between AUD groups and controls (e.g. Bauer & Cox, 1998; Stetter *et al.*, 1994).

Despite their widespread use in assessing attentional bias in AUDs, questions have recently begun to arise concerning the internal reliability of the visual probe and modified Stroop tasks (Field & Christiansen, 2012). In the first and only study of its kind, Ataya *et al.* (2012) estimated the internal reliability of the visual probe task and unblocked[4] versions of the Stroop task to be very poor. Blocked versions of the Stroop task, however, demonstrated acceptable levels of reliability (i.e. $\alpha > 0.70$). Ataya *et al.* (2012) attribute poor reliabilities in the visual probe task to the use of reaction time – a 'noisy' measure – as the index of attentional bias. Given the superior reliability of the blocked Stroop, Ataya *et al.* (2012) recommend

[4] In the blocked version of the modified Stroop, substance-related words are presented in one sub-block and neutral words are presented in another, whereas in the unblocked version of the task, substance-related and neutral words are randomly intermixed.

researchers use this version of the task to assess attentional bias. In relation to the Stroop, Field & Christiansen (2012) suggest that poor reliability may reflect the varying relevance of different substance-related stimuli to individual participants. For example, the words 'beer', 'wine', 'spirits' and 'cider' will not be of equal significance to a particular respondent: if s/he drinks only a certain brand of beer, s/he is likely to be most responsive to words associated with that brand, less so to words associated with other beer brands and possibly not at all responsive to those associated with wine, spirits or cider. Thus, the overall index of attentional bias may be small and unreliable, since it is diluted by the lesser or non-reactivity to all the presented stimuli. This might also explain the apparently greater sensitivity and internal consistency of blocked, compared to unblocked, formats: though participants may still only respond strongly to a minority of stimuli, carry-over effects may cause colour-naming interference even in response to less salient words.

Field and Cox (2008) have noted that observed Stroop interference effects could result from attempts to *avoid* elaborative processing of alcohol-related words just as well as from heightened processing. Consistent with this interpretation, Klein (2007) found that alcohol abusers instructed to suppress their thoughts about alcohol demonstrated interference in response to the word 'alcohol', whereas those encouraged to freely experience alcohol-related thoughts did *not* show interference. Another alternative explanation relates to Tiffany and Conklin's (2000) argument that subjective craving utilises cognitive resources. If alcohol-related words in a Stroop task elicit subjective craving, this could itself give rise to a general cognitive slowing (Algom, Chajut & Lev, 2004; Field & Cox, 2008).

The alcohol Stroop effect is seen not only in people with an AUD but also in healthy social drinkers. Bauer and Cox (1998) and Ryan (2002a), for example, found that alcohol-related words produced interference in drinkers regardless of their habitual level of alcohol consumption. Likewise, Sharma, Albery and Cook (2001) reported attentional bias towards alcohol-related stimuli in both problem and non-problem drinkers; and Cox *et al.* (1999) and Jones and Schulze (2000) observed such interference in heavy social drinkers. Lusher *et al.* (2004) suggest that alcohol-

related words may be distracting for drinkers in general, because such cues acquire motivational salience long before dependence develops.

Methodological factors and participant characteristics may affect the level of interference observed. For example, Sharma and McKenna (2001) reported that time pressure influenced emotional Stroop performance. Elsewhere, Ryan (2002a) has noted that low mood might amplify susceptibility to Stroop interference in alcoholics. However, Lusher *et al.* (2004) controlled for mood and demographic factors and found that alcoholics nevertheless showed greater interference from drink-related words than did controls.

6) Cue-reactivity: Theoretical explanations

CR has been suggested to play an important role in the maintenance of problematic drinking behaviour (Drummond *et al.*, 1995) and in triggering alcoholic relapse following quit attempts (Junghanns *et al.*, 2005). CR effects were for a long time interpreted in terms of Pavlovian conditioning, that is, as a consequence of repeated pairings of the effects of a psychoactive drug with contingently presented contextual cues (e.g. the sight and smell of alcohol). It was postulated that conditioned responses were either appetitive / drug-like (i.e. conditioned responses mimicking the unconditioned effects of the drug; e.g. Stewart, de Wit & Eikelboom, 1984) or compensatory / withdrawal-like (i.e. conditioned responses opposing the unconditioned effects of the drug; e.g. Siegel & Ramos, 2002). However, in a meta-analysis of CR research, Carter and Tiffany (1999) concluded that the evidence supported neither of these positions: drug-related cues, they claimed, consistently triggered increased subjective craving and changes in physiological arousal, but such responses could not easily or straightforwardly be categorised as either drug-like or withdrawal-like.

More recently, it has been suggested that alcohol-related stimuli can acquire incentive-motivational properties, thereby altering the way in which these stimuli are processed. In their 'incentive sensitisation' theory, Robinson and Berridge (1993, 2000) argue that, in susceptible individuals and under certain circumstances, the repeated administration of an abusable drug can persistently change the

structure and function of brain cells and circuits involved in regulating the attribution of incentive salience to stimuli. In particular these include DAergic projections within MCL circuitry. Neuroadaptations render these brain circuits hypersensitive such that pathological levels of incentive salience are attributed to drugs and their associated stimuli.

Robinson and Berridge (1993, 2000) contend that incentive motivation is underpinned by two separable neural substrates: (a) that associated with determining incentive value and the linked psychological state of 'wanting'; and (b) that mediating hedonic tone and the linked psychological state of 'liking'. 'Wanting' thus reflects the attribution of incentive salience to stimuli. Repeated drug administration is claimed to sensitise the neural systems mediating incentive salience, so that the drug is perceived as increasingly salient and becomes imbued with strong motivational properties, but not the neural systems which mediate 'liking'. This is consistent with the observation that the transition to addiction appears to be accompanied by decreasing drug liking, but increasing drug 'wanting'. Thus, the drug and its associated stimuli 'grab attention' and elicit approach behaviour. Procuring and consuming the drug become increasingly more important and strong subjective cravings develop.

Robinson and Berridge (1993, 2000) argue that such sensitisation, when combined with the impaired executive control and decision-making commonly observed in addicts (Jentsch & Taylor, 1999; Rogers & Robbins, 2001; Bechara, Dolan & Hindes, 2002; Schoenbaum & Shaham, 2008; see Section 7), can explain the core symptoms of addiction: compulsive drug-seeking and consumption despite profound adverse consequences, and relapse.

According to the incentive sensitisation model, then, subjective craving and attentional bias are conceptualised as cognitive and emotional outputs of the sensitised MCL DA system and both should parallel and/or influence alcohol-seeking behaviour. Accordingly, they should be positively correlated. Franken (2003) has additionally contended that a reciprocally excitatory relationship exists between subjective craving and attentional bias. That is, when alcohol-related cues become

the focus of attention, subjective craving increases, which in turn heightens the 'attention-grabbing' properties of alcohol-related stimuli. Thus, a ratchet effect occurs, increasing the likelihood of alcohol eventually being ingested. Similar models positing this bidirectional causal relationship have been advanced by Ryan (2002b) and Kavanagh, Andrade and May (2005).

Other models posit different underlying mechanisms for addicts' characteristic selective processing of drug-associated stimuli and craving. For example, Tiffany (1990) and Tiffany and Conklin (2000) contend that alcohol abusers experience subjective craving primarily when alcohol is not readily available and they have to engage in effortful behaviour to obtain it. Drug-associated stimuli then become particularly salient and able to capture attention.

7) Impulsiveness in alcohol-dependent individuals

Deficits of inhibitory control are implicated in virtually all contemporary neurobiological theories of addiction, accounting for the impulsive use of substances despite the problems they cause the individual, and their difficulty in resisting the urge to consume the substance when it is easily available to them. For example, Lubman *et al*. (2004) have characterised addiction as a compulsive disorder in which deficient inhibitory control mechanisms underpin loss of control over drug use. Likewise, the 'Impaired Response Inhibition and Salience Attribution' model (IRISA; Goldstein & Volkow, 2002, 2011) maintains that dependence is associated with overvaluing of drug rewards, undervaluing of natural rewards and deficient inhibitory control.

There appears to be a central inhibitory control mechanism which modulates pre-potent appetitive responses to reinforcers such as food, water and sex, as well as drugs of abuse. This mechanism transiently suppresses rapid, semi-automatic conditioned responses and enables more reasoned cognitive mechanisms to influence behaviour. This seems to be a function of the frontostriatal system, since dysfunction within this region is associated with pathologically impulsive behaviour in a variety of psychological disorders (Robbins, 1990, 1996; Damasio, 1996). Thus traumatic damage to frontal regions is often associated with disinhibition, whereby

behaviour becomes strongly driven by conditioned stimuli (Robbins, 1996). Damage to orbitofrontal cortex or prelimbic cortex has been associated with a tendency to prefer smaller, immediate rewards to larger, delayed rewards (Damasio, 1996). Jentsch and Taylor (1999) argue that chronic exposure to drugs of abuse induces dysfunction within the MCL DAergic system. DAergic neurons from the VTA project diffusely to prefrontal cortex (PFC), which is critically involved in higher-level 'executive' cognitive functions including inhibitory control, behavioural regulation, novel problem-solving and decision-making. Deficits in these abilities therefore manifest as impulsive/disinhibited behaviour.

Chronic drug abusers show reduced levels of DA D_2 receptors in striatal regions, and this appears to be associated with reduced PFC activity (Volkow *et al*., 1993, 2001). Addicted individuals demonstrate abnormalities in the structure and function of regions of the PFC, in particular the orbitofrontal cortex (OFC), anterior cingulate gyrus (ACG; London *et al*., 2000; Volkow *et al*., 1993) and dorsolateral PFC (DLPFC; Robinson *et al*., 2001). Chanraud *et al.* (2007) found volumetric differences between alcohol-dependent (AD) individuals and controls using MRI and voxel-based morphometry. Specifically, ADs showed significant reductions in gray matter bilaterally in the DLPFC, and in temporal cortex, insula, thalamus and cerebellum. There were also widespread decreases in white matter. These effects may have been exacerbated by elevated rates of smoking in ADs compared with controls (Feil *et al.*, 2010). Similarly, Makris *et al.* (2008), using segmentation-based MRI morphometry, reported that volumetric reductions were most prominent in the DLPFC and right insula (as well as right NAcc and left amygdala) of abstinent long-term chronic alcoholics. Interestingly, there was a positive correlation between length of abstinence and volumes in some areas, suggesting that brain volume may normalise with abstinence. However, no correlation was observed between length of abstinence and volume of the DLPFC and amygdala, possibly indicating persisting abnormality in these areas which might either have predated or resulted from chronic drinking.

Akine *et al.* (2007) assessed brain activation in 9 young AD patients and 9 controls while they completed a memory task activating the frontal lobe. Even though there

was no difference in the behavioural performance of the two groups, the ADs exhibited lower activation in the right DLPFC, ACC, left pulvinar in the thalamus, and the right ventral striatum. Clark *et al.* (2007) similarly found that young alcohol-dependent women showed lower cerebral perfusion than controls in prefrontal and left parietal regions.

However, most structural and functional brain studies are of limited conclusiveness through small sample sizes and poor matching of ADs and controls in relation to their histories of nicotine and other drug use (Feil *et al.*, 2010). Thus between-group differences may either be artificial or reflect poly-drug use and associated socio-demographic factors. In this regard, it is interesting that Loeber *et al.* (2009a, 2009b, & 2010) have argued that withdrawal from alcohol may itself produce neurotoxic lesions in the frontal lobe. They reported that alcoholic patients with two or more medically-supervised detoxifications demonstrated greater impairments than those who had been detoxified no more than once, on the IGT, a maze task, a reward delay task, and a vigilance task. Chronic alcohol consumption disrupts glutamatergic transmission in the brain and is associated with prolonged inhibition of the N-methyl-D-aspartate receptor (Lovinger, 1993). Tsai and Coyle (1998) suggest that an abrupt cessation of alcohol consumption can lead to toxicity due to under-opposed glutamate release; and since the frontal lobes are richly innervated by glutamatergic pathways (Kril *et al.*, 1997), they may be particularly susceptible.

In relation to the executive functions of the PFC noted above, Aron, Robbins & Poldrack (2004) suggest that orbitofrontal cortex (OFC) function is involved in processing the affective value of stimuli and adjusting behaviour accordingly; the anterior cingulate in inhibition of prepotent reflexive responses; and the dorsolateral PFC (DLPFC) in the monitoring of strategically-guided behaviour and working memory.

In any event, the evidence of deficient PFC functioning in ADs is complemented by questionnaire and behavioural evidence of abnormally high levels of impulsiveness. As noted previously, this is likely to be a behavioural manifestation of weak

inhibitory control and/or heightened sensitivity to appetitive stimuli. Indeed, reductions in fronto-parietal gray matter volume observed in alcoholics have been found to correlate with impairments in performance on neuropsychological tests of executive functions such as the Wisconsin Card Sorting Test, the Letter Fluency Test, the Stroop Task and the Letter-Number Sequencing Test (e.g. Dao-Castellana *et al.*, 1998; Noël *et al.*, 2001; Demir *et al.*, 2002a, 2002b; Chanraud *et al.*, 2007).

Chapter 2 will discuss in more detail the ongoing debate over how to define impulsivity. Briefly, it does not appear to be a unitary construct; Olmstead (2006), for example, has suggested that it incorporates two discrete components: a failure of inhibitory control over reward-driven behaviour or pre-potent responses, sometimes termed 'motor impulsiveness'; and impaired decision-making, arising from over-sensitivity to immediate rewards and under-sensitivity to delayed consequences ('cognitive impulsiveness'). Patton, Stanford and Barratt (1995) separated it into *three* components: 'motor impulsiveness' (action in the absence of adequate thought), 'attentional impulsiveness' (impaired focus on the task-at-hand), and 'non-planning impulsiveness' (orientation towards the present at the expense of the future). There is considerable overlap between Patton *et al.*'s (1995) components of motor and non-planning impulsiveness, and Olmstead's (2006) motor and cognitive impulsiveness components, respectively. People with AUDs consistently demonstrate high levels of both cognitive and motor impulsiveness (Verdejo-García *et al.*, 2008). Salgado *et al.* (2009) suggest that elevated attentional impulsiveness might be associated with difficulty in avoiding drug-related thoughts, or in establishing new patterns of social behaviour during the early phases of abstinence.

Instruments used to assess impulsiveness

Various instruments have been developed to assess impulsiveness. As with measures of CR, they can be broadly divided into subjective (self-report) measures and objective behavioural tests which tap specific manifestations of impulsive behaviour. There is ongoing debate concerning the relationship between *how* individuals behave and how they *report* they behave; thus, the correlations

between different indices are generally no more than weak to moderate (Reynolds *et al.*, 2006a) and they are often completely uncorrelated (Dom *et al.*, 2006b). One explanation is that although individual differences in trait impulsiveness are relatively stable, levels of state impulsiveness fluctuate (see Chapter 2). Thus, de Wit (2009, p. 28) contends that 'abrupt environmental, physiological or emotional events may cause transient 'state' changes in either self-control or inhibition'.

'Trait' impulsiveness is typically measured using self-report instruments such as the Barratt Impulsivity Scale (BIS-11; Patton *et al.*, 1995), which ask respondents to rate items such as 'I concentrate easily' and 'I act on the spur of the moment' in relation to self-perceptions developed over their lifetime.

Trait impulsiveness

Examples of widely-used self-report measures include the BIS-11, the Sensation Seeking Scale (SSS; Zuckerman *et al.*, 1964), the EASI-III Impulsivity Scales (Buss & Plomin, 1984), the Functional and Dysfunctional Impulsivity Scales (Dickman, 1990), the I-7 Impulsiveness Questionnaire (Eysenck *et al.*, 1985a) and the Urgency, Premeditation, Perseverance and Sensation Seeking Scales (UPPS; Whiteside & Lynam, 2001). With the exception of the SSS, these instruments are all detailed in Chapter 2, pages 60-62. Of these, by far the most widely-used to date has been the BIS-11. Their subscales do not generally correspond to the two-factor conceptualisation advanced by Olmstead (2006), because they have been derived from different theoretical models or have been derived from statistical data reduction techniques in particular samples. An increasing number of studies using such scales have reported greater impulsiveness in both current and former alcohol-dependent individuals and abusers compared to healthy controls (e.g. Von Knorring, Oreland & Von Knorring, 1987; Hallman *et al.*, 1990; Ketzenberger & Forrest, 2000; Bjork *et al.*, 2004; Chen *et al.*, 2007; Von Diemen *et al*., 2008; Cangemi *et al.*, 2010; Tomassini *et al.*, 2012).

Behavioural measures

'State' variations in impulsiveness are theoretically likely to be detected via performance on behavioural tasks, such as Go/No-Go and Stop Signal tasks. However, performance on different behavioural impulsivity tasks intercorrelate weakly (de Wit, 2009), suggesting that they may be sensitive to disparate processes. The behavioural tendencies tapped by the tasks are, nevertheless, individually of interest in terms of their potential relevance to real-life impulsive behaviours including alcohol consumption. The 'Delay Discounting' procedure measures the extent to which behaviour is sensitive to long-term consequences; it is a measure of cognitive impulsiveness. Participants are given a choice between a small hypothetical reward (e.g. a certain amount of money) delivered immediately or a larger hypothetical reward which can only be collected following a delay. A preference for relatively small but immediate rewards over larger delayed rewards is believed to reflect difficulty in delaying gratification. A number of studies have observed greater discounting in alcohol dependent and abusing samples relative to controls. Petry (2001) reported that current and former alcoholics both demonstrated abnormally high discounting of monetary and alcohol rewards. Similar findings have been reported by Bjork *et al.* (2004), Mitchell *et al.* (2005, 2007), Boettiger *et al.* (2007), Bobova *et al.* (2009) and MacKillop *et al.* (2010). Negative findings have however been reported by Kirby & Petry (2004) and MacKillop *et al.*, 2007). Elevated delay discounting has also been reported in smokers (e.g. Baker, Johnson & Bickel, 1997; Fields et al., 2007), cocaine addicts (e.g. Coffey *et al.*, 2003; Heil *et al.*, 2006;) and heroin abusers (e.g. Madden et al., 1997; Bickel & Marsch, 2001).

Many behavioural tasks tap inhibitory control. For example, the Stop Signal task (Logan, 1994) assesses the ability to override a pre-potent 'go' response when an infrequent 'stop' signal is given. Because the difficulty of the task can be adjusted by manipulating the delay between the 'go' stimulus and the 'stop' signal, it is highly sensitive to inhibitory deficits. Stop-signal reaction time (SSRT) is estimated for each participant, indexing the efficiency of the stopping process. Goudriaan *et al.* (2006), Lawrence *et al.* (2009) and Schmaal *et al.* (2013) have all reported significant

performance deficits in an alcohol-dependent group compared with controls. The Stop Signal Task has also identified inhibitory control impairments in abusers of other substances, including cocaine (Lane *et al.*, 2007). Li *et al.* (2009) tried to identify the underlying neural circuits involved in impaired impulse control. Twenty-four abstinent alcohol-dependent patients and 24 controls underwent fMRI whilst they completed the Stop Signal Task. It was found that dysfunctional impulse control in the clinical group was associated with low cortical activation in the DLPFC, while risk-taking decisions were related to low activation of the medial OFC, bilateral parietal cortices and rostral ACC.

Bjork *et al.* (2004) used another behavioural assessment of inhibitory control, the Continuous Performance Test (CPT; Conners *et al.*, 2003). In this task, the participant must respond (e.g. by pressing a button) when specified 'go' stimuli are presented and inhibit responding when a 'no-go' stimulus appears. A 'commission error' occurs when the participant responds to a no-go stimulus and reflects failure to inhibit a pre-potent motor response. Examples of this task are described in detail in Chapters 2 (pp. 122-123) and 3 (pp. 177-178). Alcohol-dependent patients in Bjork *et al.*'s (2004) study exhibited higher rates of commission errors, as predicted. Similarly, Salgado *et al.* (2009) found that a sample of 31 AD individuals who had been abstinent for between 15 and 120 days made more commission errors in the CPT than 30 healthy controls. Another popular measure of inhibitory control, similar to the CPT, is the Go/No-Go task; Kamarajan *et al.* (2005), however, found no difference in response inhibition between alcoholics and controls using this task.

Impulsivity is often measured by tasks assessing decision-making ability. Probably the most widely-used such instrument, the Iowa Gambling Task (IGT; Bechara *et al.*, 1994), was developed specifically to simulate real-life decision-making under ambiguous conditions. This task is described in detail on pages 178-179. Performance on the IGT has been empirically linked with activity in the ventromedial prefrontal cortex (VMPFC). Thus, lesion studies have revealed that IGT performance is impaired following damage to the VM, but not the dorsolateral, region of the PFC (Bechara *et al.*, 1998); positron emission tomography (PET) has shown VM activation during IGT performance (Grant, Contoreggi & London, 2000);

and electrophysiological studies have likewise shown greater activity in the VM during IGT performance, particularly during the period immediately prior to decision-making (Adolphs *et al.*, 2000).

Bechara *et al.* (2001) tested individuals dependent on either alcohol or stimulants (SDs), healthy controls, and patients with bilateral lesions of the ventromedial prefrontal cortex (VMs) on the IGT. As predicted, SDs performed worse than controls: 61% performed within the range of the VM patients, compared with only 32.5% of the controls. Neither age, sex, level of education, intelligence (IQ) or memory, nor performance on standard tasks of executive function, could account for these performance differences. IGT performance was best predicted by years of abuse, duration of abstinence, number of relapses and number of times in treatment. Other evidence has found impaired decision-making in people addicted to opiates (Mintzer, Copersino & Stitzer, 2005; Verdejo-García, Perales & Pérez-García, 2007), psychostimulants (Bechara *et al.*, 2001; Bolla *et al.*, 2003) and marijuana (Bolla *et al.*, 2005). Within drinkers, 'early-onset' alcoholism has been found to be particularly characterised by decision-making impairment (Dom *et al.*, 2006b; Mazas, Finn & Steinmetz, 2000).

Heightened impulsiveness may be either a determinant or a consequence (or both) of alcohol and other drug use. As indicated previously, there is some evidence that chronic drug use causes prefrontal cortical dopaminergic hypofunction and other changes in cortical neurobiology which may result in difficulty inhibiting inappropriate responses. Conversely, trait impulsivity has been implicated as a risk factor for problematic drug use. Longitudinal and cross-sectional studies have indicated that high impulsiveness pre-dates chronic drug use. For instance, in a sample of 457 young adults, Sher, Bartholow and Wood (2000) found that 'behavioural disinhibition', a trait measured by standardised self-report personality instruments, predicted substance use disorder six years later. Habeych *et al.* (2006) reported impairments on an oculomotor response inhibition task, which is sensitive to prefrontal dysfunction, in a sample of children at high familial risk for alcohol-use disorder. Interestingly, Jones *et al.* (2011) reported that inducing a state of disinhibition in social drinkers led to increased alcohol consumption, relative to a

control manipulation, suggesting a causal effect of disinhibition on alcohol consumption. The importance of delay aversion and inhibitory control failures may change across the development and course of alcohol dependence. Rubio *et al.* (2008) assessed 384 heavy drinkers and 149 healthy volunteers at baseline and four years later. Over the course of this period, 33% of the heavy drinkers developed alcohol dependence. Whereas difficulty in delaying reward correlated with baseline substance use, impaired inhibitory control at baseline predicted the subsequent development of dependence.

8) Aetiology of mesocorticolimbic dysfunction in substance dependence

The mechanisms via which a substance user's MCL system becomes hypodopaminergic are at present unclear, though could relate to both chronic alcohol intake and genetic factors. Crabbe (2002) has proposed a diathesis-stress relationship.

Numerous family, twin and adoption studies, as well as linkage analyses, have estimated the heritability of alcohol dependence as between 50 and 60 percent (Stacey, Clarke & Schumann, 2009). Genes which code for DA synthesis, degradation, receptors and transporters might mediate this heritability. A number of studies have reported a relationship between the DRD_4 gene and alcohol abuse. Laucht *et al.* (2007) found that male adolescents carrying the 7-repeat allele of DRD_4 consumed more alcohol per occasion and reported higher rates of lifetime heavy drinking than males without this allele. However, the DRD_2 TaqI A1 gene has generated the most interest in relation to AUDs. In a post-mortem study of 35 alcoholics and 35 non-alcoholics, Blum *et al*. (1990) reported that the presence of the DRD_2 TaqI A1 allele correctly classified 77% of alcoholics, whilst its absence classified 72% of non-alcoholics. In this study, however, most of the former died due to the effects of alcohol; it may therefore be that the DRD_2 TaqI A1 allele is related to a particularly severe presentation of alcoholism. A recent meta-analysis (Smith *et al.*, 2008) of fifty-four studies collectively including 9,382 participants found a more modest association between this allele and alcohol dependence.

The presence of the DRD_2 TaqI A1 allele has been repeatedly associated with reduced D_2 receptor density in the striatum (Bowirrat & Oscar-Berman, 2005). Noble (2000) has proposed that this gives rise to 'Reward Deficiency Syndrome' in which compromised DAergic activity produces an anhedonic state which individuals seek to reverse by engaging in activities such as use of alcohol and/or other drugs of abuse which potentiate midbrain DA activity. The finding that unaffected members of alcoholic families have higher-than-normal levels of DA D_2 receptors (Volkow *et al*., 2006) adds support to this hypothesis, as do empirical findings that the DRD_2 TaqI A1 allele predicts an individual's subjective response to alcohol consumption (London *et al*., 2009) and impulsiveness (Eisenberg *et al*., 2007; Esposito-Smythers *et al*., 2010; Limosin *et al*., 2003).

There is some evidence that chronic alcohol consumption can induce dysfunction within MCL DAergic circuitry, though many studies have failed to control for potential genetic factors. Reviewing preclinical studies, Weiss and Porrino (2002) suggest that over the course of chronic ethanol exposure, adaptations develop within MCL DAergic circuitry and counteract the sustained stimulation of the system by ethanol. Such studies have revealed that withdrawal from chronic ethanol is followed by substantial decrements in extracellular NAcc DA levels (Rossetti, Hmaidan & Gessa, 1992; Weiss *et al*., 1996) and VTA DA neuron activity (Diana *et al*., 1992a, 1992b; Shen & Chiodo, 1993). These findings are consistent with the view that heavy drinkers may increase their consumption in order to compensate for decreasing levels of DA activity.

The mechanisms via which chronic ethanol intake induces DA hypofunction are controversial. Following the observation that pharmacological inhibition of L-type calcium channels selectively blocks the withdrawal syndrome, Rossetti *et al*. (1999) suggested that over-activity of such channels may suppress DA release during withdrawal. Rats maintained on ethanol show reduced expression of tyrosine hydroxylase and elevated levels of DA transporters, suggesting that DA hypofunction might result from decreases in DA synthesis and enhanced clearance of synaptic DA (Rothblat, Rubin & Schneider, 2001).

DA deficits appear to be long-lasting. Bailey *et al.* (2000) reported changes in NAcc DA turnover and synthesis for as long as two months after ethanol withdrawal in mice. In human alcoholics, DA transporter (DAT) binding has been found to be depressed four days after withdrawal, but appears to recover with continued abstinence (Laine *et al*., 1999). Clinical studies suggest that a slow rate of recovery of DA receptor function predicts relapse and poor treatment outcome (Heinz *et al*., 1995), possibly because the individual is motivated to reinstate 'normal' DA function by drinking.

9) Evidence for biological and behavioural dysfunction in non-dependent 'social' drinkers

The vast majority of the aforementioned clinical research has been with long-term, chronically relapsing alcohol-dependent samples. Yet since addiction theory (e.g. Robinson & Berridge, 1993, 2000; Jentsch & Taylor, 1999) conceptualises such chronic patterns of addictive behaviour as the 'end-point' of a progressive development, those with non-dependent patterns of consumption should also demonstrate some of the psychological features of addiction. This view has increasingly been corroborated by research with non-dependent samples, including so-called 'hazardous' drinkers (see p. 22) as well as more moderate social drinkers.

Cue-reactivity (CR)

When presented with alcohol cues, non-dependent heavy drinkers (HDs) have reported greater desire for alcohol than light social drinkers (LDs) (Greeley, Swift, Prescott & Heather, 1993; McCusker & Brown, 1990; Walitzer & Sher, 1990). HDs have also been reported to show cue-elicited autonomic responses, including increases in pulse rate (McCusker & Brown, 1990), salivation, skin temperature reactivity and skin conductivity (Walitzer & Sher, 1990). HDs' automatic cognitive processing, like that of dependent drinkers, is affected by alcohol cues. Thus, Cox *et al.* (1999) reported that after being exposed to such cues, HDs were slower in colour-naming alcohol-related words than they were after exposure to neutral stimuli; LDs were not affected by exposure to such cues. Similar findings have been reported by Jones and Schulze (2000). Stroop interference effects have also been

documented in non-dependent problem and moderate social drinkers (see pp. 31-32). These findings suggest that CR is not an 'all-or-none' phenomenon which occurs only in drinkers with a diagnosis of alcohol dependence.

Impulsiveness

There is accumulating evidence that HDs are more impulsive than LDs. This has been reported in terms of higher levels of delay discounting of hypothetical monetary and alcohol rewards (Field *et al.*, 2007; Vuchinich & Simpson, 1998; Moreno *et al.*, 2012). Similarly, Kollins (2003) reported a significant positive correlation between the number of times college students had 'passed out' from alcohol use and their scores on a delay discounting task. Amongst 13-17 year olds, Rossow (2008) found delay discounting to be positively associated with drinking frequency and intoxication frequency even when age, gender, impulsivity and disposable income were controlled for. These effects seem to reflect observations in 'real-life' settings. In a study by Moore & Cusens (2010), 46 male social drinkers were breathalysed twice: once as they entered a bar and again when they left. In an earlier interview, participants' delay aversion had been estimated via an interviewer-led screening task consisting of 12 questions. Those who discounted future rewards more heavily demonstrated a greater degree of alcohol intoxication at the end of their drinking session. However, results are conflicting as a few studies have reported no association between alcohol consumption and delay discounting rate (e.g. MacKillop *et al.*, 2007; Reimers *et al.*, 2009; Fernie *et al.*, 2010). A meta-analysis by MacKillop *et al.* (2011) found that although evidence exists for elevated delay discounting of future rewards amongst clinical samples dependent on or abusing alcohol, this seems much less pronounced in non-clinical samples. It may be that the non-clinical samples in such studies do not exhibit increased discounting of future rewards because they do not contain enough participants with a substantial drinking history (Christiansen *et al.*, 2012); this account is supported by the observation that negative findings have often been reported in studies of largely undergraduate drinkers (e.g. MacKillop *et al.*, 2007; Fernie *et al.*, 2010).

Effects of drinking status have also been reported on measures of response inhibition. In the Go/NoGo task, Colder & Connor (2002) reported that in a sample of 106 undergraduates, high numbers of commission errors were associated with high levels of alcohol use. Similarly, Henges & Marczinski (2012) found that in social drinkers aged between 18 and 21, commission errors correlated with the highest number of drinks they had consumed on one occasion during the previous month. Recent cross-sectional studies have supported this association. Ahmadi *et al.* (2013) found that, compared to light drinkers, heavy drinkers exhibited dysfunction in suppressing prepotent responding in the Go/NoGo task as manifested via increased reaction times for Go correct-hits and NoGo false alarms. These authors also found that during fMRI NoGo correct rejections, light drinkers showed greater BOLD response than heavy drinkers in a number of relevant brain regions. Similar results have been reported by Murphy & Garavan (2011), and Petit *et al.* (2012). In the Stop Signal task, Smith & Mattick (2013) found that young female heavy drinkers exhibited a longer stop-signal reaction time (i.e. the time required to inhibit the inappropriate response) than lighter drinking controls. However, results are not consistent across studies as Fernie *et al.* (2010) and Moreno *et al.* (2012) reported no differences in response inhibition between heavy drinkers and controls. As suggested above in relation to delay discounting, it may be that inconsistent findings are related to the non-dependence of these samples. It is notable in this respect that though Yan & Li (2009) reported no performance differences between heavy and light drinkers in a Stop Signal Task, they *did* find heavy drinkers to exhibit reduced amygdala activation[5] during 'risk-taking' in this task (i.e. post-go 'speeding' versus post-go 'slowing') compared to light drinkers. Similarly, Bednarski *et al.* (2012) reported decreased activation in right superior frontal gyrus and left caudate nucleus during 'risk-taking' trials. Thus, it may be that though behavioural tasks – typically developed on clinical samples – are sometimes not sensitive enough to distinguish between non-dependent groups, differences in 'direct' brain activation measures can reflect an underlying inhibitory control dysfunction in heavier social drinkers. Using event-related potentials (ERPs), Oddy & Barry (2009) have also

[5] Amygdala activation has previously been shown to be related to the 'risk-taking' measure used in Yan & Li's (2009) study (Li, Chao & Lee, 2009).

reported differences in brain activity between non-dependent heavy and light drinkers in a CPT in the absence of performance differences (for more detail, see Chapter 3, pp. 115-116).

As per observations in dependent samples, a number of cross-sectional and longitudinal studies suggest that elevated impulsivity on self-report scales, such as the BIS-11 and SSS, correspond with increased alcohol consumption and related problems in non-alcohol-dependent adolescents and adults alike (Waldeck & Miller, 1997; Gunnarsson *et al.*, 2008; McAdams & Donnellan, 2009; Carlson *et al.*, 2010; Fernie *et al.*, 2010; Hamilton, Sinha & Potenza, 2012; Henges & Marczinski, 2012; Lyvers *et al.*, 2012; Papachristou *et al.*, 2012). Evidence for the association between self-report trait impulsiveness and alcohol use has at present been more consistently demonstrated than for either measure of behavioural impulsivity.

More research is needed to elucidate the relationship between impulsiveness and the development of heavy or problematic drinking, in particular the chronological relationship and the extent to which impulsivity may predict or arise as a consequence of chronic heavy social drinking.

10) The present thesis

Since research investigating addiction has most commonly recruited chronic and physically-dependent individuals, there has been little exploration/testing of theory-driven hypotheses concerning the development of heavy drinking and addiction. In order to enhance understanding of the mechanisms leading to addiction, it is necessary to investigate social drinkers and non-dependent problem drinkers. The evidence reviewed in Section 9 adds weight to the notion that cognitive and behavioural impairments parallel a continuum of severity of maladaptive drinking.

The present thesis sought to examine the extent putative manifestations of a dysfunctional underlying MCL DAergic system are present in non-physically-dependent social and problem drinkers. The first study developed a new self-report measure of state impulsiveness to parallel existing trait measures and to enable

subsequent exploration of relationships with alcohol consumption. Study 2 thus investigates whether heavy social drinkers demonstrate evidence of greater electrophysiological CR and impulsiveness than light social drinkers; and Study 3 investigates whether social and heavy drinkers are differentially affected by 'priming' doses of alcohol in terms of their performance on tests believed to index relevant brain circuitry.

Chapter 2: The development of a self-report questionnaire to measure recent impulsiveness and an exploration of its association with recent alcohol consumption

Abstract

Background: *Traditionally, impulsiveness has been regarded as a stable construct; this view is reflected by widely-used self-report impulsiveness measures. Recently, however, behavioural laboratory studies (e.g. Fillmore & Vogel-Sprott, 1999) have indicated that, firstly, impulsivity can fluctuate within individuals over time, and secondly, that acute increases in impulsivity can be observed following the ingestion of a small dose of alcohol. Such studies appear consistent with the view that the construct has a state as well as a trait manifestation. Yet whilst traditional impulsiveness questionnaires can be said to tap the former, there is not self-report instrument to assess recent fluctuations in impulsivity.*

Research aims and design: *The present study set out to develop and validate a measure of recent impulsivity; part of the validation included an examination of the association between this scale and recent alcohol intake. In developing a Recent Impulsivity Scale (RIS), traditional impulsiveness questionnaires were examined in order to identify items amenable to being converted into a 'recent' format. These converted items were included in a pilot version of the instrument which was administered, along with an accompanying trait version (the Trait Impulsiveness Scale; TIS), to two cohorts of first-year Psychology undergraduates on two occasions 1 month apart. Respondents also completed the BIS-11 (Patton, Barratt & Stanford, 1995) and gave information concerning their habitual and recent alcohol intake.*

Results: *Factor analyses revealed two factors, which were named 'Cognitive Impulsivity' (CI) and 'Motor Impulsivity' (MI). Consistent with the hypothesis that recent impulsivity would be less stable than trait impulsivity, correlational analyses revealed, firstly, that: i) the TIS correlated more highly than the RIS with the BIS-11; and ii) the MI subscale of the RIS showed lower test-retest stability than the MI subscale of the TIS. Additional analyses exploring associations between subscale*

scores and patterns/recency of alcohol use yielded some further evidence that state impulsivity was more sensitive than trait impulsivity to factors known to increase the likelihood of impulsive behaviour.

Conclusions: *These data offer some, albeit mixed, support for the contention that recent changes in alcohol intake are related to real-world recent impulsiveness as assessed by self-report. In broad terms, these findings are consistent with laboratory studies, such as that of Fillmore and Vogel-Sprott (1999), showing alcohol to induce increased impulsivity.*

Introduction and rationale

Jentsch and Taylor's (1999) important theoretical framework of addiction contends that chronic drug abuse compromises pre-frontal neurobiological integrity with the consequence that impulsiveness becomes elevated. Recent research has suggested that the tendency to act impulsively is not static but dynamic and that alcohol can induce acute fluctuations in impulsiveness in non-addicted individuals. The primary purposes of the present study were firstly, to develop a self-report scale to capture recent impulsiveness (RI: such a measure does not at present exist), and secondly, to examine the associations between scores on this scale and recent alcohol intake.

Overview of introduction and rationale: To contextualise the principal issues that this study was designed to examine, Section 1. i first addresses the facts that (a) defining impulsiveness has proved difficult, since it appears to be a multi-faceted construct; and (b) there are a variety of methods designed to measure these various facets. Section 1. ii considers evidence of little correlation between self-report and behavioural laboratory indices of impulsiveness, possibly indicating that it is to some extent a dynamic construct, and that behavioural measures are more sensitive to state fluctuations than self-report. Self-report measures are quicker and easier to administer, yet for recent fluctuations in impulsivity no such measure at present exists. Sections 2. i and ii address the relationship between impulsivity and alcohol use: alterations in impulsivity following both acute and chronic intake of drugs of abuse is a focus of modern theories of alcohol dependence, and alcohol

can also induce acute changes in impulsivity in non-dependent social drinkers. The aims and hypotheses of the present study are set out in Section 3.

1. i) Defining and measuring impulsiveness

Impulsiveness has been defined as 'a predisposition toward rapid, unplanned reactions to internal or external stimuli with diminished regard for the negative consequences of these reactions to the impulsive individual or others' (Moeller *et al.*, 2007, p. 1784). It is postulated to be a dimension of normal behaviour, the higher end of the continuum being associated with a wide range of maladaptive behaviours including inability to wait, difficulty withholding responses, insensitivity to negative or delayed consequences (de Wit, 2009) and substance abuse (Koob & LeMoal, 2001).

It appears that impulsivity is a complex, multi-dimensional construct, and a range of conceptualisations have been proposed. Currently, there is widespread agreement that it consists of at least two different but related components, commonly referred to as 'behavioural disinhibition' and 'delay aversion' (Dom *et al.*, 2006a). Behavioural disinhibition is the inability to appropriately inhibit maladaptive actions; delay aversion the extent to which immediate rewarding consequences have greater control over an individual's behaviour than do delayed rewards (Ainslie, 1975). De Wit (2009) has argued for a third component, 'attentional impulsiveness': difficulty in focusing attention or concentrating, which is related to executive functioning deficits and reduced cognitive flexibility (Stanford *et al.*, 2009).

Reflecting the variety of conceptualisations of impulsiveness, a range of measures have been developed. The two principal classes of instrument are self-report and behavioural laboratory measures. Widely-used self-report measures include the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995) and the Sensation Seeking Scale (SSS; Zuckerman *et al.*, 1964). These tend to include items indexing the diverse behaviours falling under the umbrella of 'impulsiveness', and when factor analysed give rise to orthogonal subscales; they do not, however, always clearly correspond with the currently-favoured two-factor model of

impulsiveness. The items of the BIS-11, for example, yield three subscales labelled Attentional Impulsiveness, Motor Impulsiveness, and Non-Planning Impulsiveness. A recent incarnation of the SSS, the Sensation Seeking Scale-Form V (SSS-V), comprises four subscales: Boredom Susceptibility, Experience Seeking, Disinhibition, and Thrill and Adventure Seeking.

Behavioural laboratory measures fall broadly into those measuring either delay aversion or behavioural inhibition (Dom *et al.*, 2006b). With respect to the former, Delay Discounting tasks (DDTs) tap the respondent's preference for smaller, more immediate rewards compared to larger, more delayed rewards (Rachlin, Raineri & Cross, 1991). Impulsive individuals tend to prefer more immediate rewards and, in the context of a specified delay, 'discount' the greater value of a delayed monetary reward relatively quickly (Rachlin & Green, 1972); that is, compared to less impulsive individuals, they are prepared to wait less long in order to obtain the larger reward.

Behavioural Inhibition tasks measure the ability to refrain from making a prepotent response. During the commonly used Go/NoGo, Stop Signal Task (SST; Logan, 1994), and Continuous Performance Task (CPT; Conners *et al.*, 2003), the participant must make rapid motor responses in 'go' trials but inhibit responses when a 'no-go' signal is presented. Children with a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD), who are disinhibited and demonstrate poor behavioural control in daily life, show impairment on these tasks (Tannock, Ickowicz & Schachar, 1995). For more detailed descriptions of these behavioural tests of impulsivity, see Chapter 1 (pp. 39-40).

1. ii) Sensitivity of different measures to transient changes in impulsiveness

There is often little association between self-report and behavioural laboratory measures of impulsiveness. For example, Dom *et al.* (2006b) reported no significant correlations between delay discounting rates and any of the subscales of either the BIS-11 or the SSS. This may be because different impulsiveness instruments measure different aspects of a genuinely multifaceted construct. However, there are some important methodological differences inherent to the two forms of

measurement. Firstly, self-report questionnaires are sensitive to reporting bias, whereas behavioural measures are more objective. Thus, whilst self-report measures often have greater face validity, they may be less reliable. Secondly, existing self-report questionnaires generally assume that impulsiveness is a stable characteristic (i.e. a trait), whereas recent research suggests that it can fluctuate within individuals over time (de Wit, Enggasser & Richards, 2002; Shiels *et al.*, 2009; Strakowski *et al.*, 2010). The wording of items in trait instruments is, by definition, insensitive to transient changes in impulsiveness, asking about general propensities. For example, the BIS-11 presents statements such as 'I plan tasks carefully', 'I am restless at the theatre or lectures' and 'I do things without thinking', with response options referring to overall frequency ('Rarely/Never', 'Occasionally', 'Often' and 'Almost Always/Always'). They thus implicitly require the respondent to average over an extended period of time, rather than to focus more narrowly on recent behaviour. Behavioural measures, by contrast, should be sensitive to transient variations in impulsiveness as they measure the individual's actual responses at that precise moment.

Most individual studies have employed *either* self-report *or* behavioural laboratory measures. Since behavioural measures often require the use of computer software and/or other specialised apparatus, they can be rather hard to administer. A potentially easier and quicker method of assessing a person's current propensity towards impulsive behaviour would be a self-report instrument designed to gauge recent changes in impulsivity. In the current absence of such an instrument, the present study has been designed to develop one and subject it to preliminary validation.

2. i) Altered, dysfunctional impulsiveness is a prominent part of alcohol dependence

Heightened impulsiveness is a characteristic of a variety of psychiatric disorders and is a prominent feature of substance use disorders, including alcoholism (Dougherty *et al.*, 2004). In tests of behavioural disinhibition, such as the Continuous Performance and Go/No-Go tasks for example, participants with alcohol dependence demonstrate greater performance deficits than non-alcohol dependent

controls (Bjork *et al.*, 2004; Duka *et al.*, 2003). Those with alcohol dependence also tend to discount future rewards relative to immediate rewards at higher than normal rates (Bjork *et al.*, 2004; Mitchell *et al.*, 2005).

Recent theories of alcohol use disorders emphasise the importance of heightened impulsiveness in the development and maintenance of these disorders. Thus, Jentsch and Taylor (1999) have proposed that the neurobiological and neurochemical integrity of frontal cortical areas is crucial for 'normal' control of impulsive responses. Since chronic exposure to drugs of abuse is believed to produce neurochemical dysregulation in these areas, it could lead to elevated impulsivity, manifesting in impairments of inhibitory control and delay discounting. This theory draws upon preclinical evidence that, administered chronically or at high doses, drugs of abuse can be neurotoxic to monoaminergic neurons, causing loss of dopamine, serotonin and noradrenaline concentrations in the prefrontal cortex and striatum (Ridley *et al.*, 1982; Ricaurte *et al.*, 1984). Importantly, these reductions appear to be relatively selective for frontal cortical areas. If these findings generalise to humans, the dysfunction of orbitofrontal and prelimbic cortex could explain the observed tendency of heavy drinkers to discount delayed rewards (Damasio, 1996). Inhibitory control deficits may likewise reflect underfunctioning in frontal areas including the dorsolateral prefrontal cortex, lateral orbitofrontal cortex, ventromedial and limbic frontal cortex. Jentsch and Taylor (1999) argue that hypofunction of the prefrontal regions, which normally modulate the subcortical DA responses to salient stimuli, means that behaviour is more strongly stimulus-driven. Low prefrontal activity may thus lead to weak inhibition and, indirectly, to elevated reward sensitivity.

The relationship between impulsivity and substance abuse could well be bi-directional. For example, heightened TI appears to predate dysfunctional drinking behaviour, as evidenced by several prospective longitudinal studies. In 457 young adults, Sher, Bartholow and Wood (2000) reported subsequent substance use disorder to be predicted by 'behavioural disinhibition', a trait measured at baseline by standardised self-report questionnaires. One interpretation of the findings is that individuals higher in impulsiveness are more drawn to the short-term rewards of

alcohol and/or less able to control their intake, resulting over time in their becoming heavy drinkers. There is some evidence that genetic factors may influence vulnerability to dependence. The serotonin system has been associated with impulsiveness, and Nordquist *et al.* (2009) have found female alcoholics to have high rates of a functional polymorphism with potential effects on this system. Specifically, they found the functional polymorphism of the transcription factor TFAP2B to be more common in a sample of female alcoholics than in controls. TFAP2B has been shown to be involved in monoaminergic transmission via its regulatory effect on genes coding for fundamental elements of this system, such as monoamine oxidase type A and the serotonin transporter.

2. ii) Acute alcohol and transient changes in impulsivity

Broadly, Jentsch and Taylor's (1999) theory suggests that impulsiveness may be heightened by chronic drug intake. Elsewhere, many studies have demonstrated that alcohol acutely increases impulsive behaviour in non-dependent social drinkers. Alcohol impairs cognitive control, as evidenced by increased aggressiveness, risky driving, risky sexual behaviours and an increase in the likelihood of committing suicide (Steele & Southwick, 1985). Figures from the United States indicate that alcohol is involved in 45 percent of violent crimes, 45 percent of episodes of marital violence, 20 percent of non-fatal industrial accidents and 15 percent of non-fatal traffic accidents (Sher, 2008). This may simply reflect its general sedating effects, but could also reflect its acute effects upon dopaminergic systems in regions of the mesocorticolimbic system which are implicated in impulsive behaviour (see Chapter 1, pp. 34-36).

Behavioural laboratory studies have recently begun to elucidate the effects of alcohol on impulsiveness. A number of studies have reported that even relatively moderate doses of alcohol (approximately 0.4-0.6 g/kg), which produce blood alcohol concentrations (BACs) of around 0.06%, can induce behavioural disinhibition in procedures such as the Go/No-Go, Continuous Performance and Stop Signal Tasks. For example, in a study by Fillmore and Vogel-Sprott (1999), healthy undergraduates received either 0.6 g/kg of alcohol or placebo before completing

the Stop Signal Task. Alcohol impaired inhibition compared to placebo, but did not affect response time. Similar findings using a variety of related methodologies have confirmed alcohol's disinhibiting effect even at low doses (e.g. Fillmore & Vogel-Sprott, 1998; Dougherty *et al.*, 2000; Abroms & Fillmore, 2004; Easdon *et al.*, 2005; Abroms, Gottlob & Fillmore, 2006; Marczinksi, Combs & Fillmore, 2007; Rose & Duka, 2008). The effects on disinhibition have been found to be dose-dependent (e.g. Dougherty *et al.*, 2008), and alcohol has also been reported to produce impairments in inhibitory control over attention (Abroms *et al.*, 2006). In general, alcohol does not affect accuracy or speed of responding to 'go' cues, suggesting that the disruption of inhibitory control is relatively selective rather than part of a global disruption of psychomotor performance (Field *et al.*, 2010).

Neurobiologically, the effects of alcohol appear to be biphasic. Thus at low doses it has an activating effect specifically on prefrontal cortex (Sano *et al.*, 1993), whereas at higher doses it reduces activity across the whole brain (Levin *et al.*, 1998; Söderlund *et al.*, 2007; Van Horn *et al.*, 2006). This generalised depressant effect may explain the empirical observations of behavioural disinhibition at moderate to high doses. Logically, the stimulant effects of low doses of alcohol should *increase* inhibitory control. However, a literature search revealed no studies testing this hypothesis using doses of alcohol below 0.6 g/kg, and it remains an interesting issue for future research.

Steele and colleagues (Steele & Southwick, 1985; Steele & Josephs, 1988, 1990) have focused on the effect of alcohol on attentional processes. They contend that intoxication restricts the focus of attention to the most salient cues in the environment with the consequence that other cues are not fully processed. There is some evidence for this. Thus, when participants are told to attend to stimuli in one modality whilst ignoring distractor stimuli in another, intoxicated participants (i.e. those administered 0.8 millilitres of ethanol per kilogram of body mass) perform better than their sober counterparts (e.g. Patel, 1988; Erblich & Earleywine, 1995). Similarly, in experimental tasks requiring participants to divide their attention across multiple tasks or locations, alcohol impairs performance on those tasks

considered to be least important (i.e. secondary tasks), whilst performance on primary tasks is relatively unaffected (Fisk & Scerbo, 1987).

Research investigating the effect of acute alcohol on Delay Discounting (DD) is relatively scant and results are inconsistent. For example, Dougherty *et al.* (2008) reported that alcohol doses of 0.4, 0.6 and 0.8 (but not 0.2) g/kg increased DD. Reynolds *et al.* (2006b) found that a dose of 0.8 but not 0.4 g/kg of alcohol increased impulsive decision-making in a novel Experiential Discounting Task (EDT); however, these effects were not apparent on a question-based DD task. Conversely, Ortner, MacDonald and Olmstead (2003) reported that following 0.7 g/kg of alcohol, participants tended to discount delayed rewards at *lower* rates than sober participants, and that blood alcohol level was inversely correlated with DD. Other studies, for instance one by Richards *et al.* (1999), have reported no relationship between intoxication and DD.

There has been little attempt to systematically investigate the acute effects of alcohol on behavioural disinhibition in 'real-world' settings. Therefore, the present study sought to examine how recent alcohol intake was related to scores on the new measure of recent impulsivity. It was hypothesised that recent increases in drinking would be reflected in increased impulsiveness in daily life situations.

3. The present study

A core theme of this thesis is the way in which variations in impulsiveness might be related to responses to alcohol-related stimuli. The present study sought: i) to develop and pilot a Recent Impulsivity Scale (RIS); ii) to examine the associations between the RIS and a parallel Trait Impulsiveness Scale (the TIS); and iii) to examine the relative sensitivities of RIS and TIS to recent and habitual alcohol intake.

The RIS was created by selecting items from a variety of existing self-report impulsiveness instruments and rephrasing them to capture the level of impulsive behaviour during the preceding two weeks. A trait version was also developed which contained the same items as the RIS but asked the respondent about their

general behaviour (i.e. without specifying a narrow time-frame). Both of the new scales were evaluated with respect to an existing widely-used trait impulsiveness scale, the BIS-11 (Patton *et al.*, 1995).

Hypotheses

Test-retest stability was investigated by administering the questionnaires on two separate occasions one month apart. It was expected that stability would be greater for the TIS than the RIS.

It was hypothesised that recent changes in alcohol consumption would be associated with fluctuations in impulsiveness to which the RIS would be more sensitive than the TIS. By the same logic, it was also predicted that habitual alcohol intake and trait impulsivity would be more strongly associated than habitual intake and recent impulsivity. To test this, participants were asked to indicate how their intake during the preceding two weeks had compared to their typical consumption in the preceding twelve months.

In summary then, the specific hypotheses were as follows:

i. The BIS-11 should correlate more highly with the TIS than the RIS;
ii. The test-retest correlation for the RIS should be lower than for the TIS;
iii. In all participants, habitual alcohol intake will share a greater correlation with the TIS, relative to the RIS;
iv. Recent changes in alcohol consumption will be reflected in changes in impulsiveness in daily life, as tapped by scores on the RIS relative to the TIS. For this purpose, participants were categorised as either:
    a) Stable drinkers (SDs; no recent change in consumption compared to the preceding twelve months);
    b) Increasing drinkers (IDs; recent consumption greater than in the preceding 12 months), or;
    c) Decreasing drinkers (DDs; recent consumption smaller than in the preceding twelve months).

    It was predicted that:

i. In all participants, recent alcohol intake should correlate more highly with the RIS than the TIS;
ii. Recent increases or decreases in alcohol consumption will be associated with corresponding recent changes in impulsivity, calculated by subtracting TIS score from current RIS score;
iii. TIS and RIS scores would be more highly correlated with one another in stable drinkers than in IDs or DDs.

Methods

Design and procedure: The first part of the study developed two new questionnaires based on existing trait impulsiveness inventories. One was another trait questionnaire (Trait Impulsiveness Scale; TIS), the other a parallel short-term questionnaire (Recent Impulsiveness Scale; RIS). Both were administered to a large sample of first year undergraduate psychology students. They were subjected to exploratory and confirmatory factor analyses, and items which did not load strongly on the major factors were eliminated. The second part of the study tested the hypotheses specified above concerning their psychometric properties and associations with alcohol consumption.

Participants completed the TIS, RIS and the BIS-11, and answered questions concerning typical and recent alcohol intake. These were given in fixed order. A subgroup of participants repeated the battery after a four-week interval.

Ethical Approval: Approval for this study was given by the Ethics Committee at Goldsmiths College, University of London; participants gave informed written consent after reading an information sheet outlining the study. As required by the Helsinki Declaration (World Medical Association, 2002), individuals were assured of confidentiality and could terminate their participation at any stage.

Participants: In total, 277 participants were recruited via the first year Psychology undergraduate 'credit system'[6] at Goldsmiths College (University of London), and

[6] Credit system: Students received course credit for taking part and, subsequent to their participation, writing a reflective commentary on this or another study in which they had been involved.

were thus relatively homogeneous with respect to age and educational attainment. They were drawn from two consecutive first-year psychology cohorts, with 145 from the first, and 132 from the second. There were no exclusion criteria.

Developing the new impulsivity scales

It was decided to use 'the previous two weeks' as the frame of reference for measuring recent impulsivity because this period: i) is short enough for the respondent to recall his/her behaviours and experiences with reasonable clarity; ii) is long enough to provide sufficient opportunities for many specific impulsive behaviours to have occurred; and iii) it corresponds with the time period employed in other mood 'state' questionnaires such as the Beck Depression Inventory (Beck, Steer & Carbin, 1988).

In developing a measure with the potential to be sensitive to fluctuations in impulsive tendencies over relatively short time periods, it was necessary to identify behaviours or situations that are likely to occur on a day-to-day basis. The items of the widely-used and well-validated trait impulsiveness instruments listed below were scanned for items that were amenable to being converted into the 'two-week' format.

- ***The Barratt Impulsiveness Scale*** *(BIS-11; Patton et al., 1995; Appendix 1)*: Thirty questions concern control of thoughts and behaviour. Each item is measured on a four-point Likert scale, ranging from 'rarely/never' through to 'almost always'. Some items are reverse-coded and a score of four indicates the most frequent impulsive response; therefore, the higher the subscale score, the higher the level of impulsiveness. An overall score is determined by summing the 30 items. The scale relates to a three-factor model of impulsivity, yielding indices of: (a) 'motor impulsiveness', measured by 11 items (e.g. 'I do things without thinking'); (b) 'attentional impulsiveness', measured by eight items (e.g. 'I do not pay attention'); and (c) 'non-planning impulsiveness', measured by 11 items (e.g. 'I plan tasks carefully'; reverse-coded). Patton *et al.* (1995) reported internal consistency coefficients ranging from 0.79 to 0.83.

- ***The EASI-III Impulsivity Scales*** *(Buss & Plomin, 1984; Appendix 2):* The EASI-III is a self-report questionnaire which was designed to reflect Buss and Plomin's (1975) 'four temperament' theory of personality: emotionality, activity, sociability and impulsivity. Impulsivity comprises four subscales: inhibitory control (e.g. 'I have trouble controlling my impulses'); decision time (e.g. 'I often say the first thing that comes into my mind'); sensation seeking (e.g. 'I generally seek new and exciting experiences'); and persistence (e.g. 'I generally like to see things through to the end'). Braithwaite *et al.* (1984) have reported reliability coefficients of 0.61, 0.40, 0.46 and 0.54 for the four subscales, respectively.

- ***The Functional and Dysfunctional Impulsivity Scales*** *(Dickman, 1990; Appendix 3):* Dickman (1990) contended that there are two separate impulsiveness traits. The first, 'Functional Impulsivity', refers to a tendency towards rapid responding in situations where accuracy is not critical, whilst 'Dysfunctional Impulsivity' refers to rapid responding which may have adverse consequences. Functional Impulsivity is assessed by 11 items, such as 'I like to take part in really fast-paced conversations, where you don't have much time to think before you speak'. Dysfunctional Impulsivity is assessed by 12 items, such as 'I often make up my mind without taking the time to consider the situation from all angles'. Cronbach's alphas of 0.83 and 0.86 have been reported for the two subscales (Dickman, 1990).

- ***The I-7 Impulsiveness Questionnaire*** *(I-7; Eysenck et al., 1985a; Appendix 4):* The I-7 is a 54-item 'yes or no' inventory designed to measure Impulsiveness (e.g. 'Do you often buy things on impulse?'), Venturesomeness and Empathy. Only the impulsiveness subscale was searched for potential RIS items. Eysenck *et al.* (1985a) reported a reliability coefficient above 0.80 for this scale.

- ***The Urgency, Premeditation, Perseverance and Sensation Seeking Scales*** *(UPPS; Whiteside & Lynam, 2001; Appendix 5):* The UPPS is a 45-item self-report inventory derived from a factor analysis of several widely-used impulsiveness scales. 'Urgency' (twelve items) refers to the tendency to experience strong impulses, often under conditions of negative affect (e.g. 'When I am upset I often

act without thinking'). 'Premeditation' (eleven items) taps the tendency to think and consider the potential consequences of an action before engaging in it (e.g. 'I like to stop and think things over before I do them'). 'Perseverance' (ten items) is concerned with the individual's ability to remain focused upon a task which may be boring or difficult (e.g. 'I generally like to see things through to the end'). 'Sensation Seeking' measures the tendency to pursue and enjoy activities which are exciting or may be dangerous (e.g. 'I quite enjoy taking risks'). Verdejo-García *et al.* (2007) have reported α coefficients between 0.77 and 0.91.

The wording of some items in these trait impulsiveness instruments does not lend itself to the 'previous two weeks' format. For example, some are attitudinal: for example, 'Would you agree that almost everything enjoyable is illegal or immoral?' and, 'Do you think an evening out is more successful if it is unplanned or arranged at the last moment?'[7] Some other items were excluded because of the low likelihood of their having occurred within any given two week period – for example, 'I change jobs' and, 'I change residences'.

The 68 items that were initially identified related to the existing scales as shown in Table 2.1.

[7] Several other scales including the SSS were also considered but the content or format of the questions did not lend themselves to re-framing in terms of frequency within the previous two weeks.

Table 2.1: Number of items drawn from traditional impulsiveness instruments

Name of instrument	Number of preliminary items taken
Attentional Impulsiveness subscale (BIS-11)	4
Motor Impulsiveness subscale (BIS-11)	5
Non-Planning Impulsiveness subscale (BIS-11)	6
I-7 Scale	14
Urgency subscale (UPPS)	6
Premeditation subscale (UPPS)	2
Perseverance subscale (UPPS)	9
Inhibitory Control subscale (EASI-III)	5
Decision Time subscale (EASI-III)	4
Sensation Seeking subscale (EASI-III)	1
Persistence subscale (EASI-III)	5
Dysfunctional Impulsivity Scale	7

Narrowing down the preliminary set of items due to item similarity: Amongst the preliminary set of 68 items, there were many which although phrased differently, were very similar (see Table 2.2 on p. 64). For example, item 17 of the BIS-11 states, 'I act "on impulse"', item 19 of the BIS-11 states, 'I act on the spur of the moment', item 4 of the I-7 asks, 'Are you an impulsive person?', and item 4 of the EASI-III Decision Time subscale states, 'I often act on the spur of the moment'.

In order to generate a reasonably brief instrument which tapped a wide range of the behaviours identified in existing measures but minimised redundancy and repetition, the researcher used his judgement to categorise the 68 items shown in Table 2.1 into 17 general themes, as set out in Table 2.2, then generating a single question which captured the essence of each theme.

Table 2.2: The preliminary set of 68 items taken from traditional impulsiveness scales, grouped by their underlying theme and the single RIS item which was produced in each case

General theme of items	Source instrument (item number)	Resulting RIS item
1. The tendency to do and say things without adequate prior thought	I-7 (5); I-7 (2); I-7 (7); I-7 (17); BIS-11 (2); UPPS Premeditation (4); UPPS Premeditation (10); Dysfunctional Impulsivity (1); Dysfunctional Impulsivity (6); EASI-III Decision Time (1)	'In the last two weeks, I have thought carefully before doing and saying things' (R)
2. The tendency to be surprised at people's reactions to things one does or says	I-7 (12)	'In the last two weeks, I have been surprised at people's reactions to things that I have done or said'
3. The ability to tolerate frustration	UPPS Inhibitory Control (2); UPPS Inhibitory Control (3)	'In the last two weeks, I have become so frustrated when waiting, for example in a shop queue, that I have left'
4. The ability to concentrate	UPPS Perseverance (5); BIS-11 (9)	'In the last two weeks, I have found it easy to concentrate' (R)
5. The tendency to behave impulsively	BIS-11 (17); BIS-11 (19); I-7 (4); I-7 (6); EASI-III Decision Time (4)	'In the last two weeks, I have tended to act "on impulse"'
6. The tendency to work quickly at the expense of making potential mistakes	I-7 (14)	'In the last two weeks, I have tended to work quickly, without bothering to check'
7. The tendency to plan things carefully before doing them	BIS-11 (1); EASI-III Decision Time (5); Dysfunctional Impulsivity (8)	'In the last two weeks, I have planned work tasks and activities in my free time carefully' (R)

Table 2.2 continues over the page

Table 2.2 continued

General theme of items	Source instrument (item number)	Resulting RIS item
8. The tendency to think ahead to the future	BIS-11 (27); BIS-11 (30)	'In the last two weeks, I have found it difficult thinking ahead'
9. The ease of exercising self-control	BIS-11 (8); I-7 (10); UPPS Urgency (1); UPPS Urgency (2); UPPS Urgency (8); UPPS Urgency (11); EASI-III Inhibitory Control (1); EASI-III Inhibitory Control (4)	'In the last two weeks, I have found it easy to exercise self-control' (R)
10. The tendency to see things (e.g. work tasks) through to the end	EASI-III Persistence (1); UPPS Perseverance (1); UPPS Perseverance (2); UPPS Perseverance (3); UPPS Perseverance (4); UPPS Perseverance (6); UPPS Perseverance (8); UPPS Perseverance (9); UPPS Perseverance (10); EASI-III Persistence (3); EASI-III Persistence (4); EASI-III Persistence (5)	'In the last two weeks, I have been focused, seeing things through to the end' (R)
11. The tendency to encounter problems due to doing things without adequate prior thought	I-7 (3); Dysfunctional Impulsivity (7); UPPS Urgency (12); Dysfunctional Impulsivity (12)	'In the last two weeks, I have encountered problems because I did things without thinking'
12. The tendency to spend money impulsively	BIS-11 (25); Dysfunctional Impulsivity (4); BIS-11 (22); BIS-11 (10); I-7 (1); EASI-III Inhibitory Control (5)	'In the last two weeks, I have spent more money than I should have'
13. The tendency to become restless when sitting (for a period of time)	BIS-11 (28); BIS-11 (11)	'In the last two weeks, I have been restless when watching things, e.g. at the cinema / theatre, on television, at lectures'

Table 2.2 continues over the page

Table 2.2 continued

General theme of items	Source instrument (item number)	Resulting RIS item
14. The tendency to become involved with things which one subsequently either does not want to or cannot go through with	I-7 (8); UPPS Urgency (3); Dysfunctional Impulsivity (3)	'In the last two weeks, I have become involved with something that I later wished I could have got out of'
15. The tendency to plan things well ahead of time	BIS-11 (7); EASI-III Decision Time (3)	'In the last two weeks, I have planned events and activities well ahead of time' (R)
16. The tendency to frequently change one's interests	BIS-11 (24); I-7 (15); EASI-III Persistence (2)	'In the last two weeks, I have tended to jump from one interest to another'
17. The ease with which one becomes bored (when working)	BIS-11 (18); EASI-III Sensation Seeking (5)	'In the last two weeks, I have become easily bored when working'

Ordering of items: Finally, items were put into the pilot RIS questionnaire in an order so that conceptually very similar items (e.g. those involving some aspect of inhibitory control) were not adjacent.

The response options of the RIS were the same as used in the BIS-11 and the UPPS and related to probability or frequency of acting in the specified way: 'Rarely/Never', 'Occasionally', 'Often' and 'Almost always/Always'). Some items were reverse-scored (indicated by R in Table 2.2). Responses were converted to numbers such that for every item scores from 0 to 3 represented increasing impulsivity. Appendix 6 shows the instrument in full.

- ***The Trait Impulsivity Scale*** *(TIS; see Appendix 7):* This comprised the same items as the RIS but rephrased to reflect general response tendencies without reference to any specific timeframe. For example, whereas the RIS item would be 'In the last two weeks I have thought carefully before doing things', the corresponding TIS item would be, 'I think carefully before doing things'. The response options were the same as for the RIS.

Alcohol Intake

As participants were completing these questionnaires as part of a very extensive battery for the course credit system, it was unfortunately not possible to gather very precise or complex data concerning their background histories or alcohol/other substance use. It was therefore decided to restrict the questions to two very straightforward questions, namely:

1) Habitual alcohol intake: Participants were asked to give the number of units of alcohol that they had typically consumed within an average week during the preceding twelve months. There were nine response options, coded as follows: 0 = 'None'; 1 = '1-4'; 2 = '5-8'; 3 = '9-12'; 4 = '13-16'; 5 = '17-20'; 6 = '21-24'; 7 = '25-28'; and 8 = '29+', and;

2) Alcohol intake within the previous two weeks (compared to the previous twelve months): Participants were asked to indicate how their alcohol intake in the preceding two weeks had compared to their alcohol intake over the preceding

twelve months. Participants responded on the following 5-point scale: -2 = 'A lot less'; -1 = 'A bit less'; 0 = 'No change'; 1 = 'A bit more'; and 2 = 'A lot more'.

In hindsight it would have been desirable to collect more precise information concerning recent intake, but this was a preliminary study in which the issue of alcohol use was initially only a minor issue.

Order of tests

This is shown in Table 2.3.

Table 2.3: Schematic overview of design and order of assessments at Times 1 and 2 for Cohorts 1 (*n* = 145) and 2 (*n* = 132)

Assessments (in order)	Time 1 (*N* = 277; Cohort 1 = 145, Cohort 2 = 132)	Time 2 (*N* = 200; Cohort 1 = 112, Cohort 2 = 88)
RIS	✓	✓
Demographics	✓	-
BIS-11	✓	✓
Alcohol consumption within the preceding 12 months	✓	-
Change in alcohol consumption within the previous 2 weeks	✓	✓
TIS	✓	✓

Data analysis

Examining the composition of the TIS and RIS scales: In order to reduce the data, an Exploratory Factor Analysis (EFA) was first conducted upon participants' scores for the TIS at Time 1. Confirmatory Factor Analyses (CFAs) were subsequently performed upon the TIS at Time 2 and the RIS at Time 1. Given that the RIS was designed to capture fluctuations in impulsivity, it was expected that the CFAs on the RIS data at both Times 1 and 2 would indicate a structure similar to, though less stable than, the FAs performed upon the TIS at both times.

Correlations between scales: Pearson's product-moment correlations (1-tailed) with listwise exclusion were carried out between the RIS, TIS and BIS-11 scores. Dunn

and Clark's (1969) Z_1^* statistic for comparing two dependent correlations measured on the same participants was then used to examine whether the correlations were significantly different in size.

Test-retest reliability of the TIS and RIS scales and subscales: Pearson's product-moment test-retest correlations (1-tailed) with listwise exclusion were carried out for T1 and T2 scores on each RIS and TIS scale and subscale. Steiger's (1980) *Z* statistic for comparing two independent correlations in the same participants then examined whether the test-retest correlations for corresponding RIS and TIS subscales differed in magnitude.

Sensitivity of the RIS and TIS scales and subscales to changes in alcohol intake within the previous two weeks: This was examined in four sets of analyses performed upon data from Time 1. These will be explained in the Results section.

Results

Number of participants who completed the measures/instruments at Time 1 and Time 2: Table 2.4 shows the numbers of participants contributing data on each measure at Times 1 and 2.

Table 2.4: Numbers (and percentages) of participants with data on each variable at Time 1 and Time 2

	Time 1 **Total *N* = 277**	**Time 2** **Total *N* = 200**
Measure/instrument	*Number of participants with complete data*	*Number of participants with complete data*
Age (years)	262 (94.58%)	n/a
Gender (male/female)	262 (94.58%)	n/a
Drinking status (social drinker/abstainer)	259 (93.50%)	n/a
Typical weekly alcohol intake of social drinkers (units per week during previous 12 months)	259 (93.50%)	n/a
Alcohol intake during previous 2 weeks compared to intake during previous 12 months ('A lot more' / 'A bit more' / 'No change' / 'A bit less' / 'A lot less')	253 (91.34%)	191 (68.95%)
RIS scale	277 (100%)	200 (72.20%)
TIS scale	270 (97.47%)	196 (70.76%)
BIS-11 scale	261 (94.22%)	199 (71.84%)

Demographic and alcohol-related characteristics: Table 2.5 shows the demographic and alcohol-related characteristics of the whole sample that completed the battery at Time 1. Some participants omitted to provide some information, but overall there was relatively little missing data.

Table 2.5: Demographic and alcohol-related characteristics of the whole sample of participants who completed the whole instrument battery at Time 1 (*N* = 277)

Variable		Valid *N*
Age (years)		
Mean (SD)	20.24 (4.85)	262
Range	18 – 60	
Gender (male: female)	211:51	262
Drinking status (social drinkers: abstainers)	183:76	259
Typical weekly alcohol intake of social drinkers (units per week during previous 12 months)		
Mean (SD)	2.58 (1.52)	183
Range	'1-4' – '29+'	

Section 1: Structure of the Trait Impulsiveness Scale (TIS) and the Recent Impulsivity Scale (RIS)

Exploratory factor analysis (EFA) of the TIS at Time 1:

Principal factors extraction with varimax rotation was performed upon the 17 items of the TIS. A preliminary principal factors extraction was used prior to the principal factors extraction-proper to estimate number of components, and to check for presence of multivariate outliers, absence of multicollinearity and factorisability of the correlation matrices.

Using an $\alpha = 0.001$ cut-off level, eight participants' scores identified them as multivariate outliers. These cases were deleted from the principal factors extraction, leaving 262 participants. There was no evidence of multicollinearity. Factorisability of the initial correlation matrix was acceptable as: there were numerous correlations in the correlation matrix which exceeded 0.3 (see Appendix 8); Bartlett's test of sphericity was significant, indicating that some correlations in the original matrix were greater than 0; the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (MSA) was 0.83 (factorisability is widely considered to be acceptable if this figure is above 0.6); and the partial correlations between each pair of variables tended to be close to zero. For further details of these issues see Tabachnik and Fidell (2007).

There were four factors with initial eigenvalues above one (see Table 2.6 and Figure 2.1). However, two of these factors were each loaded onto by only 2 items, making them potentially unstable and incapable of replication in CFA, which requires a minimum of three items. It was decided on this basis to select a two-factor solution.

Table 2.6: Initial eigenvalues, percentages of variance and cumulative percentages of variance for first four factors

Factors	Initial eigenvalue	Percentage of variance	Cumulative percentage of variance
1	4.24	24.95	24.95
2	1.92	11.32	36.27
3	1.48	8.69	44.96
4	1.13	6.67	51.63

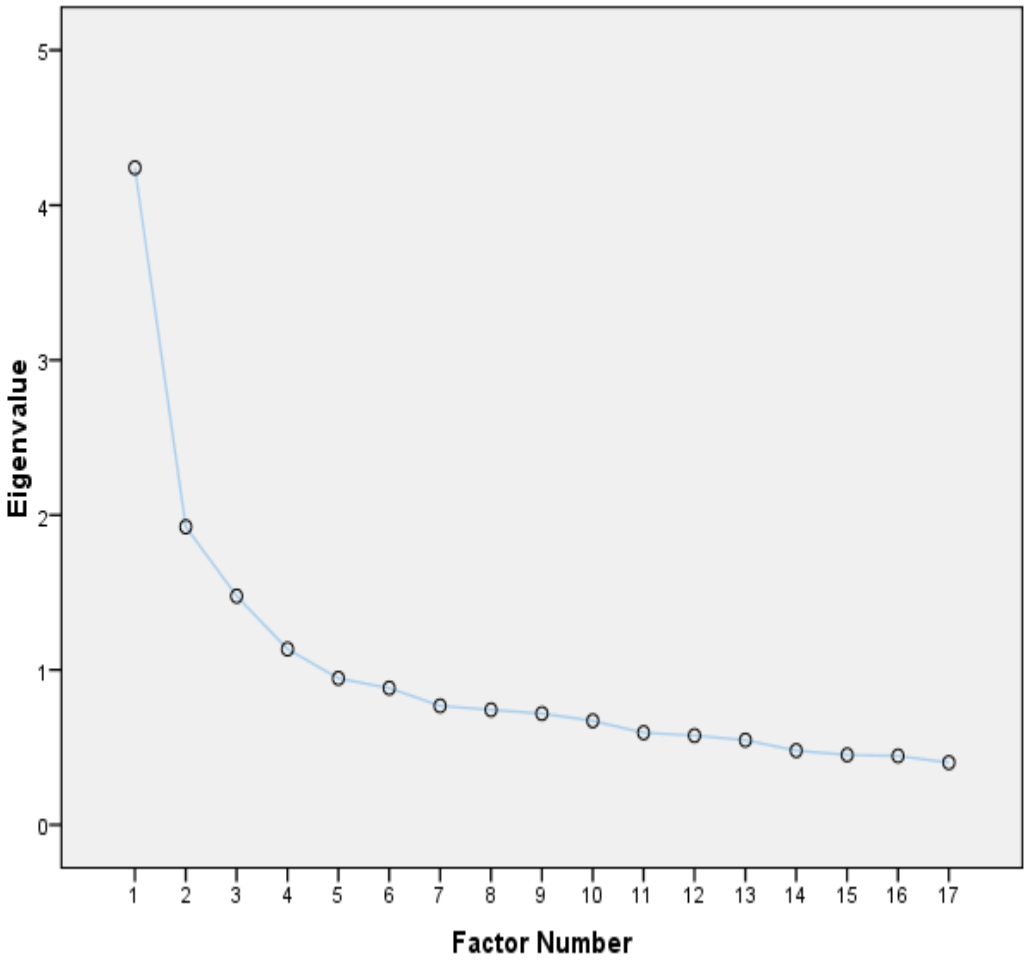

Figure 2.1: Scree Plot of the 17 items of the TIS at Time 1 (*N* = 262)

The data were reasonably well-described by this two-factor solution. Communality values (see Table 2.7) tended to be moderate.

One of the aims was to derive a reasonably concise scale which would be quick to administer on repeated occasions. A decision was therefore made to reduce the total number of items by retaining only those which loaded highly (> 0.50) on one of the two factors and which did not cross-load. In practice, as shown in Table 2.7, the 0.50 cut-off led to the retention of four items on each factor; no variable loaded at more than half this level on the other factor.

Table 2.7: Factor loadings, communalities (h^2) and percentages of variance and covariance explained for exploratory principal factors extraction and varimax rotation on the 17 TIS items at Time 1 (N = 262)

Item	Cognitive Impulsivity	Motor Impulsivity	h^2
I plan work tasks and activities in my free time carefully.	**0.67**	0.05	**0.46**
I am focused, seeing things through to the end.	**0.67**	0.24	**0.50**
I plan events and activities well ahead of time.	**0.57**	0.06	**0.33**
I think carefully before doing and saying things.	**0.55**	0.26	**0.37**
I encounter problems because I do things without stopping to think.	0.20	**0.64**	**0.45**
I become involved with things that I later wish I could get out of.	0.19	**0.55**	**0.34**
I tend to jump from one interest to another.	0.10	**0.54**	**0.30**
I tend to act 'on impulse'.	0.12	**0.50**	**0.27**
I find it difficult thinking ahead.	0.45	0.12	**0.22**
I find it easy to exercise self-control.	0.45	0.30	**0.29**
I find it easy to concentrate.	0.43	0.25	**0.25**
I tend to work quickly, without bothering to check.	-0.33	0.17	**0.14**
I am surprised at people's reactions to things that I do or say.	-0.01	0.43	**0.19**
I become easily bored when working.	0.29	0.40	**0.24**
I get restless when watching things, e.g. at the cinema / theatre, on television, at lectures.	0.12	0.38	**0.16**
I spend more money than I should do.	0.21	0.37	**0.18**
I become so frustrated when waiting, for example in a shop queue, that I leave.	-0.04	0.35	**0.13**
Percentage of variance explained	14.94	13.68	
Percentage of covariance explained	52.20	47.80	

Based on consideration of the item content, the two factors were provisionally labelled 'Cognitive Impulsivity' (CI) and 'Motor Impulsivity' (MI). All subsequent analyses relate to the eight items in these two subscales; total score is the sum of these items.

Internal reliability: The alpha coefficient of 0.72 for the total TIS score is considered acceptable (George & Mallery, 2003).

Component inter-correlations: Pearson's product-moment correlations (2-tailed) with listwise exclusion were calculated between the two subscale scores and between each subscale score and the total score. As shown in Table 2.8, all were significant, though that between the two subscales was fairly low, consistent with the emergence of orthogonal factors.

Table 2.8: Pearson's product-moment correlations (2-tailed) between each pair of component subscale scores at Time 1 (*N* = 270)

Pair of scales/subscales correlated	Correlation (*r*)	*p*
CI and MI subscales	0.28	< 0.01
Total TIS scale and CI subscale	0.80	< 0.01
Total TIS scale and MI subscale	0.80	< 0.01

Test-retest reliability: In the 191 participants who completed the TIS at both Times 1 (T1) and 2 (T2), Pearson's product-moment correlations (2-tailed) with listwise exclusion were calculated for the T1 and T2 total score and for each component subscale score. As shown in Table 2.9, all test-retest correlations were significant, and moderate in size.

Table 2.9: Pearson's product-moment correlations (2-tailed) for the total TIS scale score and each component subscale score between Time 1 and Time 2 (*N* = 191)

Scale/subscale test-retest correlated	Correlation (*r*)	*p*
CI subscale	0.51	< 0.01
MI subscale	0.55	< 0.01
TIS Total scale	0.63	< 0.01

Confirmatory FA (CFA) on the TIS at Time 2: A CFA, based on the T2 data from 196 participants, was performed through MPlus on the eight items of the newly-abbreviated TIS.

Assumptions: The assumptions of multivariate normality and linearity were evaluated. Using Mahalanobis distance, two participants were multivariate outliers ($p < 0.001$), and were thus excluded. There were no missing data.

Model estimation: Maximum Likelihood Ratio (MLR) estimation was employed to estimate the model. χ^2 ($df = 19$) was 34.51 ($p = 0.02$), indicating that the observed covariance matrix did not match the estimated covariance matrix within sampling variance. However, there are several problems with using this test alone to estimate fit (Hair *et al.*, 2008), and it is therefore important to consider other fit statistics as well. In terms of 'absolute' fit measures, the value for Root Mean Square Error of Approximation (RMSEA) was 0.07, which indicates a good fit. A second absolute fit statistic, the normed χ^2, was 1.82 – again considered very good. This measure is the chi-square value divided by the degrees of freedom. The most widely-used 'incremental' fit index, the Comparative Fit Index (CFI), was 0.94, exceeding the recommended cutoff of 0.90 for confirming fit.

The standardised factor loadings for each item onto its corresponding factor, as well as the corresponding *Z* values, are presented in Table 2.10. All but one (item 16) of the standardised loadings exceeded 0.5, and this item loaded at 0.48. No loadings were more than 0.1 below those found in the EFA on T1 data. On balance, therefore, the CFA suggested a good fit to the data.

Table 2.10: Standardised factor loadings (SLs; TIS T1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 (*N* = 194)

Construct	Item	SL (*T1*)	SE	*Z* value
Cognitive Impulsivity	*I plan work tasks and activities in my free time carefully.*	**0.69** (*0.67*)	-[a]	-[a]
	I am focused, seeing things through to the end.	**0.57** (*0.67*)	**0.17**	**4.76**
	I plan events and activities well ahead of time.	**0.66** (*0.57*)	**0.10**	**9.20**
	I think carefully before doing and saying things.	**0.64** (*0.55*)	**0.22**	**4.05**
Motor Impulsivity	*I encounter problems because I do things without stopping to think.*	**0.73** (*0.64*)	-[a]	-[a]
	I become involved with things that I later wish I could get out of.	**0.65** (*0.55*)	**0.15**	**6.28**
	I tend to jump from one interest to another.	**0.48** (*0.54*)	**0.12**	**4.96**
	I tend to act 'on impulse'.	**0.61** (*0.50*)	**0.14**	**6.30**

[a]Not estimated when loading set to fixed value (i.e. 1.0).

CFA on the RIS at Time 1:

A CFA, following the same processes as described for TIS-T2, was conducted on the RIS at T1.

Assumptions: The assumptions of multivariate normality and linearity were evaluated. Using Mahalanobis distance, one participant was a multivariate outlier, $p < 0.001$ and was excluded. There were no missing data for the remaining 276 participants.

Model estimation: Maximum Likelihood Ratio (MLR) estimation yielded a χ^2 (*df* = 19) of 27.41 (ns; $p > 0.10$); thus, the observed covariance matrix matched the estimated covariance matrix within sampling variance. Three other measures also confirmed the good fit of the model to the TIS T2 data. Thus, two indices of 'absolute' fit

(RMSEA, 0.04; normed χ^2, 1.44) and one of 'incremental' fit, the CFI (0.96) all fell above or below the cutoffs recommended by Hair *et al.* (2008). The CFA therefore suggested that the measurement model provided a good fit.

The standardised factor loadings for each item onto its corresponding factor, as well as the accompanying *Z* values, are shown in Table 2.11. Most of the standardised loadings were above 0.5, and all were above 0.40; all loadings were significant, as indicated by *Z* values above 1.96. For only one item ('I have been focused, seeing things through to the end') was the loading markedly lower than in the EFA (0.51 versus 0.67). The CFA therefore suggested that the measurement model provided a good fit to the data.

Table 2.11: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on RIS items at Time 1 (*N* = 276)

Construct	Item	SL (*TI*)	SE	*Z* value
Cognitive Impulsivity	*I have planned work tasks and activities in my free time carefully.*	**0.70** (*0.67*)	-[a]	-[a]
	I have been focused, seeing things through to the end.	**0.51** (*0.67*)	**0.14**	**4.43**
	I have planned events and activities well ahead of time.	**0.60** (*0.57*)	**0.12**	**7.13**
	I have thought carefully before doing and saying things.	**0.52** (*0.55*)	**0.13**	**4.59**
Motor Impulsivity	*I have encountered problems because I did things without stopping to think.*	**0.64** (*0.64*)	-[a]	-[a]
	I have become involved with things that I later wished I could have got out of.	**0.44** (*0.55*)	**0.21**	**3.76**
	I have tended to jump from one interest to another.	**0.41** (*0.54*)	**0.21**	**3.04**
	I have tended to act 'on impulse'.	**0.47** (*0.54*)	**0.22**	**3.51**

[a]Not estimated when loading set to fixed value (i.e. 1.0).

CFAs within each gender: Given the gender imbalance, and for interest, CFAs were performed upon the TIS at Time 2 within women and men separately, following the same approach as described above.

a) CFA on the TIS at Time 2 in women (n = 149):

Using Mahalanobis distance, one participant was a multivariate outlier, $p < 0.001$ and was excluded. There were no missing data for the remaining 148 participants.

Maximum Likelihood Ratio (MLR) estimation yielded a χ^2 (*df* = 19) of 23.34 (ns; $p > 0.10$); thus, the observed covariance matrix matched the estimated covariance matrix within sampling variance. Three other measures also confirmed the good fit of the model to the SIS T1 data. Thus, two indices of 'absolute' fit (RMSEA, 0.04;

normed χ^2, 1.23) and one of 'incremental' fit, the CFI (0.98) all fell above or below the cutoffs recommended by Hair *et al.* (2008).

The standardised factor loadings for each item onto its corresponding factor, as well as the accompanying *Z* values, are presented in Table 2.12. Most of the standardised loadings were above 0.5, and all were greater than 0.40; all loadings were significant, as indicated by *Z* values above 1.96. The measurement model thus provided a good fit to the data.

Table 2.12: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 in females (*N* = 148)

Construct	Item	SL (*TI*)	SE	*Z* value
Cognitive Impulsivity	*I plan work tasks and activities in my free time carefully.*	**0.69** (*0.67*)	-[a]	-[a]
	I am focused, seeing things through to the end.	**0.61** (*0.67*)	**0.16**	**5.34**
	I plan events and activities well ahead of time.	**0.64** (*0.57*)	**0.11**	**7.82**
	I think carefully before doing and saying things.	**0.62** (*0.55*)	**0.20**	**4.29**
Motor Impulsivity	*I encounter problems because I do things without stopping to think.*	**0.82** (*0.64*)	-[a]	-[a]
	I become involved with things that I later wish I could get out of.	**0.65** (*0.55*)	**0.15**	**5.92**
	I tend to jump from one interest to another.	**0.46** (*0.54*)	**0.11**	**4.53**
	I tend to act 'on impulse'.	**0.59** (*0.54*)	**0.13**	**5.76**

[a]Not estimated when loading set to fixed value (i.e. 1.0).

CFA on the TIS at Time 2 in men (n = 44):

Using Mahalanobis distance, no participants were multivariate outliers, $p < 0.001$. There were no missing data for the 44 participants.

Maximum Likelihood Ratio (MLR) estimation yielded a χ^2 (*df* = 19) of 21.17 (ns; $p > 0.10$); thus, the observed covariance matrix matched the estimated covariance matrix within sampling variance. Three other measures also confirmed the good fit of the model to the SIS T1 data. Thus, two indices of 'absolute' fit (RMSEA, 0.05; normed χ^2, 1.11) and one of 'incremental' fit, the CFI (0.96) all fell above or below the cutoffs recommended by Hair *et al.* (2008).

The standardised factor loadings for each item onto its corresponding factor, as well as the accompanying *Z* values, are presented in Table 2.13. Most of the standardised loadings were above 0.5, and all were equal to or greater than 0.40; with the exception of one item ('I think carefully before doing and saying things'), all loadings were significant, as indicated by *Z* values above 1.96. The measurement model therefore provided a good fit to the data.

Table 2.13: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 in males (*N* = 44)

Construct	Item	SL (*TI*)	SE	*Z* value
Cognitive Impulsivity	*I plan work tasks and activities in my free time carefully.*	**0.40** (*0.67*)	-[a]	-[a]
	I am focused, seeing things through to the end.	**0.51** (*0.67*)	**0.53**	**2.34**
	I plan events and activities well ahead of time.	**0.49** (*0.57*)	**0.40**	**2.80**
	I think carefully before doing and saying things.	**0.92** (*0.55*)	**1.36**	**1.78**
Motor Impulsivity	*I encounter problems because I do things without stopping to think.*	**0.47** (*0.64*)	-[a]	-[a]
	I become involved with things that I later wish I could get out of.	**0.64** (*0.55*)	**0.80**	**2.10**
	I tend to jump from one interest to another.	**0.61** (*0.54*)	**0.73**	**2.08**
	I tend to act 'on impulse'.	**0.60** (*0.54*)	**0.83**	**2.07**

[a]Not estimated when loading set to fixed value (i.e. 1.0).

Multi-group CFA on the TIS at Time 2:

A multi-group CFA, based on the T2 data from 193 participants, was performed through MPlus on the TIS at T2.

Using Mahalanobis distance, two participants were identified as multivariate outliers, $p < 0.001$, and were excluded. There were no missing data for the remaining 191 participants.

Maximum Likelihood Ratio (MLR) estimation yielded a χ^2 (df = 50) of 66.83 (p = 0.06); thus, the observed covariance matrix did not match the estimated covariance matrix within sampling variance. However, given the problems with using this test alone to estimate fit (Hair *et al.*, 2008), other fit statistics were also considered. In terms of 'absolute' fit measures, the value for RMSEA was 0.06, indicating a good

fit. A second 'absolute' fit measure, the normed χ^2, was 1.34 (any value below 2 is considered very good). The most widely-used 'incremental' fit index, the CFI, was 0.94, easily exceeding the cutoff of 0.90.

The standardised factor loadings for each item onto its corresponding factor, together with the corresponding *Z* values, for females and for males, are presented in Table 2.14. In females, all but one ('I tend to act "on impulse"') of the standardised loadings were above 0.50, and even this item loaded at 0.49; and all loadings were significant, as indicated by *Z* values above 1.96. The same pattern was observed in males; although 'I have tended to act "on impulse"' here loaded somewhat lower at 0.38, it was nevertheless significant, as indicated by its Z value of 5.26. On balance, therefore, the multi-group CFA suggested a good fit to the data.

Table 2.14: Standardised factor loadings (SLs; TIS Time 1 loadings in parentheses for comparison), standard errors (SEs) and *Z* values for confirmatory factor analysis with maximum likelihood ratio estimation on TIS items at Time 2 in females and males (*N* = 191)

Construct	Item	SL (*TI*)		SE[a]	*Z* value	
		Females	Males		Females	Males
Cognitive Impulsivity	*I plan work tasks and activities in my free time carefully.*	**0.65** (*0.67*)	**0.62** (*0.67*)	-[b]	-[b]	-[b]
	I am focused, seeing things through to the end.	**0.69** (*0.67*)	**0.62** (*0.67*)	**0.27**	**3.93**	**3.93**
	I plan events and activities well ahead of time.	**0.59** (*0.57*)	**0.54** (*0.57*)	**0.14**	**6.43**	**6.43**
	I think carefully before doing and saying things.	**0.66** (*0.55*)	**0.63** (*0.55*)	**0.24**	**4.59**	**4.07**
Motor Impulsivity	*I encounter problems because I do things without stopping to think.*	**0.62** (*0.64*)	**0.50** (*0.64*)	-[b]	-[b]	-[b]
	I become involved with things that I later wish I could get out of.	**0.76** (*0.55*)	**0.67** (*0.55*)	**0.18**	**3.76**	**6.32**
	I tend to jump from one interest to another.	**0.67** (*0.54*)	**0.60** (*0.54*)	**0.20**	**3.04**	**5.54**
	I tend to act 'on impulse'.	**0.49** (*0.54*)	**0.38** (*0.54*)	**0.12**	**3.51**	**5.26**

[a]Equal across females and males;

[b]Not estimated when loading set to fixed value (i.e. 1.0).

Section 2: Hypothesis testing

Table 2.15 summarises the RIS, TIS and BIS-11 scores at T1.

Table 2.15: Personality characteristics of the whole sample of undergraduate participants who completed the whole instrument battery at Time 1 (*N* = 277)

Variable		Valid *N*
RIS CI		
Mean (SD)	5.55 (2.01)	277
Range	0 – 10	
RIS MI		
Mean (SD)	5.18 (2.09)	277
Range	0 – 11	
RIS Total scale		
Mean (SD)	10.74 (3.17)	277
Range	1 – 20	
TIS CI		
Mean (SD)	5.42 (2.18)	270
Range	0 – 12	
TIS MI		
Mean (SD)	4.97 (2.19)	270
Range	0 – 12	
TIS Total scale		
Mean (SD)	10.39 (3.49)	270
Range	1 – 24	
BIS-11 Attentional Impulsiveness		
Mean (SD)	16.93 (3.86)	261
Range	9 – 30	
BIS-11 Motor Impulsiveness		
Mean (SD)	22.34 (4.59)	261
Range	13 – 37	
BIS-11 Non-Planning Impulsiveness		
Mean (SD)	26.39 (4.85)	261
Range	15 – 40	
BIS-11 Total scale		
Mean (SD)	65.66 (10.58)	261
Range	39 – 100	

Values are mean (± SD).

The subsample of 277 participants was aged between 18 and 60 years; fifteen participants did not give their age. It can be seen from the table that only 51 (19.47%) of participants were male; again, fifteen participants did not provide gender data. This gender imbalance is not surprising given the typical over-

representation of females to males in undergraduate psychology degrees. As evident from the table, 76 participants (29.34%) reported abstention from alcohol.

Table 2.16 summarises female and male participants' scores on the TIS and RIS subscales and scales at Time 1. As demonstrated by the table, there were no differences between females and males in terms of scores on any of the TIS and RIS subscales and scales.

Table 2.16: Personality characteristics of female and male undergraduate participants who completed the whole instrument battery at Time 1

Variable	***N* (females versus males)**	**Females**	**Males**	**Females versus males**	
				t	***p***
TIS CI subscale					
Mean (SD)	205:50	5.38 (2.27)	5.54 (1.67)	-0.48	ns
Range		0 – 12	1 – 9		
TIS MI subscale					
Mean (SD)	205:50	4.96 (2.14)	4.92 (2.36)	0.11	ns
Range		0 – 12	0 – 9		
TIS Total scale					
Mean (SD)	205:50	10.33 (3.44)	10.46 (3.39)	-0.24	ns
Range		2 – 24	1 – 17		
RIS CI subscale					
Mean (SD)	211:51	5.46 (2.01)	5.73 (2.08)	-0.84	ns
Range		0 – 10	1 – 10		
RIS MI subscale					
Mean (SD)	211:51	5.11 (2.04)	5.27 (2.25)	-0.51	ns
Range		0 – 11	0 – 10		
RIS Total scale					
Mean (SD)	211:51	10.57 (3.04)	11.00 (3.52)	-0.88	ns
Range		2 – 20	1 – 19		

TIS and RIS subscales and scales

Figures 2.2 i) to iii) show the distributions of scores on the TIS and RIS for the whole sample of undergraduates at Time 1. It can be seen that all scores were broadly normally distributed.

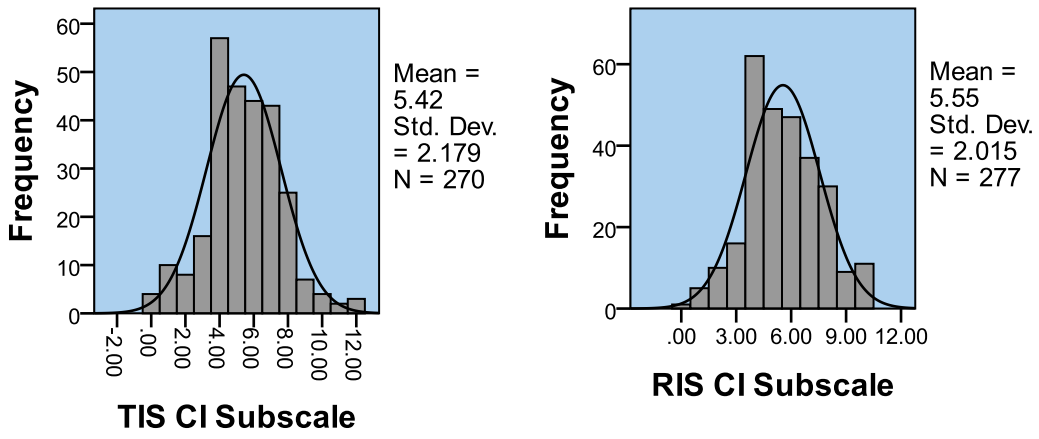

Figure 2.2 i): Histograms showing normality of the TIS and RIS CI subscales at Time 1

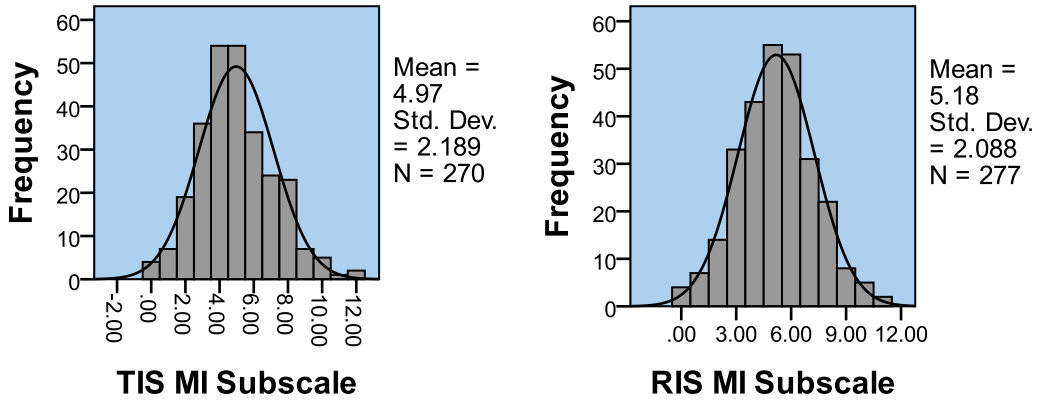

Figure 2.2 ii): Histograms showing normality of the TIS and RIS MI subscales at Time 1

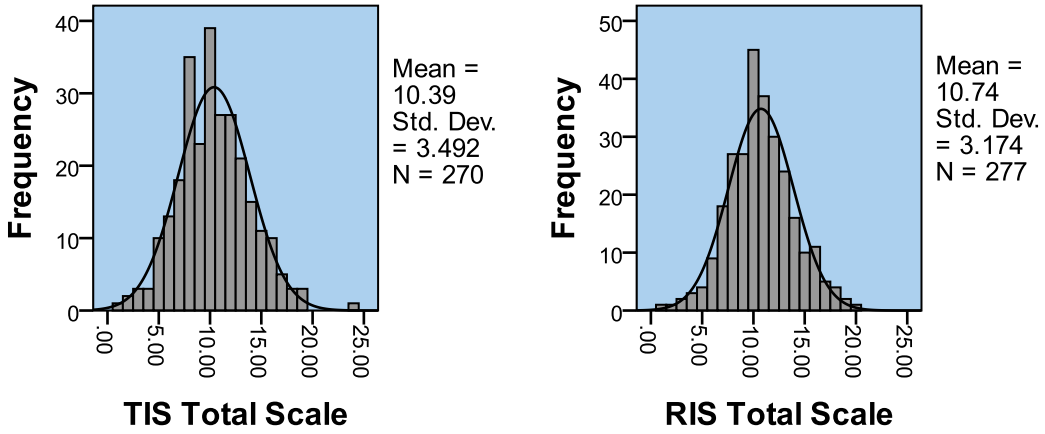

Figure 2.2 iii): Histograms showing normality of the TIS and RIS total scales at Time 1

Figures 2.3 i) to iii) show the distributions of scores on the TIS subscales and scale for females and males at Time 1.

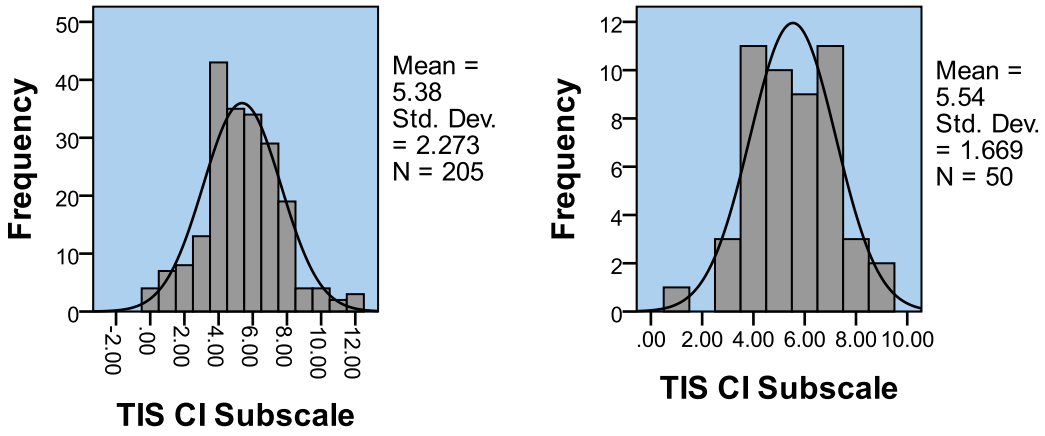

Figure 2.3 i): Histograms of the TIS CI subscale in females (left) and males (right)

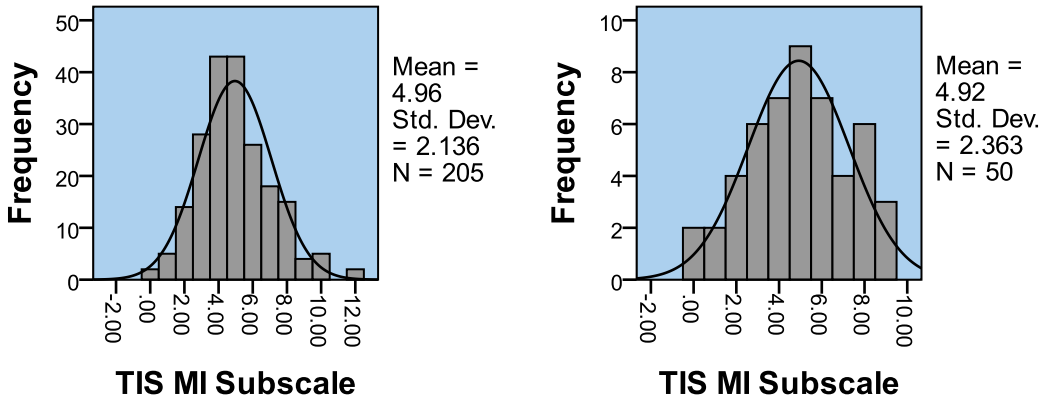

Figure 2.3 ii): Histograms of the TIS MI subscale in females (left) and males (right)

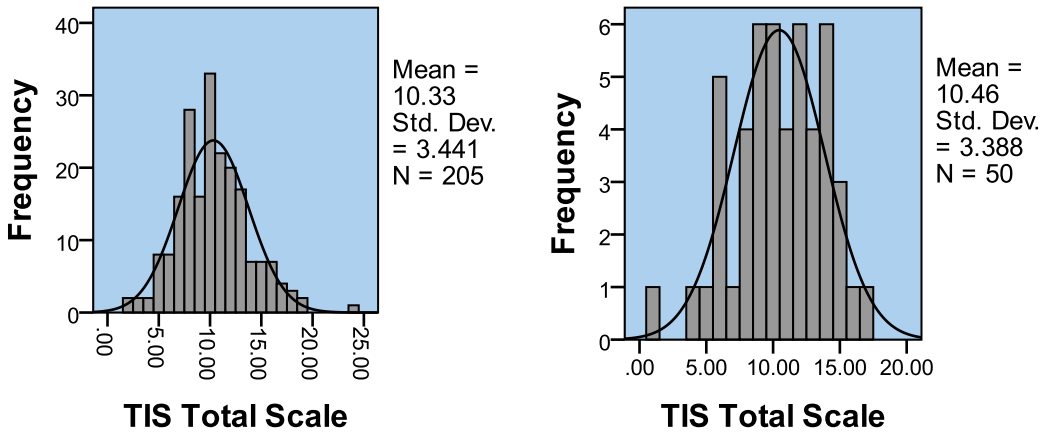

Figure 2.3 iii): Histograms of the TIS Total scale in females (left) and males (right)

Table 2.17 shows statistics confirming normality for scores on the TIS and RIS for the whole sample of undergraduates at Time 1.

Table 2.17: Mean (SE) skewness and kurtosis statistics for scores on the TIS and RIS for the whole sample of undergraduates at Time 1 (*N* = 277)

Normality statistic	TIS Cognitive Impulsivity	TIS Motor Impulsivity	TIS Total	RIS Cognitive Impulsivity	RIS Motor Impulsivity	RIS Total
Skewness	0.11 (0.15)	0.40 (0.15)	0.29 (0.15)	0.13 (0.15)	0.07 (0.15)	0.13 (0.15)
Kurtosis	0.51 (0.30)	0.26 (0.30)	0.48 (0.30)	-0.21 (0.29)	0.03 (0.29)	0.33 (0.29)
Valid N	270	270	270	277	277	277
Missing	7	7	7	0	0	0

Alcohol intake within the previous two weeks compared to the previous twelve months

Figure 2.4 shows a histogram of responses concerning 'Alcohol intake within the previous two weeks compared to the previous twelve months'. There was a slight negative skew, with participants tending to report an increase in recent drinking, but the distribution was not significantly non-normal (skewness = -0.21; kurtosis = -1.17).

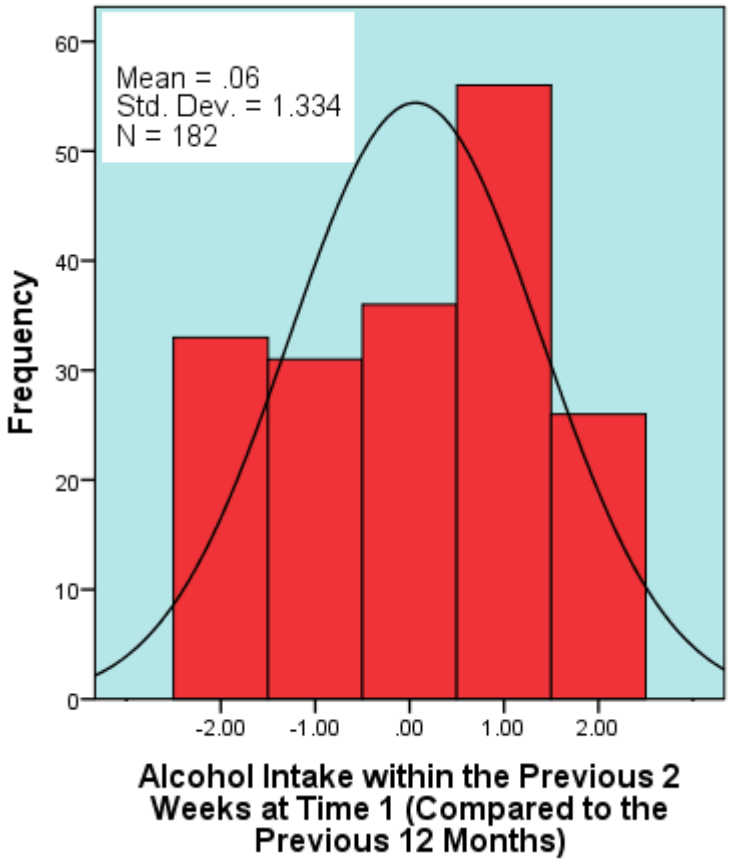

Figure 2.4: Histogram demonstrating normality of the variable 'Alcohol Intake within the Previous Two Weeks (Compared to the Previous Twelve Months)'

Hypothesis-testing: Each of the hypotheses set out on pages 58 to 59 is recapitulated below, followed by the corresponding analysis/analyses.

Hypothesis 1: ***The BIS-11 should correlate more highly with the TIS than the RIS***

In the 254 participants with complete data at Time 1, and excluding data listwise, the 1-tailed Pearson's correlation between BIS-11 Total and TIS Total was 0.75 ($p <$

0.01) and that between BIS-11 Total and RIS Total was 0.68 ($p < 0.01$). Dunn & Clark's (1969) Z_1^* statistic indicates that the former correlation is significantly greater than the latter [$Z_1^* = -2.31$; $p = 0.01$, 1-tailed]. Therefore, Hypothesis 1 was supported.

<u>Hypothesis 2:</u> The test-retest correlation for the RIS should be lower than for the TIS

Pearson's product-moment correlations (1-tailed) with listwise exclusion were carried out between each pair of variables (see Table 2.18). There were 191 participants with complete data for these analyses.

Table 2.18: Pearson's product-moment test-re-test correlations for trait and recent subscales and scales ($N = 191$)

	Test-retest correlations		**Differences between TIS and RIS test-retest correlations**	
Scale/subscale	*TIS*	*STIS*	*Z value*	*p value (1-tailed)*
Cognitive Impulsivity	0.51*	0.51*	0.00	ns
Motor Impulsivity	0.55*	0.48*	1.15	0.13

*Correlation significant at the $p < 0.01$ level (1-tailed).

Test-retest correlations were moderate and significant for all scores on both TIS and RIS, with the MI correlation being slightly but not significantly higher for the TIS than the RIS. There was no difference for Cognitive Impulsivity. Therefore, Hypothesis 2 was not supported.

<u>Hypothesis 3):</u> In all participants, habitual alcohol intake will share a greater correlation with the TIS, relative to the RIS

Amongst the 253 participants with complete data, there were no differences between the correlations of: i) habitual alcohol intake and TIS Cognitive Impulsivity ($r = 0.09$, $p = 0.08$) compared to habitual alcohol intake and RIS Cognitive Impulsivity ($r = 0.16$, $p < 0.01$) ($Z_1^* = -1.27$, ns), or; ii) habitual alcohol intake and TIS Motor

Impulsivity (r = 0.11, p < 0.05) compared to habitual alcohol intake and RIS Motor Impulsivity (r = 0.16, p < 0.01) (Z_1^* = -0.98, ns).

<u>Hypothesis 4):</u> Recent changes in alcohol consumption will be reflected in changes in impulsiveness in daily life, as tapped by scores on the RIS relative to the TIS

In the following analyses, 76 participants who reported no alcohol consumption in the preceding 12 months were excluded.

<u>i)</u> In all participants, recent alcohol intake should correlate more highly with the RIS than the TIS

Pearson's product-moment correlations (1-tailed) were performed between recent alcohol intake and the TIS and RIS subscales in the 178 participants with complete Time 1 data (see Table 2.19). Dunn & Clark's (1969) Z_1^* statistic for comparing two dependent correlations was used to examine the significance of the differences between the correlations.

Table 2.19: Pearson's product-moment correlations between recent alcohol intake and trait and recent impulsivity subscales and scales (N = 178)

	Correlation with recent alcohol intake		**Differences between TIS and RIS test-retest correlations**	
Scale/subscale	*TIS*	*RIS*	Z_1^* *value*	*p value (1-tailed)*
Cognitive Impulsivity	0.09†	0.10†	0.15	ns
Motor Impulsivity	0.19*	0.36*	2.69	< 0.01

*Correlation significant at the p ≤ 0.01 level; †Trend – p ≤ 0.10.

Amongst the 178 participants with complete data, the correlation between recent alcohol intake and RIS Motor Impulsivity was significantly larger than that between recent alcohol intake and TIS Motor Impulsivity. There was no difference between the correlations of recent alcohol intake within the previous 2 weeks and RIS Cognitive Impulsivity and recent alcohol intake and TIS Cognitive Impulsivity.

ii) Recent increases or decreases in alcohol consumption will be associated with corresponding recent changes in impulsivity, calculated by subtracting TIS score from current RIS score

In the 138 participants with complete data at Time 1, and excluding data listwise, the 1-tailed Pearson's correlation between the Motor Impulsivity 'change' variable and alcohol intake within the previous 2 weeks was 0.24 ($p < 0.01$); thus, RIS Motor Impulsivity increased with greater levels of recent drinking. Whilst this was consistent with the hypothesis, the same was not true for Cognitive Impulsivity, where the corresponding correlation was 0.03 (ns).

iii) TIS and RIS scores should be more highly correlated with one another in stable drinkers than in increasing drinkers or decreasing drinkers

Pearson's product-moment correlations (1-tailed) were conducted on Time 1 data between the TIS and RIS separately in 35 participants who maintained that there had been no change in their weekly alcohol consumption and 143 who said it had either increased or decreased (see Table 2.20). Cohen & Cohen's (2003) formula for comparing two independent correlations was used to examine the significance of the differences between the correlations.

Table 2.20: Correlations between TIS and RIS scales and subscales in participants with stable versus changing patterns of alcohol consumption

	Correlations in subgroups		**Comparison of correlations in stable drinkers versus changers**	
Variables	*Stable drinkers (n = 35)*	*Changers (n = 143)*	*Z value*	*p value (1-tailed)*
TIS Cognitive Impulsivity and RIS Cognitive Impulsivity	0.80	0.59	2.15	0.02
TIS Motor Impulsivity and RIS Motor Impulsivity	0.57	0.61	-0.31	ns

All correlations significant at the 0.01 level (1-tailed).

To summarise, the TIS and RIS Cognitive Impulsivity subscales, as hypothesised, were more strongly correlated in those whose alcohol intake had not changed in the previous two weeks than in those whose drinking had either increased or decreased [Z = 2.15; p = 0.02, 1-tailed]. However, the hypothesis was not borne out for the Motor Impulsivity subscale [Z = -0.31; ns, 1-tailed].

Discussion

Overview of Discussion: The primary purpose of this study was to develop and start validation of a new instrument to measure impulsiveness, with corresponding trait (TIS) and recent (RIS) versions. Over 200 participants completed each version of the instrument on two occasions (Time 1 and Time 2) one month apart.

Exploratory factor analyses (EFAs) revealed a TIS with two factors, labelled Cognitive Impulsiveness (CI) and Motor Impulsiveness (MI). Confirmatory Factor Analyses (CFAs) subsequently performed upon the TIS at Time 2 and the RIS at Times 1 were broadly consistent with this two-factor solution.

Correlational analyses at Time 1 confirmed that, as expected, the trait version correlated more highly with an existing trait impulsiveness measure (the BIS-11) than did the recent version. For the MI subscale, test-retest correlation showed a trend, albeit a relatively weak one, to being higher in the trait version (TIS) than in the recent version (RIS).

In order to explore the notion that recent changes in alcohol consumption should be reflected in changes in impulsiveness in daily life, as measured by the RIS compared to the TIS, correlations were performed between the TIS and RIS subscales and recent alcohol intake as a non-categorised variable. These revealed the correlation between RIS MI and recent alcohol intake to be greater than that between TIS MI and recent alcohol intake (though there was no equivalent difference for CI). Similarly, there was a positive and significant correlation between changes in Motor MI (but not CI) and changes in alcohol intake within the previous two weeks. Finally, correlations between TIS and RIS subscales were performed separately within participants who had indicated a recent change in their alcohol

consumption and within those who had indicated no recent change. The correlation between the TIS and RIS CI subscale was, as predicted, greater amongst those who had indicated no recent change compared to those who had indicated a change; however, this was not the case for the MI subscale.

The following discussion first focuses on the structure of the newly-developed TIS and RIS scales, and then considers the relationships between scores on these scales and participants' recent alcohol intake.

1) The structure and content of the newly-developed TIS and RIS scales

The exploratory and confirmatory FAs of the TIS revealed that eight items loaded evenly on two factors. The MI factor reflected the respondent's tendency to behave rashly, without considering potential negative consequences. This is illustrated by the top-loading two items, 'I encounter problems because I do things without stopping to think' and 'I become involved with things that I later wish I could get out of'. In contrast, the CI subscale appeared to tend towards planfulness and greater control, as illustrated by its two highest-loading items: 'I plan work tasks and activities in my free time carefully' and 'I am focused, seeing things through to the end'. CI and MI were relatively independent of one another, with a low to moderate correlation of 0.28.

Nine additional items had loadings between 0.3 and 0.5 on these or other (smaller) factors. Although items with loadings of at least 0.32 can be included in the interpretation of a factor (Comrey & Lee, 1992), the aim here was to create a short scale which would be quick to administer.

In terms of content, the CI and MI subscales resemble certain of the subscales of the source measures. Thus, the CI subscale is similar to the Non-Planning Impulsiveness subscale of the BIS-11 (Patton *et al.*, 1995), the Premeditation subscale of the UPPS (Whiteside & Lynam, 2001), and the Decision Time subscale of the EASI-III (Buss & Plomin, 1975). Likewise, the MI subscale resembles the Motor Impulsiveness subscale of the BIS-11, the Urgency subscale of the UPPS, and the Inhibitory Control subscale of the EASI-III.

Relatedly, the two subscales do not correspond simply to conceptualisations of behavioural inhibition and delay aversion. The MI, including the items 'I encounter problems because I do things without stopping to think' and 'I tend to act "on impulse"', appears to incorporate elements of both behavioural disinhibition as well as delay aversion. The CI subscale likewise includes elements of forward planning and impulse control.

For questionnaire development, a sample of 262 is considered to lie somewhere between 'fair' (i.e. 200) and 'good' (i.e. 300; Comrey & Lee, 1992), and as such might be considered to have represented a strength. Also, for the CFAs, there was a relatively high participant-to-variable ratio of around 200:8, making the sample size rather robust. However, the sample was clearly not representative of the general population: All were first year Psychology undergraduates, and predominantly female (c. 4:1). Consequently, the question of generalisability needs to be addressed, especially since males tend to score higher than females on measures pertaining to impulsiveness (e.g. Cyders, 2011). CFAs were therefore conducted in female and male subgroups separately, and revealed a very similar factor structure. This is consistent with data recently reported by Cyders (2011), in which the five subscales of the UPPS were found to be structurally invariant across gender. Furthermore, men and women did not differ in their mean scores on the TIS CI and MI subscales.

Given the homogeneity of the present sample, its psychometric properties in the general population are unknown and need further investigating. However, the primary objective of the present study was to produce an instrument potentially sensitive to transient fluctuations in impulsivity, in order to explore associations with other variables hypothetically influencing or influenced by Recent Impulsivity. The utility of the RIS in this regard is addressed in the following sections.

2) Investigating the validity of the TIS and RIS scales

Hypothesis 1, that the well-established trait impulsiveness measure, the BIS-11, would correlate more strongly with the BIS-11 Total score than the RIS Total score, was supported. Since the only difference between the TIS and RIS was the time-

frame within which the items were contextualised, this confirms the more trait-like nature of the former, and adds weight to the thesis that the RIS is relatively more sensitive to fluctuations in state.

Hypothesis 2, that the test-retest correlation for the TIS would be greater than for the RIS, was not supported. There was a suggestion of a trend for the greater test-retest correlation of the TIS MI subscale compared to that of the RIS MI subscale, but this was relatively weak. The lack of support for Hypothesis 2 may have derived from the majority of people within the whole sample being relatively stable across the test-retest interval. In order to explore this possibility, future studies should therefore aim to recruit a larger sample in order to detect differences in stability of the TIS and RIS subscale scores. The observation that those whose drinking had recently changed also showed shifts in MI (though not CI) (Hypothesis 3. iii, see Section 3 below) would appear to support such notions.

It would have been interesting and highly relevant to test participants on behavioural measures of impulsivity alongside the self-report measures. The recent measure would be predicted to correlate more strongly than the trait measure with such indices. Correlational analyses between the TIS and RIS and, for example, Go/NoGo and Continuous Performance Tasks, would thus have acted as further tests of validity. Although it was not practical to do so, given limited time and resources, it would be desirable for future studies to explore such associations.

It must be acknowledged that the RIS questionnaire is limited in its ability to tap moment-to-moment variations in *state* impulsivity, since its items relate to behaviours which occur over somewhat extended time periods. It may not be possible to construct a truly 'state' impulsivity instrument; whilst it is relatively straightforward to indicate how anxious one is feeling at a certain moment, for example, it is by definition rather more difficult to reflect on one's tendency to be impulsive.

3) The relationship between the TIS and RIS scales and habitual alcohol intake

Hypothesis 3, which predicted that in all participants, habitual alcohol intake would share a greater correlation with the TIS than the RIS, was not supported. Thus, in the sample as a whole, and in line with expectations, the TIS and RIS MI subscales, as well as the RIS CI subscale, shared positive and significant correlations with habitual alcohol intake; although the positive correlation between TIS CI and habitual alcohol intake did not reach statistical significance, it nevertheless showed a clear trend. It is unclear why there were no differences between the scales' respective correlations with habitual intake, although given the large degree of overlap between the TIS and RIS scales, and the relatively modest sample size for such correlational analyses, to become statistically significant any differences would have had to have been large indeed. Further studies with larger samples are therefore needed.

4) The relationship between the TIS and RIS scales and recent alcohol intake

Hypothesis 4. i), which predicted that in all participants, there would be a stronger association between recent alcohol intake and the RIS than between recent alcohol intake and the TIS, was borne out for Motor Impulsivity but not Cognitive Impulsivity. A recent increase in alcohol intake, compared to habitual intake, was therefore more associated with an increase in 'rash' behaviour. Similarly, Hypothesis 4. ii), predicting that recent changes in alcohol consumption would be associated with recent changes in impulsivity, was also supported for MI but not CI. Thus, participants who had increased their alcohol intake within the previous two weeks, compared to their habitual intake, reported higher than normal levels of MI within the previous two weeks.

Hypothesis 4. iii), predicting that TIS and RIS scores would be more highly correlated with one another in stable drinkers than in those whose consumption had recently changed, was confirmed for CI but not for MI. Thus, a recent change in alcohol intake was associated with a change in the extent to which participants were able to demonstrate forethought, plan activities in their life and concentrate. This is consistent with the present theses that, firstly, 'real-world' impulsiveness fluctuates

over time, and secondly, that alcohol consumption can influence such fluctuations. It is not clear why MI was not similarly related to changes in alcohol consumption.

Taken at first glance, this finding appears to represent the converse of those observed in relation to Hypotheses 4. i) and 4. ii). However, the positive correlations observed between recent (change in) MI and recent (change in) alcohol intake indicated direct relationships within the whole sample. By contrast, Hypothesis 4. iii) related to the relationships between recent alcohol intake and recent impulsivity in separate subgroups of stable drinkers and changers; accordingly, although the correlation between CI scores on the TIS and RIS was lower in participants whose drinking level had recently changed, we cannot be sure that this was attributable to or caused by the change in their drinking; there could have been other relevant but unmeasured differences between the groups.

At a general level, the findings relating to Hypothesis 4. iii) appear to conflict with research, such as that described by Fillmore and Vogel-Sprott (1999), which suggests that alcohol given acutely increases the tendency towards impulsive actions. However, there are important differences between the studies, which may account for their apparently contradictory findings. Firstly, Fillmore and Vogel-Sprott observed the effect of alcohol administration upon clearly defined operational outcomes (i.e. rates of commission error in response to no-go stimuli) in a laboratory setting, whereas the present study correlated participants' alcohol intake with their 'real-world' self-reported impulsiveness. Secondly, Fillmore and Vogel-Sprott measured the effect of alcohol upon these outcomes at a particular moment in time, whereas the present study looked at associations over a two-week period.

Seventy-six participants (more than a third of the sample) denied consuming any alcohol within the previous 12 months. This unexpectedly high figure may have been a result of individuals who were adhering to orthodox religious lifestyles, for example Islam which, given the diversity of students at London Universities in general and possibly Goldsmiths College in particular, would probably have been relatively well-represented in the sample.

The present data therefore offer some, albeit mixed, support for the contention that recent changes in alcohol intake are related to real-world recent impulsiveness as assessed by self-report. In broad terms, therefore, these findings are consistent with laboratory studies, such as that of Fillmore and Vogel-Sprott (1999), showing alcohol to induce increased impulsivity.

Since all of the present analyses were correlational, it cannot be concluded that recent increases in alcohol intake *caused* increases in impulsivity. It is quite plausible that the relationship between these variables is bi-directional. As has been set out by Jentsch and Taylor (1999), high levels of impulsivity are thought to contribute to chronic levels of drug intake. Also, longitudinal prospective studies have indicated that young adults higher in trait impulsiveness are subsequently more likely to present with substance use disorders (e.g. Sher *et al.*, 2000). Clearly, individuals high in trait impulsiveness are more likely to be high in RI at any given time, and therefore more likely to engage in a higher frequency of impulsive behaviours, including alcohol and other drug use, over an extended period.

Even assuming that increased alcohol intake did lead to increased recent impulsivity in the present study, there would still be many questions concerning whether this could be attributed to the same process(es) as observed in behavioural laboratory studies. It remains unknown how long an alcohol-induced elevation in impulsivity lasts for or, relatedly, whether the heightened recent impulsivity observed here reflected single episodes of drinking or a collection of discrete episodes. This may well have varied between participants. It is possible that repeated bouts of heavy drinking engender longer-lasting increases in impulsivity, but the present data do not enable this to be tested. These are important issues which could, in practice, be addressed by future research.

It is important that laboratory studies are complemented by research utilising self-report questionnaires and adopting a correlational approach, since it remains unclear to what extent their findings generalise to more naturalistic settings. Thus, the acute increases in behavioural impulsivity following alcohol consumption in laboratory situations may not reflect what happens in real-world contexts.

Chapter 3: Examining electrophysiological and subjective cue-reactivity and electrophysiological and behavioural impulsiveness in non-dependent heavy social drinkers

Abstract

***Background and aims**: Previous studies have reported non-dependent heavy social drinkers to show heightened impulsiveness and cue-reactivity to alcohol-related stimuli, but there has been little investigation of these variables in lighter drinkers. The present study compares subjective and electrocortical cue-reactivity and self-report, behavioural and electrocortical indices of impulsiveness in samples of 12 non-dependent heavy drinkers (HDs) and 10 light drinkers (LDs).*

***Hypotheses**: Compared to LDs, HDs will: i) show greater electrocortical reactivity (larger P3 amplitudes) to alcohol-related stimuli than to neutral stimuli; ii) report greater craving for alcohol following exposure to alcohol-related than to neutral stimuli; iii) assign higher arousal ratings to alcohol-related than neutral stimuli; iv) self-report higher impulsiveness; v) show higher behavioural impulsiveness on a Continuous Performance Task (CPT); and vi) show reduced no-go P3 and no-go N2 amplitudes and increased no-go P3 and no-go N2 latencies whilst they perform the CPT. In addition, electrophysiological cue-reactivity will correlate significantly with subjective cue-reactivity and with ratings of stimulus arousal; and recent impulsiveness will correlate more strongly than trait impulsiveness with: i) electrophysiological and subjective measures of cue-reactivity and; ii) behavioural and ERP measures of impulsiveness.*

***Methods:** EEG was recorded during (a) exposure to alcohol-related and neutral words and (b) the CPT. Participants rated their craving for alcohol immediately following exposure to each type of word stimulus, and at the end of the study they rated all words for arousal.*

***Results:** HDs but not LDs showed greater P3 amplitudes to alcohol-related words than to neutral words, and gave higher arousal ratings to alcohol-related than neutral words. By contrast, there were no differences in subjective craving. Neither*

were there any differences between the groups in terms of self-report, behavioural or electrocortical indices of impulsivity. It did not appear that recent impulsiveness was more strongly associated than trait impulsiveness with: i) electrophysiological and subjective measures of cue-reactivity and; ii) behavioural and ERP measures of impulsiveness.

Conclusions: *The electrocortical cue-reactivity data were partially consistent with previous findings in non-dependent drinkers and with Robinson & Berridge's contention that repeated drug administration leads to drug-related cues acquiring incentive salience. That this was not reflected in between-groups differences in subjective cue-reactivity or impulsiveness may indicate that in non-dependent drinkers, these phenomena can occur somewhat independently of one another.*

Introduction and rationale

Current theoretical frameworks of addiction contend that drug abuse is associated with increases in the salience of drug-associated stimuli, as manifested in characteristic subjective, physiological and electrophysiological responses when dependent individuals are presented with drug-associated stimuli ('cue-reactivity'; Drummond *et al.*, 1995), and increases in aspects of impulsivity (Vuchinich & Simpson, 1998). Recent research has revealed that non-physically dependent social drinkers (i.e. those who do not experience a withdrawal syndrome upon cessation of drinking and metabolism of alcohol) sometimes demonstrate subjective and electrophysiological changes when presented with alcohol-relevant stimuli (Herrmann *et al.*, 2001), as well as heightened behavioural (Colder & Connor, 2002) and electrophysiological (Oddy & Barry, 2009) impulsiveness. The questions of whether social drinkers exhibit similar subjective and electrophysiological correlates of cue-reactivity and impulsiveness as their alcohol-dependent counterparts remain open ones; answering them may help to elucidate the mechanisms involved in the development of problematic alcohol consumption. The primary purposes of the present study were to examine subjective and electrophysiological cue-reactivity and behavioural and electrophysiological impulsiveness in non-dependent heavy social drinkers (HDs).

Overview of introduction and rationale: In the pages which follow, brief summaries will firstly show that: research has consistently reported appetitive responses to alcohol-related stimuli in alcoholics, which can be explained by current models of alcohol addiction (Section 1. i); and that non-dependent HDs also demonstrate these physiological and subjective responses to alcohol-related stimuli (Section 1. ii). It will then be argued that electrophysiological measures such as event-related potentials represent a promising means of studying the brain correlates of cue-reactivity (Section 1. iii), and that alcohol-dependent individuals demonstrate characteristic electrophysiological waveforms when presented with alcohol-related stimuli (Section 1. iv). Despite theoretical reason to expect that non-dependent HDs might similarly exhibit electrophysiological cue-reactivity, only one study has at present examined this. Although it reported positive results, its conclusions appear rather questionable (Section 1. v).

Sections 2.i and 2.ii briefly present research which has consistently reported heightened impulsiveness in alcoholics, as measured by behavioural inhibitory tasks, as well as the small but promising literature documenting similar patterns in non-dependent HDs. As well as having impaired behavioural inhibition, it appears that alcohol-dependent individuals also demonstrate abnormal event-related potentials whilst they perform such tasks (Sections 2. iii and 2. iv). As with electrophysiological cue-reactivity, only one study appears to have investigated deficient electrophysiological correlates of inhibitory control in non-dependent social drinkers (Section 2. v), and more research is therefore needed. The theoretical association between cue-reactivity and heightened impulsiveness is discussed in Section 3, prior to the aims and hypotheses of the present study (Section 4).

1. Appetitive responses to alcohol-related stimuli in problem drinkers

1. i) Appetitive responses to alcohol-related stimuli in alcohol-dependent individuals

As detailed in Chapter 1 (pp. 26-34), individuals who engage in problematic drinking behaviour demonstrate characteristic responses to alcohol-related stimuli, a phenomenon known as ‘cue-reactivity’ (CR). These CR effects have been interpreted

within different theoretical models. Tiffany (1990) interpreted CR in the context of a cognitive-processing framework (Cox *et al.*, 1999). This theory contends that through repeated alcohol or other drug use, cognitive processes associated with alcohol or other drug procurement – termed 'action schemata' – become increasingly automatic. Tiffany argues that non-automatic cognitive processes can become engaged during exposure to alcohol/other drug-related cues and are experienced by the individual as a desire for alcohol/other drugs.

A related model, 'incentive sensitisation theory' (Robinson & Berridge, 1993; 2000), asserts that the repeated administration of drugs of abuse leads to the sensitisation of dopamine activity within the mesocorticolimbic pathways which mediate responses to motivationally salient stimuli. Consequently, intense craving for the drug develops and drug-associated environmental cues acquire conditioned incentive properties: that is, they develop 'incentive salience'. Behaviourally, therefore, drug-paired cues act as intense conditioned incentives which 'grab attention, become attractive and "wanted", and guide behaviour to the incentive' (Robinson & Berridge, 1993, p. 261). This increased salience is likely to play a role in the development and maintenance of substance use disorders, since repeated involuntary attentional orienting to drug-related cues is likely to lead to further drug use; thus, there may be a reciprocal causal relationship between incentive salience and drug use. It follows that individuals engaging in frequent, albeit non-dependent, drinking behaviours should also display CR, albeit to a lesser extent than dependent drinkers. If CR develops linearly as a function of drinking experience, heavier drinkers should show stronger CR than lighter drinkers.

1. ii) Cue-reactivity in non-dependent heavy drinkers: the evidence

Chapter 1 (pp. 44-45) presented evidence that upon exposure to alcohol cues, heavy drinkers (HDs) have been reported to demonstrate CR via both self-report and behavioural and physiological measures. Thus, CR appears to occur not only in those with a diagnosis of alcohol dependence but also in less severe drinkers. Understanding of the mechanism(s) by which increased incentive salience relates to increased alcohol intake is, however, far from complete. The elucidation of brain

mechanisms associated with CR may contribute to this understanding; electrophysiological measures provide one means of doing this.

1. iii) Event-related potentials as a useful means of examining cue-reactivity

Electrophysiological indices, such as event-related brain potentials (ERPs), are a potentially valuable means by which to investigate the biological substrates of CR. ERPs are time-locked electrical potentials which reflect synchronous neural activity in specific brain areas and have been reliably associated with neurosensory and cognitive processing (Handy, 2005). Participants are presented with stimuli in some modality, and the electroencephalogram (EEG) over the period of observation is averaged to produce a series of waves of differing polarity and amplitude – that is, 'components' (Ehlers *et al.*, 2003). The particular components elicited in a given ERP, and its particular scalp distribution, differ depending on the sensory modality in which stimuli are presented (Handy, 2005). Figure 3.1 depicts an idealised ERP wave recorded over the posterior of the scalp and elicited by a visual stimulus.

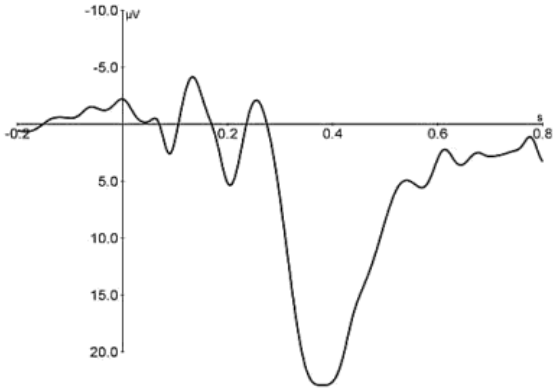

Figure 3.1: Diagram of an idealised ERP wave recorded over the posterior of the scalp elicited by a visual stimulus, showing the components P1, N1, P2, N2 and P3, and the times at which they each approximately tend to appear following stimulus presentation (image taken with permission from Handy, 2005). The names of each component peak are given according to whether the peak is positive or negative (hence 'P' or 'N') and its position relative to other peaks of the same polarity (hence '1', '2', '3'). For example, 'P3' is the third positive component peak (peaking at around 0.4 seconds). (Note that in this figure, the *y* axis locates its negative values above the point at which it transects the *x* axis, and its positive values below. However, it is also common for this positioning to be reversed. Either presentation is considered acceptable.)

Convincing data suggest that the amplitude and latency of particular ERP components can be related to awareness processes (Brandeis & Lehmann, 1986) and to the processing of emotional stimuli (Schupp *et al.*, 2000). Studies examining the electrophysiological correlates of CR have tended to focus upon one particular 'cognitive' component of the ERP wave: the P3 (also called P300, but referred to throughout this chapter as P3 for consistency). This is a positive deflection in voltage – amplitude measured in microvolts (µV) – with a latency (i.e. delay between stimulus and response) of between 300 and 600 milliseconds (Hansenne, 2000). It has been related functionally to stimulus evaluation (Kutas, McCarthy & Donchin, 1977) and 'context updating' (Donchin, 1981). Thus, for example, in the 'oddball' task participants show greater P3 amplitudes in response to novel or unexpected stimuli which differ in some important way (e.g. semantic category)

from the standard, repetitive stimuli to which they are attending (Gaeta *et al.*, 1998).

The P3 is elicited by emotionally-salient stimuli and not by neutral stimuli, and is widely distributed across left and right lateral recording sites (Palomba, Angrilli & Mini, 1997; Cuthbert *et al.*, 2000; Schupp *et al.*, 2000; Carretie *et al.*, 2001), making it especially relevant for examining CR. Johnson (1986) proposed that P3 amplitude is contingent on the value and/or significance of the stimulus to the particular individual, as opposed to its physical attributes. Thus stimuli of high emotional salience elicit a high-amplitude P3 (Lang, Bradley & Cuthbert, 1997). Importantly, amplitude is influenced similarly by emotional cues of both positive and negative valence (e.g. pleasant and unpleasant; Lang *et al.*, 1997; Rozenkrants & Polich, 2008). Furthermore, studies in clinical groups have revealed that disorder-specific stimuli evoke increased P3 amplitudes compared to neutral stimuli: for example, individuals with combat-related post-traumatic stress disorder show elevated P3s in response to trauma-relevant combat stimuli (Stanford *et al.*, 2001), as do panic-disordered individuals exposed to anxiety-related words (Pauli *et al.*, 1997). It therefore follows that the magnitude of social drinkers' P3 responses to alcohol stimuli, relative to neutral stimuli, is likely to be an indicator of the degree of motivational salience such stimuli have acquired. It is accordingly predicted that HDs will show greater P3 reactions to alcohol stimuli than will LDs.

Another commonly investigated ERP component is the N2 – the second negative peak following stimulus presentation (see Figure 3.1 on p. 106). This component is discussed in Section 3 of this chapter.

1. iv) Greater P3 responses to alcohol-related stimuli in those with alcoholism

In one of the first studies to investigate ERPs within an alcohol-dependent sample, Genkina and Shostakovich (1987) reported that the P3 potential was greater during presentations of the word 'vodka' than during neutral words. A limitation of this study, however, is that the alcohol-related and neutral word stimuli were presented within a single session in a ratio of 1:5. Semantic category was therefore confounded with frequency. This is critical, since infrequent or 'alerting' stimuli

themselves elicit an increased P3 component (Pontifex, Hillman & Polich, 2009). This is thought to reflect the selection of stimulus information governed by attentional orienting (Rushby, Barry & Doherty, 2005); put differently, Squires, Squires, & Hillyard (1975) have suggested that it reflects attentional focus being disengaged from routine information and shifted to an unexpected stimulus. The observed elevation of P3 amplitude to alcohol cues in Genkina and Shostakovich's study may therefore index attentional orienting to relatively infrequent stimuli rather than a response specifically to their alcohol-related content.

Subsequent studies have remedied this confound by presenting equal numbers of alcohol-related and neutral stimuli. Herrmann *et al.* (2000) presented nineteen male alcoholics and nineteen healthy male controls with fifteen alcohol-related and fifteen neutral word cues. At the posterior electrode (Pz) location, alcoholic participants but not controls demonstrated significantly higher P3 amplitudes to the alcohol-related words than to the neutral words. Furthermore, within the alcoholic participants those who rated the alcohol stimuli as more pleasant exhibited higher electrophysiological responses, consistent with the notion that the amplitudes reflect the strength of subjectively-experienced appetitive/approach processes.

Namkoong *et al.* (2004) presented six alcohol-related and six neutral pictures to twelve control participants and sixteen abstinent alcoholics. In alcoholics but not controls, P3 responses to the alcohol-related pictures were significantly larger than those to the neutral pictures. Since the pictorial stimuli were carefully matched for dimensions and visual content (e.g. a colour photograph of a bottle of alcoholic beverage versus a colour photograph of a milk bottle), it is likely that their contingent P3 amplitudes reflected the motivational significance of the stimuli, rather than their physical properties. Finally, the alcoholic participants but not the controls reported greater craving following the alcohol pictures than the neutral pictures, and there were significant correlations between cue-elicited craving and cue-elicited P3 amplitudes. The findings therefore strongly suggest that P3 amplitudes are an electrophysiological correlate of craving. Similarly, Heinze, Wolfling and Grusser (2007) exposed ten detoxified alcoholics and ten healthy controls to complex alcohol-associated sounds (e.g. opening of a beer can) and

neutral sounds (e.g. opening a door); alcoholics demonstrated significantly higher craving and higher amplitude P3 responses to alcohol cues than did controls.

The results of the above studies indicate ERP CR in alcohol-dependent individuals. This is consistent with findings in users of other addictive substances including nicotine (Warren & McDonough, 1999; McDonough & Warren, 2001), cocaine (van de Laar *et al.*, 2004; Franken *et al.*, 2008) and heroin (Franken *et al.*, 2003). These studies tend to report significant positive correlations between self-reported CR and P3 amplitudes, though there are exceptions; McDonough & Warren (2001), for instance, found no correlation.

An alternative possible explanation relates to Johnson's (1995) finding in a retrieval paradigm that stimuli which are more familiar than others elicit stronger late positive potentials, most clearly at around 600 msec. All of the alcohol CR studies mentioned above observed P3 effects at a latency less than 500 msec; although familiarity effects are *maximal* at 600 msec, they could still be evident at earlier latencies. However since the control stimuli in these studies were either pictures of everyday items or word stimuli matched with alcohol words for lexical frequency there is no reason to expect them to be relatively less familiar. This explanation is thus not persuasive.

1. v) ERP cue-reactivity in non-dependent social drinkers

The evidence reviewed in the preceding sections has indicated that alcoholics and non-dependent HDs demonstrate autonomic arousal and subjective urge to drink in response to alcohol-related cues, and that alcoholics also demonstrate CR as measured by ERP responses. However only one published ERP study has examined CR to alcohol stimuli in HDs. Herrmann *et al.* (2001) presented fifteen HDs and fifteen LDs – all male and matched for family history of alcohol use disorders – with forty alcohol-relevant pictures (e.g. a bottle of brandy) and forty non-alcohol-related neutral pictures (e.g. a bottle of water). Participants rated the stimuli on a 5-point scale ranging from '-2' ('very unpleasant') to '+2' ('very pleasant'). HDs but not LDs demonstrated greater P3 amplitudes at the frontal electrode (Fz) in response to alcohol stimuli, and also rated alcohol-related pictures as more pleasant than

neutral pictures. In the whole sample, but not within each group individually, cue-elicited craving correlated significantly with peak P3 amplitude at the electrode locations Fz and Cz. These findings suggest that non-dependent HDs, but not LDs, attribute greater motivational salience to alcohol-related stimuli than to non-alcohol-related stimuli, as revealed by their electrophysiological as well as self-report responses, and that this reflects drinking behaviour rather than pre-existing genetic differences.

There are, however, methodological limitations to Herrmann *et al.*'s (2001) study. Participants in the two groups were not recruited on the basis of specified levels of habitual alcohol consumption; rather, they were categorised on the basis of a post-hoc median split. The principal problem with a median split is that often the resulting groups do not necessarily correspond with more formal taxonomies or diagnostic classifications. Indeed, Herrmann *et al.*'s so-called 'heavy drinkers' consumed an average of only about 15 units per week; this is hardly representative of heavy social drinking, given that the UK government currently considers 21 units per week to be reasonable. Furthermore, there was a large standard deviation (+/- 36.80 units per month), meaning that some of the 'HDs' would have been drinking markedly below even this level. That differences between the groups were nevertheless observed is interesting. However, in terms of validity (both internal and external) and replication, it is preferable to specify parameters for heavy and light drinking groups prior to recruitment.

Importantly, although Herrmann *et al.* (2001) reported a significant correlation between 'emotional cue-reactivity' and electrophysiological CR, their measure of the former is atypical: participants rated the alcohol-related and neutral stimuli for pleasantness/unpleasantness rather than rating their desire to consume alcohol immediately following exposure to both alcohol-related stimuli and neutral stimuli. The study described in the present thesis therefore includes self-report measures of subjective alcohol desire as well as ratings of affective salience analogous to those used by Herrmann *et al*.

Finally, it is possible that Herrmann *et al.*'s results might be explained by personality differences rather than level of alcohol consumption. Vollrath and Torgersen (2008), among others, have reported higher extraversion in 'risky' drinkers. If the HDs in Herrmann *et al.*'s study were more extraverted than controls, it is possible that they responded more appetitively to alcohol-relevant pictures because their association with social rewards is more salient to extraverts than introverts. This is plausible given the inherently social nature of most alcohol consumption. More than almost any other drug (with the possible exception of caffeine) alcohol consumption takes place predominantly in the presence of others. The current study therefore additionally explored whether extraversion was associated with the amplitude of the P3 response to alcohol-related stimuli. Relatedly, another potentially relevant personality factor is impulsivity, one of the key themes of the present thesis. This is considered in the following section.

2) Impulsiveness and behavioural disinhibition in problem drinkers

2. i) High impulsiveness in alcohol-dependent individuals

There is much evidence that problem drinkers are high in 'impulsiveness' or 'impulsivity'. As has already been discussed (see Chapter 2, pp. 51-52), there is considerable debate concerning how to define impulsivity. Briefly, it does not appear to be a unitary construct (Reynolds *et al.*, 2006a), and is often suggested to incorporate two (discrete) components (de Wit, 2008): i) a failure of inhibitory control, or failure to inhibit reward-driven behaviour or pre-potent responses, sometimes termed 'motor impulsiveness' (Olmstead, 2006); and ii) impaired decision-making, arising from over-sensitivity to immediate rewards and under-sensitivity to delayed consequences ('cognitive impulsiveness'; Olmstead, 2006). Accordingly, a range of self-report and behavioural measures have been used to index impulsiveness (see Chapter 1, pp. 37-41).

2. ii) Evidence for heightened impulsiveness in HDs

As related in Chapter 1 (pp. 45-47), accumulating evidence suggests that HDs are more impulsive than LDs in terms of behavioural delay discounting and inhibitory

control tasks and self-report measures. Further research is needed to examine the relationship between impulsiveness and the development of heavy or problematic drinking, and specifically, whether impulsivity may predict or arise as a consequence of chronic heavy social drinking.

2. iii) Heightened behavioural impulsiveness and abnormal electrophysiology in problem drinkers

In addition to alcoholics' more impulsive performance on tests of inhibitory control, they also tend to demonstrate characteristic abnormalities in electrophysiology during the response inhibition, or no-go, conditions of these tasks. Two major ERP components have been implicated as markers for response inhibition: first, the P3 ('no-go P3'), an augmented positive-going component usually peaking between 300 and 600 msec post-stimulus, and the same as that associated with emotional responding/CR; and second, the N2 ('no-go N2'), a negative voltage deflection which tends to peak frontocentrally at around 200-300 msec post-stimulus (see Figure 3.1 on p. 106; Eimer, 1993; Pfefferbaum *et al.*, 1985; Jodo & Inoue, 1990; Jodo & Kayama, 1992).

According to conflict control theory, the Go/NoGo task involves conflict monitoring and attentional control processes (Botvinick, Cohen & Carter, 2004). Conflict arises in the no-go condition as motor response expectancy is violated (Bekker, Kenemans & Verbaten, 2004). No-go P3 is considered to relate to attentional control processes, and no-go P3 with frontocentral distribution correlates with inhibition control (Bokura, Yamaguchi & Kobayashi, 2001). No-go N2 seems to reflect monitoring in the conflict situation (Bruin, Wijers & van Staveren, 2001), with source location analysis indicating that no-go N2 is generated in anterior cingulate cortex (ACC) and prefrontal cortex (PFC). This converges with findings from neuroimaging studies which suggest that ACC activation reflects conflict detection (Botvinick *et al.*, 2004).

Oddy & Barry (2009) suggest that the N2 might be more associated than the P3 with response inhibition, since the latter occurs relatively late in the stimulus processing chain and is therefore more likely to be associated with finalisation or closure of the

mental process than with the process itself (Falkenstein, Hoormann & Hohnsbein, 1999). Nevertheless, since it appears that both components reflect some aspect of inhibition in cognitive processing significant abnormalities in either component might relate to a degree of inhibitory deficiency (Kaiser *et al.*, 2003).

Research into ERP inhibitory abnormalities in those with a diagnosis of alcohol dependence has focused almost exclusively upon the no-go P3, as discussed in the following section. A literature search did not return any studies comparing the N2 in alcoholics versus controls.

2. iv) P3 responses during inhibitory control tasks in alcoholics versus controls

The go and no-go conditions of inhibitory tasks are associated with different forms of P3: the P3a and the P3b. The P3b component is typically produced during response production to target stimuli (i.e. the go condition) whilst the P3a is thought to reflect the orienting response to unexpected non-target stimuli and is larger to novel or rare non-targets (i.e. the no-go condition; Rodríguez Holguín *et al.*, 1999a).

The P3a may be a response to intrusive or 'novel' stimuli such as dog barks, abstract colour forms, etc (Rodríguez Holguín *et al.*, 1999a). The P3a occurs earlier, and is sometimes confused with the later P3b peak (Squires, Squires & Hillyard, 1975). P3a is typically larger in amplitude than the P3b over the frontal and central electrode sites and is thought to reflect an alerting process which originates in the frontal cortex (Courchesne, Hillyard & Galambos, 1975). It appears that P3a generation depends upon the stimulus context within which novel stimuli are presented (Comerchero, Katayama & Polich, 1997; Katayama & Polich, 1998). For example, the P3a component is elicited when infrequently-presented novel stimuli interrupt attentional mechanisms engaged in performance of the primary task (Rodríguez Holguín *et al.*, 1999a). Since the present research focuses specifically on inhibition, the following review is concerned only with studies which have examined the P3a. This component is henceforth referred to simply as the no-go P3.

There is evidence that no-go P3 components are abnormal in alcoholics, though the precise nature of this abnormality is at present equivocal. For example, Rodríguez Holguín *et al.* (1999a) required forty-four male alcoholics and twenty-eight controls to make a difficult perceptual discrimination between frequently occurring vertical lines (80% of trials) and infrequent 'target' lines that were tilted 2^{o} to the right of the vertical (10% of trials). In addition, infrequent horizontal lines occurred on 10% of trials. Participants were required to respond, by a button press, only to the tilted 'targets'. Alcoholic participants produced smaller no-go P3 amplitudes than healthy controls, but there were no differences in its latency. Similar results have been reported by Hada *et al.* (2000) and Realmuto *et al.* (1993) in auditory Go/No-Go paradigms. Rodríguez Holguín *et al.* (1999a) suggest that given the relationship between the no-go P3 and frontal lobe activity, this component might represent an electrophysiological correlate of alcoholics' well-documented frontal lobe dysfunctions (see Chapter 1, pp. 34-36).

However, other studies have reported increased no-go P3 latencies but no differences in no-go P3 amplitude. In a similar 'three-stimulus' visual paradigm to that used by Rodríguez Holguín *et al.* (1999a), Fein and Chang (2006) presented 'standard' stimuli (which appeared 210 times), target stimuli (which appeared 35 times), and novel rare non-target stimuli (which also appeared 35 times) to chronic alcoholics and healthy controls, with participants similarly being instructed to respond only to target stimuli. Alcoholics did not display no-go P3 amplitude reductions compared to controls, but their no-go P3 components were delayed. Biggins *et al.* (1995) have reported similar findings in three-stimulus visual and auditory paradigms.

The apparently contradictory findings reported by Rodríguez Holguín *et al.* (1999a) and Hada *et al.* (2000) on the one hand, and Fein and Chang (2006) and Biggins *et al.* (1995) on the other might reflect sample characteristics. The former studies tested active alcoholics undergoing treatment whilst the latter recruited abstinent alcoholics: indeed, Biggins *et al.*'s (1995) participants had been abstinent for between six months and two years. Thus reductions in no-go P3 amplitude might reflect recent levels of alcohol consumption.

There may also be a degree of genetic influence on no-go P3 effects, though findings are again mixed. For example, whilst Rodríguez Holguín *et al.* (1999b) reported that high-risk participants (that is, offspring and siblings of people with alcohol dependence) demonstrated reduced no-go P3 amplitudes but no latency effects compared to low-risk participants, the same researchers have elsewhere reported increased latency of no-go P3 in a high-risk group, but no abnormality of no-go P3 amplitude (Rodríguez Holguín, Corral & Cadaveira, 1998).

Some studies reporting a reduced no-go P3 in alcoholics or their children have not observed parallel performance abnormalities. For example, a series of studies by Kamarajan *et al.* (2004, 2005a, & 2005b) reported reduced no-go P3s but found no significant differences from healthy controls in terms of response time or proportion of errors. One possible explanation is that the no-go P3 reflects less efficient inhibitory processing but that the relatively undemanding level of the tasks means that the behavioural responses themselves are not compromised. In order to address this, future studies should ensure that the inhibitory tasks are sufficiently difficult to be discriminative.

2. v) ERP research examining inhibitory control in non-dependent social drinkers

Only one published study has examined the electrophysiological correlates of response inhibition/impulsiveness in non-dependent social drinkers. Oddy and Barry (2009) required thirteen light and thirteen heavy socially drinking undergraduate psychology students to perform a visual CPT whilst their EEG was recorded. On no-go trials, P3 amplitude was considerably reduced globally in the heavy social drinkers, and their no-go N2 was slightly smaller centrally. The magnitude of the P3 but not of the N2 reduction on no-go trials was negatively correlated with alcohol consumption. However, in line with the studies of Kamarajan *et al.* (2004, 2005a & 2005b), there were no differences between the groups in terms of behavioural performance: error rates in both groups were negligible and they did not differ in response time. Oddy and Barry concluded that HDs did not show impaired inhibitory control and that the electrophysiological group difference instead reflected impairment of the involuntary orienting response

(OR). They argue that the reduced no-go P3 reflected impaired aspects of reflexive stimulus processing rather than dysfunctional inhibition. However, given the relative paucity of such research in alcohol abusers generally and non-dependent drinkers specifically, such conclusions are perhaps premature. More research in non-dependent social drinking groups is therefore needed.

3. The present study: Design considerations

There is virtually no research examining the relationships between electrophysiological and subjective indices of alcohol CR in non-dependent HDs. However, ERPs are an important tool for understanding CR, since they provide information on the extent to which cues provoke physiological responses known elsewhere to correlate with emotional reactions. Studying them within social drinkers who, though non-dependent, are drinking in a dysfunctional manner which puts them at risk of future problematic alcohol consumption may provide insight into mechanism(s) involved in the progression from heavy social drinking to problematic consumption. If heightened P3 amplitudes to alcohol-related stimuli are present in non-dependent HDs, this would be consistent with such responses preceding the development of alcohol use disorders, rather than simply being symptomatic of them.

This study of heavy and light social drinkers was therefore designed to: i) replicate and extend previous findings that heavy social drinkers and alcoholics show elevated late positive potentials (such as the P3) in response to alcohol-related stimuli; and ii) to explore the interrelationships between self-reported subjective CR, arousal ratings of alcohol-related stimuli, and ERP indices. In order to avoid the diagnostic issues noted in relation to Herrmann *et al.*'s (2001) study, clear criteria for heavy and light social drinking were specified prior to recruitment. An additional issue explored here was the potential mediating role of personality traits, in particular extraversion and impulsivity. Participants completed the self-report Trait and Recent Impulsivity Scales developed for this thesis, and also a modification of the classic CPT, a behavioural index of impulsiveness. The Recent Impulsiveness Scale (RIS) asks respondents about their behaviour during the previous two weeks.

As demonstrated in Study 1, this measure of recent impulsiveness correlates only moderately with its trait equivalent (TIS), and theoretically could share greater variance than the TIS with CR and impulsivity because it reflects very recent/current functioning. Participants' ERPs were recorded whilst they completed the CPT, to examine whether HDs demonstrate inhibitory-related ERP abnormalities on no-go trials similar to those reported in alcoholics.

If any of these measures are elevated in heavy compared to light drinkers, there are at least three possible interpretations: (1) Impulsiveness might pre-exist and predispose individuals to heavy alcohol use; (2) it might develop as a consequence of heavy social drinking; or (3) it could be non-causally correlated with drinking level, though shared relationships with a third factor (e.g. social modelling, genetic disposition). Whilst it is beyond the scope of this cross-sectional study to distinguish between different causal relationships, it is nevertheless of interest to investigate the patterns of association in order to provide a basis for future longitudinal research.

As noted earlier, the ERP P3 component may reflect different aspects of cognitive processing depending on the context in which it is produced. To maximise the likelihood of eliciting no-go N2s and no-go P3s, the present study utilised Oddy & Barry's (2009) version of the CPT in which relative to go stimuli, non-target no-go stimuli occurred infrequently in a ratio of 9:1. In order to focus specifically on the effect of stimulus emotional salience, equal numbers of alcohol-related and neutral words were presented within separate viewing conditions. This removed the possibility that P3s would be explained by an 'oddball' effect (i.e. responses to novel or low-frequency stimuli).

Participants were all undergraduate students from Goldsmiths, University of London. The sample was thus relatively homogeneous with respect to age and educational attainment. Potential participants completed a modified version of the Alcohol Use Questionnaire (AUQ; Mehrabian & Russell, 1978); if they fell into the diagnostic 'light' or 'heavy' drinker categories, they were invited to take part in the cue reactivity (CR) procedure. This involved measuring their electrophysiological

responses whilst they were presented with alcohol-related (AR) and household-related (HR) control word stimuli. Equal numbers of AR and HR word stimuli were presented in separate trials. Participants rated all word stimuli for arousal.

In addition, they completed a modified version of the Continuous Performance Test (CPT), various measures of their personal and family history of alcohol use, and personality questionnaires tapping extraversion, (EPQ-R), recent impulsivity (RIS) and trait impulsiveness (TIS).

Prior to testing, participants were required to abstain from alcohol for 12 hours and from nicotine and caffeine for three hours, to exclude the possibility of acute drug effects influencing results.

Hypotheses

The following hypotheses were tested:

[A] Personality variables: Compared to LDs, HDs will:

1) Have higher EPQ-E scores
2) Show higher impulsiveness as indexed by (i) subjective ratings (TIS and RIS scores), and (ii) more commission errors in the CPT

[B] ERPs during the CPT: Compared to LDs, HDs will:

3) Show reduced no-go P3 amplitude and increased no-go P3 latency in the CPT
4) Show reduced no-go N2 amplitude and increased no-go N2 latency in the CPT

[C] Cue reactivity:

Within the combined sample of HDs and LDs:

5) Recent Impulsiveness (RIS scores) will correlate more strongly than Trait Impulsiveness (TIS scores) with scores for: i) subjective and ERP cue reactivity (CR) and; ii) behavioural and ERP measures of impulsiveness in the CPT
6) ERP CR will correlate significantly with (i) subjective CR and (ii) subjective ratings of stimulus arousal

And compared to LDs, HDs will:

7) Assign higher arousal ratings to alcohol-related (AR) stimuli, relative to household-related (HR) stimuli
8) Report greater subjective alcohol desire after presentation of the AR stimuli
9) Show a pronounced P3 amplitude response specifically to AR stimuli

Methods

DESIGN: This study comprised two parts.

Part 1 examined subjective and electrophysiological responses to alcohol-related (AR) and control (household-related; HR) word stimuli. It employed a 2 x 2 mixed-measures design, with the independent-measures factor of **Drinking Group** (two levels: heavy drinkers (HDs) vs. light drinkers (LDs)), and the repeated-measures factor of **Word-Type** (two levels: AR vs. HR). Participants' ERPs were recorded whilst they were shown a block of 17 AR words and a block of 17 HR words during a single testing session; order of the two conditions (word blocks) was counter-balanced, and in each block the set of 17 words was repeated eight times in random order. Participants rated their subjective alcohol desire prior to and immediately following each word condition. The two word blocks were separated by an interval of thirty minutes, during which participants completed: (i) a series of personality questionnaires in fixed order; and (ii) the second part of the research design. At the end of the session, participants rated each word stimulus for arousal.

Part 2 examined event-related potentials (ERPs) during completion of a Continuous Performance Test (CPT). The 2 x 2 mixed-measures design had the independent-measures factor of **Drinking Group** (two levels: HDs vs. LDs), and the repeated-measures factor of **Word-Type** (two levels: 'go' vs. 'no-go'). Participants' ERPs were recorded whilst they were presented with go (animal-related) and no-go (stationery-related) words; they were required to press a button in response to the former and to withhold responding following the latter. A total of 280 CPT trials comprised go and no-go stimuli randomly presented in a ratio of 9:1.

Ethical approval: Approval for this study was given by Goldsmiths Ethics Committee Participants gave informed written consent after reading an information sheet outlining the study. As required by the Helsinki Declaration (World Medical Association, 2002), individuals were assured of confidentiality and could terminate their participation at any stage.

Participants: Twenty-six students at Goldsmiths College took part in this study. Fifteen were recruited via the undergraduate psychology first-year credit system. The other eleven, also undertaking degree programmes, were paid £20 for their participation.

Inclusion/exclusion criteria: Potential participants were excluded if they had a current or previous addictive disorder, as indicated by a score of 3 or more on the Drug Abuse Screening Test (DAST-10; Skinner, 1982). All had to fall into one of the following categories: Light Drinkers (LDs), with average weekly alcohol consumption over the previous twelve months being between 1-6 standard units (men) or 1-2 units (women); or Heavy Drinkers (HDs), with weekly alcohol consumption over the preceding year being over 26 standard units (men) or 16 units (women). Volunteers drinking at levels between these two bands were excluded from the study. These cut-offs have previously been used by Cox *et al.* (1999), who reported a significant difference in interference on the modified alcohol Stroop task between heavy and light drinkers.

All participants had normal or corrected-to-normal visual acuity.

ASSESSMENTS

[A] Demographic and substance use information

- ***Modified Alcohol Use Questionnaire*** *(AUQ; Mehrabian & Russell, 1978; Appendix 9):* This 12-item self-report scale asks the respondent about their alcohol consumption in a typical week over the preceding six months. This was adapted here to twelve months in order to ensure that differences between HDs and LDs were stable and long-lasting. Participants are asked to indicate, in relation to their consumption of three types of drink (wine; beer, lager and cider; spirits) the

average number of days per week over the last twelve months they have consumed it, the average quantity consumed on each occasion, and the average quantity consumed in a 'typical' week.

- ***Family Tree Questionnaire*** *(FTQ; Mann et al., 1985):* This 14-item self-report instrument lays out first-degree (parents, siblings) and second-degree (grandparents) blood relatives in the style of a family tree. The respondent categorises each of their relatives as either '1' ('never drinks/drank'), '2' ('social drinker'), '3' ('possible problem drinker') or '4' ('definite problem drinker').

- ***Drug Abuse Screening Test*** *(DAST-10; Skinner, 1982; Appendix 10):* This was used to identify and exclude participants with current or previous drug abuse or dependence. It is a 10-item self-report instrument that can be used in clinical and non-clinical settings to screen for potential abuse and dependence on a variety of substances other than alcohol. The respondent answers questions (in a dichotomous 'Yes'/'No' format) about their use and experiences of drugs other than alcohol, nicotine and caffeine in the previous 12 months. The respondent is informed that the term 'drug' includes recreational use of both prescription drugs and other illicit drugs such as marijuana, cocaine, LSD, ecstasy, etc. The total score can thus range from 0-10, with scores of 3 or higher indicating potential drug abuse or dependence. Cronbach's alpha for the DAST-10 has been reported at 0.69 (McCabe & Teter, 2007).

[B] Personality measures

- ***Extraversion: The Adult Eysenck Personality Questionnaire – Revised*** *(EPQ-R; Eysenck et al., 1985b; Appendix 11):* This 100-item self-report personality inventory measures psychoticism, extraversion, and neuroticism. Extraversion is the only trait of interest here, and refers to the propensity to be energised by active involvement in events via 23 items (e.g. 'Can you usually let yourself go and enjoy yourself at a lively party?'). Participants rate each item as 'Yes' (1) or 'No' (0) depending on whether or not the question represents the respondent's typical feelings or behaviour, independent of current mood. Scores can range from 0 (highly

introverted) to 23 (highly extraverted). The scale has good test-retest reliability (alpha = 0.88; Eysenck *et al.*, 1985).

- ***The Recent Impulsivity Scale*** *(RIS; Appendix 12)*: As described fully in Chapter 2, the RIS is an 8-item self-report questionnaire, concerned with the respondent's frequency of specific instances of impulsive behaviour (e.g. 'I have thought carefully before doing and saying things') over the previous two weeks. Each item is rated on a four-point (0-3) Likert scale ('never', 'rarely', 'quite often' or 'very often'). The items are summed into two subscales: Cognitive Impulsivity (CI) and Motor Impulsivity (MI).

- ***The Trait Impulsivity Scale*** *(TIS; Appendix 13)*: This 8-item questionnaire taps the respondent's general propensity towards impulsive behaviour. It is structurally identical to the RIS, the only difference being the temporal context within which the items are framed. For example, where a SIS item would be 'Within the last two weeks I have thought carefully before doing and saying things', the corresponding TIS item would be simply 'I think carefully before doing and saying things'. The response options are the same as for the RIS, and the items also sum into CI and MI subscales.

[C] Experimental measures

- ***Modified Continuous Performance Test*** *(CPT: Conners et al., 2003):* This taps sustained attention and response inhibition. The version used here presents participants with a sequence of animal-related and distractor (stationery-related) words on a computer screen; the participant is instructed to press a button in response to all animal-related words and not to respond to distractors. Responses to distractors are thus 'commission errors'. Details of the stimuli are given in Appendix 14.

Using e-prime, words were presented individually one after another in random sequence, in the centre of a computer screen, in 'Courier New' bold black 18-point font against a white background. Each was preceded by a 500 msec fixation stimulus ('+'), and was presented for a maximum of 1300 msec or until the

participant responded by pressing the 'go' button. There were 252 'go' (animal) and 28 'no-go' (stationery) stimuli (a ratio of 9:1).

Participants were given the following instructions, both on-screen and verbally: 'You are going to be presented with a series of words. Each word will appear at the centre of the screen and will be preceded by a fixation cross, '+'. Please keep looking at the '+' until the word appears. When the word appears, press the left-most button on the box, as quickly as you can, if it represents an animal. If the word does not represent an animal, you should withhold responding by not pressing the button.' They were instructed to press the button to begin the task when they felt ready, at which point recording began.

Before a participant completed the CPT 'proper', they became familiar with the procedure by completing a 42-trial practice version. The details of the practice version were identical to those given above, with the exception that the go to no-go stimulus word ratio was 2:1.

The dependent variables (DVs) were the total number of commission errors (i.e. responses to no-go stimuli) and the average response time for accurate go responses.

- ***Cue-Reactivity:*** As described on page 119, participants were exposed to a block of AR and a block of HR words in counter-balanced order during which their ERPs were recorded. Ratings of subjective craving were given following exposure to each block of words.

The words were selected on the basis of a pilot study in which a preliminary set of 78 alcohol-related and household-related words were rated for arousal and familiarity by a separate group of 16 undergraduate students who reported drinking at or above the UK recommended weekly limits for alcohol consumption (14 units for women and 21 for men). It was important to match the two types of word list for these characteristics since ERPs are influenced by level of emotional arousal (Carretie *et al.*, 2001) and novelty (Ruhnau *et al.*, 2010). The arousal scale ranged from '-10' ('extremely negatively arousing') through '0' ('neither positively nor

negatively arousing') to '+10' ('extremely positively arousing'). The familiarity scale ranged from '1' ('not at all familiar') to '7' ('extremely familiar'). Respondents were instructed not to think too hard about each answer, and to give their first, 'gut-level' response. The words were presented in a quasi-random order, so that the same category of word did not appear more than twice consecutively. Subsets of 17 alcohol-related and household-related words were then matched for word length, number of syllables, arousal, familiarity and frequency in the English language as indexed in the CELEX database (Baayen, Piepenbrock & Gulikers, 1995; see Table 3.1).

The final AR words were: beer; whisky; scotch; rum; vodka; liqueur; bourbon; wine; bitter; brandy; sherry; cider; booze; gin; cocktail; alcopops; and lager. The final HR words were: roof; balcony; bath; lamp; floor; fence; chimney; alcove; carpet; tap; fireplace; patio; bench; porch; towel; kitchen; and rug.

Table 3.1: Mean (standard deviations) characteristics of the final alcohol-related and household-related word stimuli

Characteristic	**AR words (*n* = 17)**	**HR words (*n* = 17)**	***t* value**	***p* value**
Word length *(no. of letters)*	5.53 (1.50)	5.30 (1.57)	0.45 (*df* = 32)	ns
Number of syllables	1.65 (0.61)	1.65 (0.79)	0.00 (*df* = 32)	ns
Arousal	1.67 (1.58)	1.39 (1.18)	0.59 (*df* = 32)	ns
Familiarity	5.54 (0.77)	5.76 (0.74)	-0.86 (*df* = 32)	ns
Word frequency *(appearances per million words)*	16.4 (22.2)	38.2 (46.6)	-1.69 (*df* = 31)	ns

Note = word frequency data for 'alcopops' was not available in the CELEX database; therefore, the independent-measures *t*-test for word frequency was conducted without this item (hence *df* = 31).

The computer program 'e-prime' was used to generate the task, which entailed presenting the words sequentially on a monitor. Within each condition, the words were presented individually one after another in random sequence, in the centre of the screen; words were typed in 'Courier New' 18 font, in white against a black background. Participants were instructed to fixate on a '+' in the centre of the screen; this appeared for 700 msec and was then immediately replaced by a word

stimulus for 200 msec; crosses and words alternated with these same durations of exposure and no inter-stimulus intervals until all 17 words had been presented eight times (i.e. 134 items in total).

Participants were given the following instructions, both on-screen and verbally: 'When you press the left-most button on the button-box, you will be presented with a set of words. Your job is to keep looking at the centre of the screen, where the words will flash up individually one after another, and to read the word (in your head, not aloud) that is presented each time.' In order to ensure that participants attended to the words, they were also instructed: 'Please make sure you focus your attention upon reading the words, as you will be asked some questions about them at the end of the experiment.' The participant was instructed to press the button to begin the first presentation when they felt ready, at which point ERP recording began.

Within each experimental condition (AR or HR), each of the 17 words was then displayed once before ERP recording stopped for around thirty seconds; the same words were then presented again in a different order. This procedure was repeated eight times, yielding eight ERP datasets. The AR and HR conditions were separated by an interval during which participants completed the RIS, EPQ-E, CPT, DAST-10, FTQ and TIS. Order of ERP stimulus conditions was counter-balanced within both groups (LDs and HDs). In total, each condition lasted around eight minutes.

Prior to and immediately following each word condition, participants were asked to rate 'How strong is your desire to have a drink right now?' by placing a mark on a 10-centimetre Visual Analog Scale (VAS) anchored by the statements 'Not at all' and 'The most I've ever felt'. The score was derived by measuring the distance (in mm) from the 'Not at all' end of the VAS to the point marked by the participant; therefore, higher scores indicated greater desire.

At the end of the testing session, participants rated the word stimuli using the arousal scale described above; they were instructed to give their first response and not to think too hard about each answer. The words were presented in a quasi-random order, so that the same category of word did not appear more than twice

consecutively. The variable of interest here was the intensity of participants' emotional response to the words and not the direction (positive or negative) of that response. Their ratings were therefore recoded to remove direction and to instead form a simple measure of deviation from centrality (i.e. deviation from '0'). That is, a score of '-6', for example, was re-coded to '6'.

PROCEDURE

At the start of the session, participants provided a breath alcohol sample on a Lion Alcometer 500 (Lion Laboratories Ltd., Barry, UK) and were excluded if their breath alcohol level (BAL) exceeded zero (this did not in fact occur).

The ERP suite comprises a central room off which are two testing booths. Participants were seated in a comfortable chair in a darkened, air-conditioned and sound-proofed booth, which was separated from the recording equipment. The door to the room remained closed throughout. Participants were seated 100 cm from the monitor. A response button-box was placed on the table in front of them, within easy reach of their dominant hand.

Overall order of tests: The sequence of assessments was fixed across all participants, as follows:

1. Subjective and ERP Cue-Reactivity – Condition I
2. Recent Impulsiveness Scale
3. EPQ-R
4. CPT
5. DAST-10
6. FTQ
7. Trait Impulsiveness Scale
8. Subjective and ERP Cue-Reactivity – Condition II
9. Ratings of cue arousal

CPT and Cue-Reactivity EEG data acquisition and segmentation: EEG data were recorded using BioSemi, an EEG-recording system. EEG was DC-recorded with a low-pass filter of 100 Hz, a high-pass filter of 0.16 Hz, and a sampling rate of 512 Hz. 64 active electrodes were mounted in an elastic cap in accordance with the 10-20 system. Horizontal eye movements (HEOG) were measured bipolarly from a pair of electrodes placed at the outer canthi of the eyes. After data acquisition, EEG was digitally re-referenced to the average of the left and right earlobes. A low-pass filter of 40 Hz was applied, along with a high-pass filter of 0.53 Hz. ERP data were taken from 37 channels across anterior (FP1, FP2, AF3, AF4, Fz, F1, F2, F3, F4, F7, F8), central (FC1, FC2, FC3, FC4, FC5, FC6, Cz, C1, C2, C3, C4, CP1, CP2, CP3, CP4, T7, T8) and posterior regions (Pz, P1, P2, P3, P4, PO3, PO4, O1, O2), and represented an even spread of electrodes by scalp region and by hemisphere.

For the stimulus presentation interval, the EEG was epoched off-line into 900 msec periods, starting 100 msec before stimulus onset, until 800 msec following the onset of the visual stimulus for both ERP cue-reactivity and ERP inhibition stimuli. A 100 msec pre-stimulus baseline correction was applied. Epochs containing blinks (automatic detection: ± 80 μV at Fpz) or other artifacts (automatic detection: ± 80 μV at all other electrodes), which can contaminate the EEG record, were eliminated from further analyses. Remaining trials were averaged offline separately for AR and HR (ERP cue-reactivity) stimuli, and for no-go (ERP inhibition) stimuli, for each participant. Because the major purpose of the present study was to evaluate no-go P3 differences between the groups, ERP data from only the no-go word stimuli are presented here.

Determining time segments for ERP CR stimuli: In order to determine the time segments for the statistical analyses in a data-driven manner, the grand mean time course of the ERPs (calculated using participants' electrophysiological responses to all eight sets of stimuli presentations) was calculated for all participants, in both conditions at the twenty-four electrode locations. The resulting ERP waves for AR and HR words were visually inspected and appeared to correspond well with ERP waves typically observed in response to visual stimuli (see Figures 3.8-3.10 on p. 142 for representations of the separate AR and HR waves in heavy and light

drinkers). P3 was defined as the largest positive peak following the N1-P2-N2 complex (that is, the series of characteristic successive negative and positive peaks which, at around 300 msec, typically begin to give way to the P3 component; see Figure 3.1 on p. 106) and in this case was measured as occurring between 390 and 470 msec post-stimulus. Following McDonough and Warren's (2001) procedure for quantitative analysis of stimulus processing within this time window (that is, 390-470 msec post-stimulus), mean amplitudes (i.e. the mean voltages occurring throughout this interval relative to the pre-stimulus baseline), were measured separately for AR and HR words.

Determining time segments for ERP inhibitory control stimuli: The grand mean time course of the ERP responses to all 28 no-go stimuli presentations was calculated for all participants at the 31 electrode locations. The resulting ERP waves for no-go stimuli were visually inspected and again appeared to correspond well with ERP waves typically observed following no-go visual stimuli (see Figures 3.2-3.6 on p. 134 for representations of the no-go waves in heavy and light drinkers); the paradigm elicited the no-go N2 and no-go P3 components. No-go N2 was defined as the second negative peak and was here measured as occurring between 250 and 400 msec post-stimulus, whilst no-go P3 was measured as occurring between 400 and 600 msec (i.e. again following the N1-P2-N2 complex). Following Holguín Rodríguez *et al.'s* (1999a, 1999b) protocol for quantitative analysis of stimulus processing within the time windows 250–400 and 400–600 msec post-stimulus, mean peak amplitudes were measured for no-go N2 and no-go P3 components in heavy and light drinkers separately: these are the highest voltages occurring during each time-frames relative to a pre-stimulus baseline. Mean latency – the amount of time taken for each participant to reach no-go N2 and no-go P3 peak amplitudes – was also recorded.

Data reduction for ERP P3 CR: Following Franken *et al.*'s (2008) approach to simplifying interpretation of the results, and to reduce the number of analyses (Dien & Santuzzi, 2005), ERP cue-reactivity data were aggregated to yield P3 indices for three regions in each cerebral hemisphere: anterior (F1/2, F3/4, AF3/4), central (FC1/2, FC3/4, C1/2, C3/4, CP1/2, CP3/4), and posterior (P1/2, P3/4, PO3/O4). The

index of electrophysiological cue-reactivity was computed as the difference between the mean P3 amplitudes during AR and HR stimuli (i.e. AR minus HR).

Data reduction for ERP no-go N2 and no-go P3 inhibitory responses: Following Rodríguez Holguín *et al.* (1999a, 1999b), no-go N2 and no-go P3 measurements were each organised into five regional electrode groupings: frontal (FP1, FP2, AF3, AF4, Fz, F3, F4, F7, F8), central (FC1, FC2, FC5, FC6, Cz, C3, C4), parietal (CP1, CP2, Pz, P3, P4), temporal (T7, T8, CP5, CP6, P7, P8) and occipital (PO3, PO4, O1, O2).

Data analysis

All statistical analyses were carried out using SPSS version 16.

Results

***Data screening**:* Prior to analysis, variables were screened for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis. There was no evidence of any clear non-linearity or curvilinearity.

Participant characteristics:

ERP data from four participants were excluded from all analyses because of excessive artifacts or noise. This left 22 (9 male and 13 female) participants; of these, 12 were HDs and 10 were LDs. One of the HDs with full ERP data lacked data for all other variables. There were one or two participants with missing data on other variables, as shown in Table 3.2, which displays the socio-demographic, personality and alcohol-related characteristics of participants in the two groups, and the results of between-groups comparisons.

Table 3.2: Socio-demographic, personality and alcohol-related characteristics of heavy versus light drinkers

Variable	*N* (HDs: LDs)	Heavy drinkers	Light drinkers	HDs vs. LDs		
				t or χ^2	*p*	*d*
Age (years)	10:10	22.7 (5.2)	21.3 (3.2)	0.73	ns	-
Gender (M:F)	12:10	5:7	4:6	0.01	ns	-
Typical weekly alcohol intake (units per week during previous year)	12:10	44.3 (18.0)	2.13 (2.76)	7.67	0.00	3.28
Family history of alcohol use disorders (present/ absent)	9:10	3:6	4:6	0.10	ns	-
Extraversion (EPQ-E)	11:9	16.0 (3.87)	10.44 (5.43)	2.67	0.02	1.27
Psychoticism (EPQ-P)	11:10	8.36 (3.47)	6.90 (3.73)	0.93	ns	-
Neuroticism (EPQ-N)	11:10	15.18 (4.81)	11.60 (6.98)	1.38	ns	-
Lie (EPQ-L)	11:9	5.45 (3.27)	7.33 (3.00)	-1.33	ns	-
Anxiety (HADS-A)	11:9	8.27 (2.70)	5.56 (4.03)	1.74	0.10	0.85
Depression (HADS-D)	11:9	4.09 (2.91)	4.22 (4.09)	-0.08	ns	-
Trait Cognitive Impulsivity (TIS-CI)	11:10	4.82 (2.56)	5.50 (1.84)	-0.69	ns	-
Trait Motor Impulsivity (TIS-MI)	11:10	5.91 (1.22)	4.60 (1.96)	1.86	0.08	0.85
Recent Cognitive Impulsivity (RIS-CI)	11:10	5.91 (2.55)	5.40 (1.78)	0.53	ns	-
Recent Motor Impulsivity (RIS-MI)	11:10	5.09 (2.21)	5.20 (2.39)	-0.11	ns	-
Commission errors (CPT)	11:10	4.27 (6.23)	3.90 (3.45)	0.17	ns	-

Values are mean +/- SD; *p* values are two-tailed.

The ten light drinkers were aged between 18 and 28 years. Two of the heavy drinkers did not give their age; the remaining ten were between 18 and 33 years. As evident from the table, the two groups did not differ in age, gender ratio, level of current reward motivation, or family history of alcohol use disorders. Reflecting the differences in alcohol consumption required for categorisation as a light or heavy drinker, there was a highly significant difference between the groups for self-reported weekly alcohol intake.

Seven individuals reported having a biological parent with a 'possible' or 'definite' history of alcohol problems (three HDs did not provide this information); the likelihood of this did not differ between LDs and HDs, suggesting no difference in their genetic predisposition towards alcohol use disorders.

ERP data quality in LDs and HDs:

- ***ERP CR data****:* For heavy drinkers, the mean number of artifact-free (or 'good') trials for AR stimuli was 120.73 (*SD* = 13.53), and for HR stimuli, the mean was 119.09 (*SD* = 14.02). For light drinkers, the mean number of good trials for AR stimuli was 116.33 (*SD* = 18.91), and for HR stimuli, the mean was 115.44 (*SD* = 24.92). The numbers of good trials for AR words and HR words did not differ significantly between heavy and light drinkers (F (1, 18) < 1, ns, in both cases).

- ***ERP no-go data****:* For heavy drinkers, the mean number of artifact-free trials for no-go stimuli was 22.63 (*SD* = 3.20), and for light drinkers the mean was 23.60 (*SD* = 3.56). The number of good trials did not differ significantly between the groups (F (1, 18) < 1; ns).

Hypothesis-testing: Each hypothesis is recapitulated below, followed by the corresponding analysis/analyses.

[A] Personality variables

Hypothesis 1: Compared to LDs, HDs will have higher EPQ-E scores

There were 11 HDs and 9 LDs for this analysis. As predicted, an independent-measures *t*-test revealed HDs were more extraverted than LDs (see Table 3.2 on p. 130).

Hypothesis 2: Compared to LDs, HDs will show higher impulsiveness as indexed by (i) subjective ratings (TIS and RIS scores), and (ii) more commission errors in the CPT

Independent-measures *t*-tests were performed on 11 heavy and 10 light drinkers' TIS and RIS sub-scale scores, and on commission errors. As shown in Table 3.2, there

were no differences between LDs and HDs on any of these indices; thus, the hypothesis was not supported.

[B] ERPs during the CPT

<u>Hypothesis 3:</u> Compared to LDs, HDs will show reduced no-go P3 amplitude and increased no-go P3 latency in the CPT

<u>Hypothesis 4:</u> Compared to LDs, HDs will show reduced no-go N2 amplitude and increased no-go N2 latency in the CPT

For both these hypotheses, the relevant ERP components were analysed separately for amplitude and latency via 2 x 5 mixed-measures ANOVAs with the independent-measures factor of DRINKING GROUP (HDs versus LDs) and the repeated-measures factor of ELECTRODE REGION (frontal vs. central vs. parietal vs. temporal vs. occipital). For these analyses there were 10 HDs and 10 LDs. All variables were screened for univariate outliers (i.e. cases having an extreme value on one variable, with standardised scores exceeding 3.29 ($p < 0.001$, 2-tailed); Tabachnik & Fidell, 2007). Only the theoretically relevant main effects of DRINKING GROUP and the ELECTRODE REGION x DRINKING GROUP interaction effects are reported (although main effects of ELECTRODE REGION are presented in Appendix 15 for completeness).

Hypothesis 3 – The no-go P3: Amplitude and latency scores are shown in Table 3.3, for HDs and LDs separately in the different brain regions.

Table 3.3: Means and SDs (μV) for the peak amplitude and latency of the no-go P3 component, among heavy and light social drinkers, across frontal (FP1, FP2, AF3, AF4, Fz, F3, F4, F7, F8), central (FC1, FC2, FC5, FC6, Cz, C3, C4), parietal (CP1, CP2, Pz, P3, P4), temporal (T7, T8, CP5, CP6, P7, P8) and occipital (PO3, PO4, O1, O2) electrode regions

	No-go P3 amplitude		**No-go P3 latency**	
Electrode region	**Heavy drinkers (*n* = 10)**	**Light drinkers (*n* = 10)**	**Heavy drinkers (*n* = 10)**	**Light drinkers (*n* = 10)**
Frontal	3.34 (2.62)	3.53 (2.44)	0.54 (0.03)	0.54 (0.03)
Central	6.11 (2.39)	7.33 (2.21)	0.52 (0.05)	0.54 (0.02)
Parietal	6.90 (2.18)	8.11 (2.23)	0.53 (0.04)	0.54 (0.03)
Temporal	3.85 (1.23)	3.80 (1.37)	0.54 (0.02)	0.55 (0.03)
Occipital	5.73 (2.08)	5.80 (2.82)	0.52 (0.03)	0.53 (0.04)
Grand mean (collapsed across all electrode sites)	5.19 (1.43)	5.71 (1.38)	0.53 (0.03)	0.54 (0.02)

Figures 3.2-3.6 illustrate the grand mean ERP curves in response to no-go words for frontal (FP1, FP2, AF3, AF4, Fz, F3, F4, F7, F8), central (FC1, FC2, FC5, FC6, Cz, C3, C4), parietal (CP1, CP2, Pz, P3, P4), temporal (T7, T8, CP5, CP6, P7, P8) and occipital (PO3, PO4, O1, O2) electrode regions in heavy and light drinkers. These figures show amplitudes and latencies for the no-go N2 (that is, the second negative peaks, occurring here between 250 and 400 msec post-stimulus) and the no-go P3 (that is, the third positive peaks, occurring here between 400 and 600 msec post-stimulus).

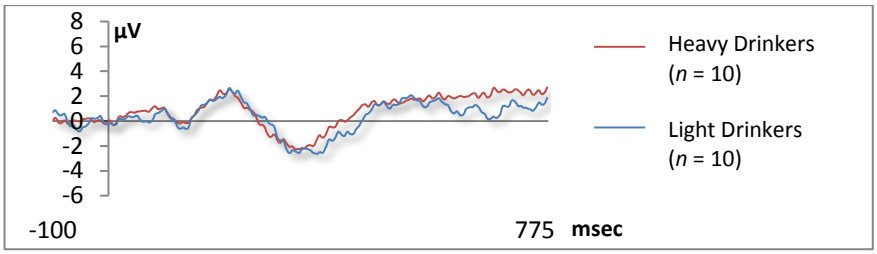

Figure 3.2: ERPs elicited by no-go words at frontal electrodes (FP1, FP2, AF3, AF4, F3, F4, F7 and F8) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10)

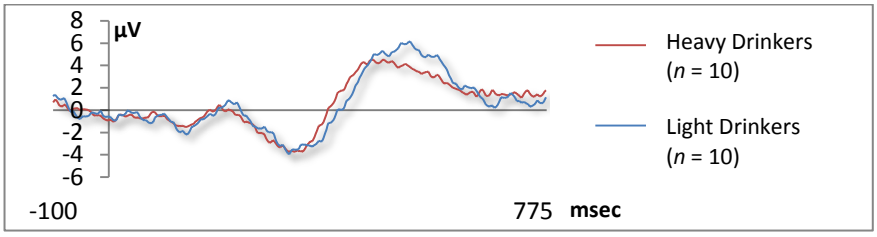

Figure 3.3: ERPs elicited by no-go words at central electrodes (FC1, FC2, FC5, FC6, Cz, C3 and C4) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10)

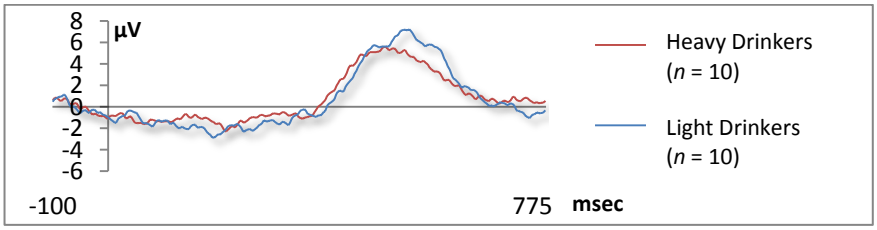

Figure 3.4: ERPs elicited by no-go words at parietal electrodes (CP1, CP2, Pz, P3 and P4) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10)

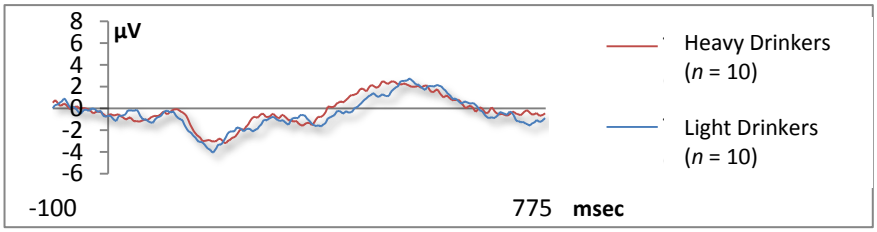

Figure 3.5: ERPs elicited by no-go words at temporal electrodes (T7, T8, CP5, CP6, P7 and P8) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10)

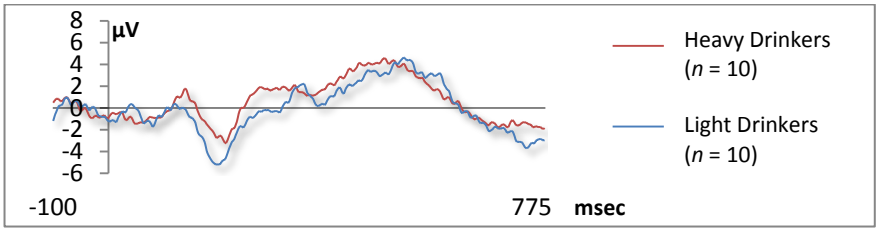

Figure 3.6: ERPs elicited by no-go words at occipital electrodes (PO3, PO4, O1 and O2) in heavy drinkers (*n* = 10) and in light drinkers (*n* = 10)

***(a) No-go P3 amplitudes**:* There were no univariate outliers. The main effect of DRINKING GROUP was non-significant [*F* (1, 18) = 0.71; ns], as was the ELECTRODE REGION x DRINKING GROUP interaction [*F* (4, 72) = 0.55; ns].

***(b) No-go P3 latency**:* Again, there were no univariate outliers. The main effect of DRINKING GROUP was non-significant [*F* (1, 18) = 0.93; ns], as was the ELECTRODE REGION x DRINKING GROUP interaction [*F* (4, 72) = 0.87; ns].

Hypothesis 3 was therefore not supported.

Hypothesis 4 – The no-go N2: Amplitude and latency scores are shown in Table 3.4, for HDs and LDs separately in the different brain regions.

Table 3.4: Means and SDs (μV) for the amplitude and latency of the no-go N2 component, among heavy and light social drinkers, across frontal (FP1, FP2, AF3, AF4, Fz, F3, F4, F7, F8), central (FC1, FC2, FC5, FC6, Cz, C3, C4), parietal (CP1, CP2, Pz, P3, P4), temporal (T7, T8, CP5, CP6, P7, P8) and occipital (PO3, PO4, O1, O2) electrode regions

Electrode region	No-go N2 amplitude		No-go N2 latency	
	Heavy drinkers (*n* = 10)	Light drinkers (*n* = 10)	Heavy drinkers (*n* = 10)	Light drinkers (*n* = 10)
Frontal	-3.41 (2.28)	-3.75 (3.19)	0.35 (0.02)	0.36 (0.01)
Central	-4.85 (2.18)	-4.84 (2.33)	0.34 (0.02)	0.35 (0.02)
Parietal	-3.10 (1.67)	-3.71 (1.85)	0.31 (0.05)	0.30 (0.03)
Temporal	-3.39 (1.70)	-3.94 (1.82)	0.32 (0.03)	0.31 (0.03)
Occipital	-1.39 (2.26)	-3.44 (2.71)	0.30 (0.05)	0.30 (0.03)
Grand mean (collapsed across all electrode sites)	-3.23 (1.48)	-3.94 (1.65)	0.32 (0.02)	0.32 (0.02)

(a) No-go N2 amplitude: There were no univariate outliers. Table 3.4 shows the mean ERP values for no-go N2 amplitude as well as no-go N2 latency. The main effect of DRINKING GROUP was non-significant [*F* (1, 18) = 1.02; ns], as was the ELECTRODE REGION x DRINKING GROUP interaction [*F* (4, 72) = 0.96; ns].

(b) No-go N2 latency: Again, there were no univariate outliers, nor were there significant effects of DRINKING GROUP [F (1, 18) = 0.00; ns] or ELECTRODE REGION x DRINKING GROUP [F (4, 72) = 1.17; ns].

Hypothesis four was therefore not supported.

[C] Cue reactivity

<u>Hypothesis 5:</u> Within the combined sample, Recent Impulsiveness (RIS scores) will correlate more strongly than Trait Impulsiveness (TIS scores) with scores for: i) subjective and ERP cue-reactivity (CR) and; ii) behavioural and ERP measures of impulsiveness in the CPT

Dunn & Clark's (1969) Z_1* statistic was used to test the significance of differences between the magnitude of RIS and TIS correlations with subjective and ERP CR and behavioural and ERP measures of impulsiveness in the CPT, within the whole sample. The data are shown in Table 3.5.

Table 3.5: Spearman correlations between RIS and TIS subscales and: i) subjective and electrophysiological CR and; ii) behavioural and ERP measures of impulsiveness in the CPT, in the combined sample of HDs and LDs

Variable	Cognitive Impulsivity			Motor Impulsivity		
	TIS (r)	RIS (r)	TIS vs. RIS (Z_1*)	TIS (r)	RIS (r)	TIS vs. RIS (Z_1*)
Subjective CR[a]	0.30†	0.39*	0.75	-0.21	-0.05	0.72
Electrophysiological CR[b]	-0.05	-0.07	0.16	0.16	0.47*	1.55†
Commission errors (CPT)[b]	-0.08	-0.02	-0.47	0.04	0.14	-0.46
Nogo P3 amplitude (CPT)[a]	0.31†	0.25	0.43	0.04	0.05	-0.05
Nogo P3 latency (CPT)[a]	-0.40*	-0.35†	-0.37	0.08	0.29	-1.00
Nogo N2 amplitude (CPT)[a]	-0.59**	-0.54**	-0.43	-0.11	0.05	-0.73
Nogo N2 latency (CPT)[a]	-0.07	-0.15	0.55	-0.20	-0.31†	0.52

[a]N = 20; [b]N = 21.
**p≤ 0.01; *p ≤ 0.05; † trend - p ≤ 0.10. All tests one-tailed.

***(a) Subjective CR**:* There was no difference in the extent to which subjective cue reactivity (ratings of desire for a drink) correlated with the RIS and the TIS, for either the Cognitive Impulsivity or the Motor Impulsivity subscales.

(b) Electrophysiological CR: There was a strong trend for this to correlate more strongly with RIS Motor Impulsivity than TIS Motor Impulsivity, though it fell short of significance. There was however no hint of any difference between its correlations with the RIS and TIS Cognitive Impulsivity subscales.

(c) Behavioural and ERP measures of impulsiveness in the CPT: There were no hints of any differences between these measures' respective correlations with the RIS and TIS Cognitive and Motor Impulsivity subscales.

Overall, hypothesis five was not supported. However, the strong trend for ERP cue-reactivity to correlate more strongly with RIS than with TIS Motor Impulsivity echoes the finding of Study 1 in which, amongst those who had reported a recent change in their alcohol intake, there was a significant correlation between the Motor Impulsivity 'change' variable and alcohol intake within the previous two weeks. This issue will be considered further in the Discussion.

***Hypothesis 6:* Within the combined sample, ERP cue reactivity (CR) will correlate significantly with (i) subjective CR and (ii) subjective ratings of stimulus arousal**

Spearman correlations explored the interrelationships between cue-elicited electrophysiological and subjective responses, and stimulus arousal.

Electrophysiological CR was computed as mean P3 amplitudes to alcohol-related (AR) words minus mean P3 amplitudes to neutral (household-related; HR) words. Similarly, the index of subjective CR was mean self-reported desire for alcohol following AR words minus mean self-reported desire following HR words. The relative arousal rating of AR words was computed by subtracting from these ratings the arousal ratings of HR words.

Correlations within the combined sample are shown in Table 3.6.

Table 3.6: Spearman correlations (*p* value, 1-tailed) between mean electrophysiological CR at all electrode locations and mean self-reported subjective CR and arousal ratings in the whole sample

Self-report variable	Correlation with mean ERP CR
Subjective CR[a]	-0.08
Relative arousal rating of AR words[b]	0.37*

[a]*N* = 20; [b]*N* = 21. *p ≤ 0.05

ERP CR correlated significantly with the relative arousal rating of AR words, as predicted, but not with subjective CR. Hypothesis six was therefore partially supported.

Exploratory analyses also examined these correlations within each group separately; although the groups are too small to give sufficient power to detect anything other than very large associations, it was of interest to see whether there were any trends. However, the correlations between ERP CR and subjective CR were very small in both the 9 LDs (*r* = -0.25, ns) and the 11 HDs (*r* = 0.15, ns). There was a trend in the LDs, but not in the HDs, for ERP reactivity to be greater towards the more arousing AR cues (LDs: *r* = 0.39, *p* = 0.13; HDs, *r* = -0.09, ns).

***Hypothesis 7:* Compared to LDs, HDs will assign higher arousal ratings to AR stimuli, relative to HR stimuli**

Table 3.7 and Figure 3.7 illustrate the mean arousal ratings for the AR and HR word stimuli for the 11 HDs and 10 LDs.

Table 3.7: Means and SDs for arousal ratings of the AR and HR words in heavy drinkers, light drinkers and the whole sample

Word-type	Heavy drinkers (*n* = 11)	Light drinkers (*n* = 10)	Whole sample (*N* = 21)
AR	3.12 (1.38)	2.35 (1.24)	2.75 (1.34)
HR	1.06 (1.17)	2.24 (2.30)	1.62 (1.85)

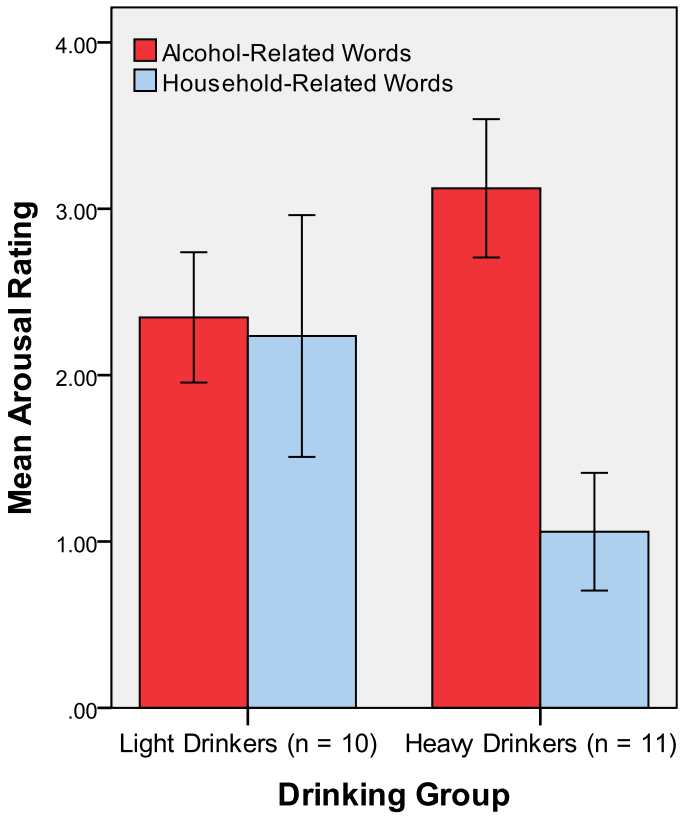

Figure 3.7: Mean (+/- 1 SE) arousal ratings in heavy and light drinkers

Arousal ratings were analysed via a 2 x 2 mixed-measures ANOVA with the independent-measures factor of DRINKING GROUP (HDs vs. LDs) and the repeated-measures factor of WORD-TYPE (AR vs. HR). There were no univariate outliers. Significant effects were examined by means of Bonferroni-corrected *post hoc* *t*-tests.

There was a significant main effect of WORD-TYPE [F (1, 19) = 10.01; p = 0.01; η_p^2 = 0.35]: AR words were rated higher for arousal than HR words. Although there was no main effect of DRINKING GROUP [F (1, 19) = 0.11; ns], there was a significant WORD-TYPE by DRINKING GROUP interaction [F (1, 19) = 8.06; p = 0.01; η_p^2 = 0.30]. Bonferroni-corrected independent-measures *t*-tests revealed no significant differences between heavy and light drinkers in their ratings of either AR or HR words [t (19) = -1.35 and 1.46; ns]. However, whilst for LDs there was no difference between ratings of AR and HR words [t (9) = 0.18; ns], HDs rated AR words as significantly more arousing than HR words [t (10) = 6.68; p < 0.01; d = 2.02].

Hypothesis seven was thus partially supported.

Exploratory analyses examined HDs' and LDs' affective *valence* ratings (i.e. taking account of the direction of the emotional reaction – positive or negative), again via a 2 x 2 mixed-measures ANOVA. Table 3.8 shows the mean valence ratings for the AR and HR word stimuli for the 11 HDs and 10 LDs. Scores could range between -10 and +10.

Table 3.8: Means and SDs for valence ratings of the AR and HR words in heavy drinkers and light drinkers

Word-type	Heavy drinkers (*n* = 11)	Light drinkers (*n* = 10)
AR	1.58 (1.86)	1.22 (1.41)
HR	0.93 (0.94)	1.48 (1.71)

There were no main effects for either WORD-TYPE or DRINKING GROUP [*F* (1, 19) = 0.34 and 0.03 respectively; both ns], nor a WORD-TYPE by DRINKING GROUP interaction [*F* (1, 19) = 1.87; ns]. Thus, the groups did not differ in their ratings of the emotional valence of terms of AR or HR words.

***Hypothesis 8:* Compared to LDs, HDs will report greater subjective alcohol desire after presentation of the alcohol-related stimuli**

Subjective alcohol desire was analysed via a 2 x 2 mixed-measures ANOVA with the independent-measures factor of DRINKING GROUP (HDs vs. LDs) and the repeated-measures factor of WORD-TYPE (AR vs. HR). There were no univariate outliers.

Table 3.9 shows mean desire ratings in response to the AR and HR word stimuli for the 11 HDs and 9 LDs.

Table 3.9: Means and SDs for subjective alcohol desire in response to AR and HR words in heavy drinkers, light drinkers and the whole sample (*N* = 20)

Word-type	Heavy drinkers (*n* = 11)	Light drinkers (*n* = 9)	Whole sample (*N* = 20)
AR	-4.18 (11.74)	-0.67 (8.59)	-2.60 (10.34)
HR	0.41 (15.62)	7.17 (11.32)	3.45 (13.94)

There was a significant main effect of WORD-TYPE [F (1, 18) = 6.83; p = 0.02; η_p^2 = 0.28], AR words eliciting greater subjective desire for alcohol in both groups. However, the main effect of DRINKING GROUP was non-significant [F (1, 18) = 1.06; ns], as was the WORD-TYPE by DRINKING GROUP interaction [F (1, 18) = 0.47; ns].

Hypothesis 8 was therefore not supported.

<u>Hypothesis 9:</u> Compared to LDs, HDs will show a pronounced P3 amplitude response specifically to AR stimuli

P3 amplitudes were analysed via a 2 x 2 x 2 x 3 mixed-measures ANOVA with the independent-measures factor of DRINKING GROUP (12 HDs vs. 10 LDs) and the repeated-measures factors of WORD-TYPE (AR vs. HR), HEMISPHERE (left vs. right) and CAUDALITY (anterior vs. central vs. posterior). There were no univariate outliers.

Significant multivariate effects were examined by means of Bonferroni-corrected *post-hoc t*-tests. Only the theoretically relevant main effects of DRINKING GROUP and WORD-TYPE, as well as the DRINKING GROUP by WORD-TYPE interaction, are presented here (though all main and interaction effects are presented in Appendix 16 for completeness).

Figures 3.8-3.10 illustrate the grand mean ERP curves for AR and HR words for anterior (F1, F2, F3, F4, AF3 and AF4), central (FC1, FC2, FC3, FC4, C1, C2, C3, C4, CP1, CP2, CP3 and CP4), and posterior (P1, P2, P3, P4, PO3 and PO4) electrodes in heavy and light drinkers. These figures demonstrate that in HDs but not LDs, P3 amplitudes (that is, the third positive peaks, occurring between 390 and 470 msec post-stimulus) following AR words were larger than those following HR words.

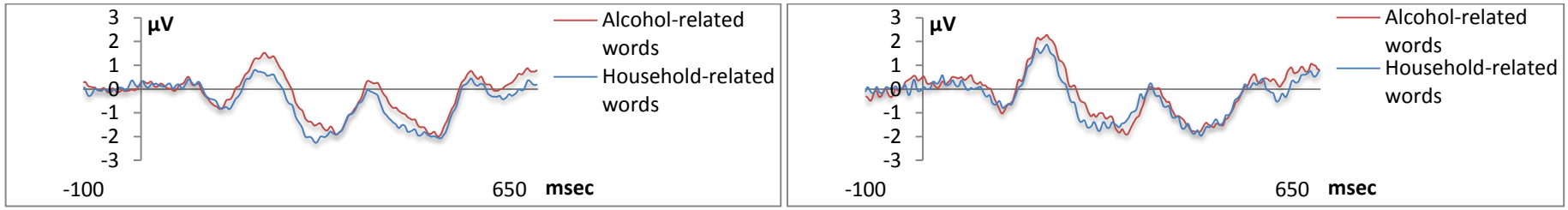

Figure 3.8: ERPs elicited by AR and HR words at anterior electrodes (F1, F2, F3, F4, AF3 and AF4) in heavy drinkers (*n* = 12; left panel) and in light drinkers (*n* = 10; right panel)

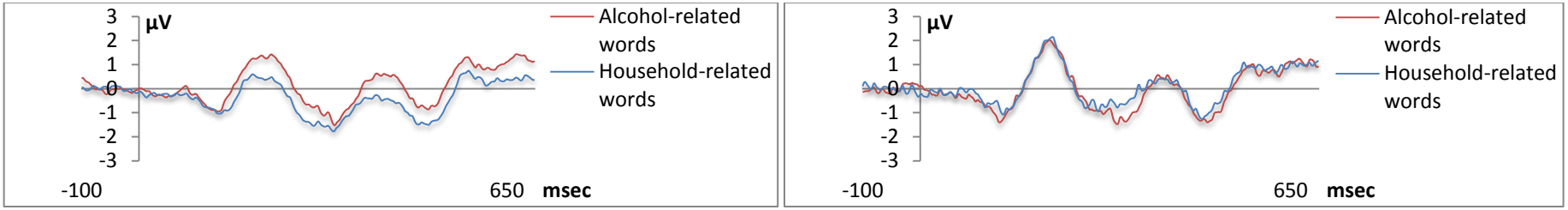

Figure 3.9: ERPs elicited by AR and HR words at central electrodes (FC1, FC2, FC3, FC4, C1, C2, C3, C4, CP1, CP2, CP3 and CP4) in heavy drinkers (*n* = 12; left panel) and in light drinkers (*n* = 10; right panel)

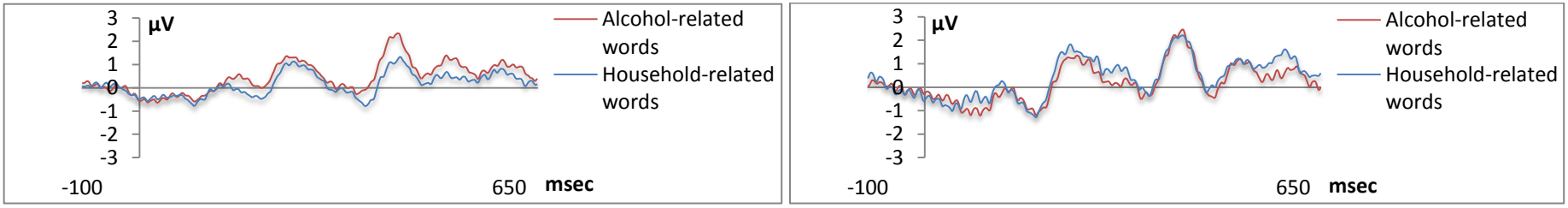

Figure 3.10: ERPs elicited by AR and HR words at posterior electrodes (P1, P2, P3, P4, PO3 and PO4) in heavy drinkers (*n* = 12; left panel) and in light drinkers (*n* = 10; right panel)

Table 3.10 and Figure 3.11 show the mean ERP values.

Table 3.10: Mean amplitude and SDs (μV) in the P3 time window on the AR and HR stimuli across anterior (F1/2, F3/4, AF3/4), central (FC1/2, FC3/4, C1/2, C3/4, CP1/2, CP3/4) and posterior electrodes (P1/2, P3/4, PO3/O4) in each hemisphere

Region	Hemisphere	Stimulus	Heavy drinkers (*n* = 12)	Light drinkers (*n* = 10)
Anterior	*Left*	*AR*	-0.18 (1.46)	-0.39 (1.25)
		HR	-0.61 (1.32)	-0.59 (1.55)
	Right	*AR*	-0.30 (1.28)	-0.64 (1.41)
		HR	-0.83 (1.27)	-0.54 (1.59)
Central	*Left*	*AR*	0.45 (1.34)	0.28 (1.34)
		HR	-0.29 (1.31)	0.33 (1.31)
	Right	*AR*	0.15 (1.12)	-0.11 (1.42)
		HR	-0.67 (1.21)	0.11 (1.41)
Posterior	*Left*	*AR*	1.11 (1.24)	1.21 (1.28)
		HR	0.30 (0.98)	1.06 (1.10)
	Right	*AR*	0.67 (0.99)	0.43 (1.11)
		HR	-0.10 (0.99)	0.71 (1.08)
Grand mean (collapsed across all electrode sites)		*AR*	0.32 (0.93)	0.13 (0.98)
		HR	-0.37 (0.87)	0.18 (1.02)

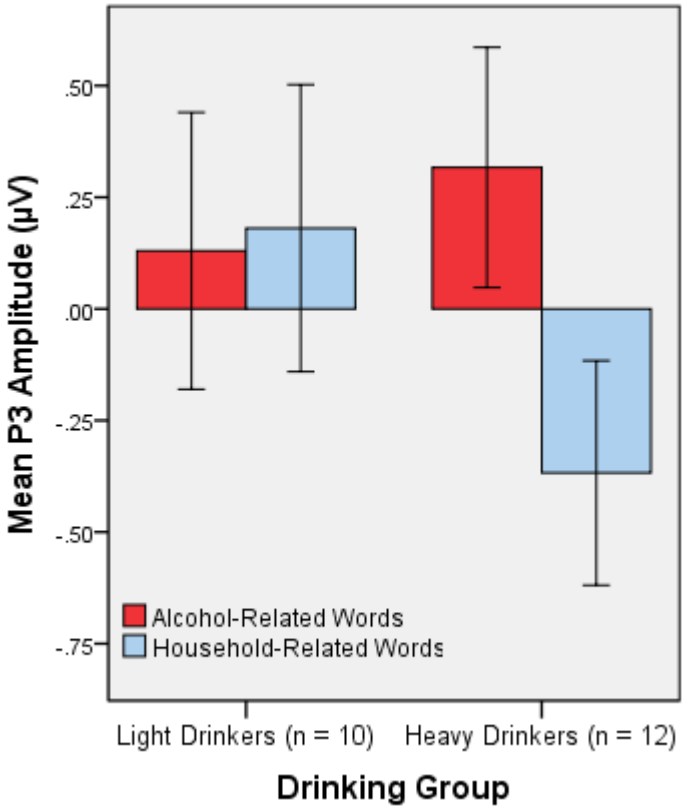

Figure 3.11: Mean (+/- 1 SE) P3 amplitude in heavy and light drinkers

The main effect of DRINKING GROUP was non-significant [F (1, 20) = 0.24; ns]. The main effect of WORD-TYPE demonstrated a strong trend towards significance [F (1, 20) = 3.63; p = 0.07], owing to greater mean P3 amplitudes in response to AR words, compared to HR words.

The WORD-TYPE x GROUP interaction was significant [F (1, 20) = 4.89; p = 0.04; η_p^2 = 0.20], but there were no further interactions with caudality or laterality. Bonferroni-corrected independent-measures t-tests revealed that although the groups did not differ in their P3 amplitudes to either AR or HR words [t (20) = -0.46 and 1.36, respectively], HDs but not LDs showed significantly greater P3 responses to AR words than HR words [HDs: t (11) = 2.35, p = 0.04; d = 0.67; LDs: t (9) = -0.52, ns].

Whilst consistent with the hypothesis, it is notable that this difference between the groups largely reflected an unexpected tendency for HDs to show somewhat blunted amplitudes to neutral (HR) words as well as a slightly greater positive amplitude to AR words.

Given the significant difference between the groups' EPQ-E scores (Hypothesis 1), and the significant CUE AROUSAL x DRINKING GROUP interaction (Hypothesis 6), a 2 x 2 analysis of covariance was conducted to explore whether these variables could explain the observed P3 effect. However, the WORD TYPE x DRINKING GROUP interaction remained significant after co-varying these factors [F (1, 16) = 4.37; p = 0.05; η_p^2 = 0.21]. Thus, neither differences in extraversion nor differences in self-reported arousal contributed to the higher P3 cue-reactivity in HDs.

Exploratory analyses examined the ERP CR values for individual participants. 5/10 LDs and 9/12 HDs individually demonstrated ERP CR as indicated by greater P3 amplitudes to AR than to HR words. However, this difference between the groups was not statistically significant [χ^2 = 0.33; p = 0.28, 1-tailed].

Discussion

The main findings of the present study were as follows. Heavy drinkers but not light drinkers demonstrated greater P3 amplitudes to alcohol-related (AR) than to neutral (household-related; HR) words, albeit that the groups did not differ in terms of the absolute level of P3 amplitude following AR words. A corresponding pattern was seen for their ratings of the words' arousal. Within the combined sample, there was a positive and significant correlation between ERP responses to, and subjective affective salience of, the cues. There were no differences in terms of subjective cue-reactivity, and there was no relationship between ERP and subjective cue-reactivity.

Heavy drinkers were more extraverted than light drinkers, but this did not explain their greater P3 amplitudes in response to AR words compared to HR words. The groups did not differ in terms of their impulsiveness as measured by the subjective trait (TIS) or recent (RIS) subscales, by commission errors on the CPT, or by P3 or N2 amplitudes and latencies during the no-go trials of the CPT. There was a strong trend for recent Motor Impulsivity (RIS-MI) to be more strongly associated than trait MI (TIS-MI) with ERP cue-reactivity; however, there was no hint of any such recent-trait difference for the Cognitive Impulsivity (CI) subscale. Subjective cue-reactivity was not differentially associated with recent or trait impulsivity, for either subscale.

None of the behavioural and ERP measures of impulsivity in the CPT shared stronger correlations with recent relative to trait impulsivity.

The following discussion first focuses on ERP CR and self-reported affective/appetitive responses to the AR words; these data are considered in the broader context of cue-reactivity theory. It then considers the possible relevance of impulsiveness and the ERPs elicited by no-go trials of the CPT.

1) Appetitive responses to alcohol-related word stimuli in HDs

i) Appetitive responses to alcohol-related word stimuli in HDs as revealed by ERPs

Hypothesis 9, that compared to LDs, HDs would show a more pronounced P3 amplitude response specifically to AR stimuli, was partially supported. HDs but not LDs showed greater P3 amplitudes in response to AR words than to HR words (Figure 3.11 on p. 144), though the groups did not differ in absolute levels of amplitude to either type of word. Unexpectedly however, this interaction was partly explained by the HDs showing a somewhat blunted amplitude to HR word presentation.

HDs' blunted reactivity to HR words may reflect a pre-existing lack of interest in and engagement by everyday stimuli, which could have contributed to these participants' heavy alcohol consumption. For example, Ziervogel *et al.* (1997) reported that amongst a sample of male adolescents, one factor which predicted higher consumption of alcohol was boredom; and Malmberg *et al.* (2010) have reported that adolescents who scored highly on trait measures of sensation-seeking (which may reflect low responsivity to stimulation) were at higher risk for early onset of alcohol use. Conversely, regular heavy alcohol consumption may reduce the extent to which attention and interest can be captured by relatively run of the mill, everyday stimuli such as household-related items. Such issues of causality are beyond the scope of the current cross-sectional study. However, it is interesting to speculate on whether heavy drinkers would show abnormal ERP responses to other non-alcohol-related stimuli – for example, to those with higher intrinsic levels of interest or motivational significance. Future studies could address this by including a

third category of word stimuli relating to powerful 'natural' reinforcers such as food and/or sex.

The findings of the present study differ from those of Herrmann *et al.* (2001), who found HDs to show significantly greater P3 amplitudes to alcohol-related stimuli than light drinkers. However, direct comparison between the two studies is limited by some important procedural and analysis differences. Firstly, the heavy and light drinkers here were classified on the basis of *a priori* assessment of their weekly alcohol intake, whereas Herrmann *et al.*'s (2001) heavy and light drinkers group were classified via median split. Thus the HDs in Herrmann *et al.* (2001) consumed an average of 15.3 units per week, markedly less than the average of 44.3 units consumed by the present HDs. Although it might normally be expected that heavier drinkers would show any such effects more strongly, it seems likely that in fact Herrmann's findings were a statistical artifact. Thus the present study analysed P3 data from an even spread of electrode sites over the scalp and across hemispheres, and found no effects either in aggregate or as a function of spatial location. Herrmann *et al.* (2001) reported a difference only at the frontal electrode location Fz, despite having recorded from 21 scalp sites. In another study with alcoholic participants, Herrmann *et al.* (2000) again recorded from 21 electrode sites but reported an effect only at the posterior site Pz. This pattern, inconsistent between their two studies, suggests that their observed P3 differences may well have been spurious.

Selecting participants based upon pre-specified drinking criteria, as the present study did, is preferable to conducting a median split. Averaging data across an even spread of scalp electrodes within anterior, central and posterior regions, rather than reporting effects at just one or two locations, may be a more robust method of examining electrophysiological response. In these respects, therefore, the present study was methodologically stronger than that conducted by Herrmann *et al.* (2001). Nevertheless, despite the differences between the two studies, in both, the P3 response to alcohol-related stimuli varied depending on an individual's typical weekly alcohol intake. The precise nature of this difference remains uncertain and further research is needed. Broadly, however, the electrophysiological results of the

present study are consistent with previous studies which have reported ERP CR in users of other addictive substances, such as those examining nicotine (Warren & McDonough, 1999; McDonough & Warren, 2001), cocaine (van de Laar *et al.*, 2004; Franken *et al.*, 2008) and heroin (Franken *et al.*, 2003).

Another methodological strength of the present study was the procedure by which the AR and HR word stimuli were presented. Having equal numbers of each word type and presenting them within separate conditions reduced the likelihood of a confound with stimulus novelty. This has complicated previous research with similar findings: thus for example Genkina and Shostakovich (1987) presented their word stimuli in the form of an oddball task, meaning that their observed P3 responses may have reflected a novelty effect. As it is, the most plausible explanation for the greater P3 amplitude elicited by AR words in HDs observed here is that they elicited were more emotionally salient than HR words.

Interestingly, there was a trend for greater P3 amplitudes in response to AR words compared to HR words across both HDs and LDs. Additional exploratory analyses found that 5/10 LDs and 9/12 HDs individually demonstrated electrophysiological cue-reactivity as indicated by higher P3s to AR than HR words. That 50% of LDs and 75% of HDs showed ERP CR is consistent with its development being in part a consequence of drinking experience, though it is notable that not all HDs demonstrated ERP CR. It is thus not a precondition or necessary consequence of heavy drinking. Nevertheless, it may be the case that LDs who are more responsive to AR stimuli are more likely to progress to heavier alcohol intake (i.e. that elevated ERP CR represents a vulnerability factor). It would be interesting to follow participants up in a few years time to see whether such differential progression has in fact occurred, though the present sample is probably too small and under-powered for detecting real effects.

These findings are consistent with those of Greeley *et al.* (1993), who found some level of CR to be present in LDs as well as HDs. Cue-reactivity therefore appears to occur (to decreasing extents) in alcohol abusers, heavy social drinkers and light social drinkers.

ii) Heightened extraversion in HDs and ERP CR

Hypothesis 1 was supported: HDs had an EPQ-E score of 16.0, significantly higher than LDs' score of 10.4. This is consistent with Vollrath and Torgersen's (2008) finding that those who engage in more risky alcohol consumption are more likely to be extraverted. However, the difference in extraversion did not account for the difference in ERP cue-reactivity. Thus the heightened CR of the HDs probably does not reflect greater sensitivity to the social connotations of the AR stimuli.

iii) Self-reported appetitive responses to alcohol-related word stimuli, and associations between these measures and ERP P3 responses

Hypothesis 7, which predicted that compared to LDs, HDs would rate AR words higher for arousal, was also partially supported. Thus HDs but not LDs rated AR words as more arousing than HR words. However, the groups did not differ from each other in the arousal they attributed to either AR or HR words separately.

For HDs, the higher arousal ratings of AR, relative to HR words, mirrors their greater P3 amplitudes to AR than HR words. It is possible that both forms of response reflect the development of incentive salience through frequent alcohol-associated experiences. However, there are some important differences between electrophysiological and self-report data. Firstly, electrophysiological data are objective and less susceptible to subjective bias than self-report measures. Secondly, electrophysiological data indexed the arousal elicited by AR words at the moment they were presented, thereby serving as a conventional index of cue-reactivity. By contrast, subjective arousal ratings were given at the end of the session: these scores (unlike the desire ratings, discussed below) were thus not necessarily an accurate index of participants' momentary emotional reactions when the words were presented. It is interesting, therefore, that despite these differences the EEG CR and self-reported arousal indices showed similar patterns.

Exploratory analyses which took account of the *direction*, as well as the strength, of the affective response (i.e. positive or negative) found no difference between HDs and LDs. However, in equivalent analyses, Herrmann *et al.* (2001) reported that

alcohol-related stimuli received higher pleasantness ratings (i.e. a greater positive emotional response) from HDs than LDs. The reason for this anomaly is unclear, particularly as the present HDs reported drinking considerably more heavily than those in Herrmann *et al.*'s study. On the other hand, the potentially greater number and intensity of unpleasant effects related to the (even) heavier drinking (e.g. hangovers) in the present HDs may have rendered alcohol a more ambiguous concept compared to its perception in Herrmann *et al.*'s HDs. However, this discrepancy between the studies is tempered by the fact that both HDs and LDs in Herrmann *et al.*'s study rated the neutral stimuli as more pleasant than the alcohol-related stimuli. Here, by contrast, neither HDs nor LDs rated AR words as more pleasant than HR stimuli.

The present groups did not differ in terms of age, gender or impulsiveness; thus these demographic and personality variables do not explain the observed differences in cue-reactivity. Furthermore, since the LDs and HDs did not differ in their family histories of alcohol use disorders, it is unlikely that the observed ERP and arousal rating differences emanated from genetic factors. This corresponds with Herrmann *et al.*'s (2001) findings of differential electrophysiological and subjective cue responses in the absence of differences in family history of alcoholism. Taken together, the two studies are consistent with emotional arousal to alcohol-related stimuli developing as a function of alcohol consumption rather than being the manifestation of an underlying genotype or other demographic factors.

Hypothesis 6, that in the combined sample there would be a significant correlation between ERP CR and self-reported appetitive responses to AR stimuli, was partially supported. The Spearman correlation between ERP CR and arousal ratings was positive and significant; that between ERP CR and subjective CR, however, was not.

Thus participants who rated AR words as more arousing than HR stimuli showed greater P3 cue-reactivity to them. This reflects the greater CR in HDs than LDs and is consistent with Herrmann *et al.*'s (2001) findings in a combined group of heavy and light drinkers that stimulus 'pleasantness' correlated 0.40 and 0.50 with ERP CR

recorded at electrode positions Fz and Cz, respectively. As in the present study, there was no correlation within either subgroup.

The lack of correlation between ERP CR and subjective CR mirrors the finding, against prediction (hypothesis 8), that HDs and LDs showed similar levels of subjective CR. Taken together, these findings indicate that ERP CR is not simply an electrophysiological correlate of subjective CR and reflect previous observations that subjective and physiological measures of CR can be desynchronised (e.g. Niaura *et al.*, 1988). The stronger association of electrophysiological CR with ratings of stimulus arousal than with subjective CR may be of theoretical interest. In rating arousal participants were asked to give their 'immediate, gut-level' responses; this may have oriented them to physiological sensations to which ERPs were similarly sensitive. By contrast subjective desire for alcohol – the index used in the cue-reactivity paradigm – is likely to be affected by other factors such as beliefs and expectancies.

The lack of correlation found here may, however, be spurious. Some similar studies in abusers of alcohol and other drugs have reported significant positive correlations between subjective and ERP CR (e.g. McDonough & Warren, 2001; Franken *et al.*, 2003; Namkoong *et al.*, 2004; van de Laar *et al.*, 2004; Heinz *et al.*, 2007; Franken *et al.*, 2008). This has not been universally the case though; for example, Warren & McDonough (1999) did not observe such an association. Most of the studies with positive findings tested samples of physically dependent or addicted substance users, so it is possible that with increasing levels of alcohol (or other drug) intake, subjective and physiological responses become more aligned. At any rate, it is clear that more research is needed to explore the relationship between ERP CR and subjective craving in non-dependent social drinkers.

Overall, the results of the current study, together with those discussed in the literature review, demonstrate that differential processing of alcohol-related stimuli compared to neutral stimuli is not confined only to those who have a diagnosis of physical dependence, but are also present in lighter drinkers. Secondly, they suggest that the degree to which a non-dependent social drinker displays CR varies to some

extent as a function of the individual's experience with alcohol consumption. This is consistent with theories relating to CR, such as those of Robinson and Berridge (1993; 2000) and Tiffany (1990), which assert that repeated administration of drugs of abuse leads to associated environmental cues progressively acquiring incentive salience. However, a large proportion of variance in participants' CR was left unaccounted for here: thus the partial η^2 (i.e. the contribution of each factor or interaction to the variance in a DV, taken as if it were the only variable; Tabachnik & Fidell, 2007) for the interaction effect was relatively small at 0.20. This raises the question of what other factors might be involved in CR.

2) Impulsiveness and its association with ERP CR

Hypothesis 2, that HDs would be more impulsive than LDs as indicated by higher TIS and RIS scores and by more commission errors and reduced response speed in the Continuous Performance Test (CPT), was not supported.

A literature search did not retrieve any previous published studies examining differences between heavy and light non-dependent social drinkers on the CPT. However, Colder and Connor (2002) reported in a sample of social drinkers that those who drank more frequently made more errors of commission in the Go/NoGo task (another test of behavioural inhibition and theoretically related to the CPT) and scored more highly on Carver & White's (1994) Behavioural Approach System (BAS) self-report scales. A number of studies have reported similar findings (e.g. Henges and Marczinski, 2012; Ahmadi *et al.*, 2013). These data contrast with the present null findings.

The findings of the present study suggest that impulsivity is not a major influence on drinkers' ERP cue-reactivity, but confidence in this conclusion is limited by the small sample sizes; replication in larger samples is needed.

The present findings were inconsistent with Hypotheses 3 and 4 that during the CPT, relative to LDs HDs would show lower no-go P3 amplitude and higher no-go P3 latency and lower no-go N2 amplitude and higher no-go N2 latency. The negative findings for P3 and N2 amplitude contradict those obtained by Oddy and Barry

(2009), the only published study to examine ERPs during performance of an inhibitory control task in 26 non-dependent social drinkers. These authors found HDs to show lower global no-go P3 and central no-go N2 amplitudes than LDs, though, as here, the groups did not differ in terms of behavioural performance.

The Go/NoGo task employed by Oddy and Barry (2009) was very similar to the CPT used here. Their participants were instructed to press a button when one class of stimulus appeared and to inhibit this response following presentation of a different class of stimulus. As in the CPT, participants received no indication as to which stimulus would occur next. The only meaningful difference between the tasks was that Oddy and Barry (2009) presented equal numbers of go and no-go trials, whereas here, in order to induce prepotency of the go response, there was a 9:1 ratio of go to no-go trials. Theoretically, this should have increased task difficulty and made it more sensitive to deficient inhibitory control in the HDs.

The two studies tested similar numbers of participants but the HDs in Oddy and Barry's study consumed much less alcohol per week than those here (approximately 100g versus more than 400g). It therefore seems anomalous that Oddy and Barry (2009) reported an effect whilst the present study did not. Further research is therefore needed to determine brain activity during inhibitory control tasks is abnormal in non-dependent social drinkers. However, it should be noted that deficient inhibitory-related electrophysiology in alcoholics is still not well-characterised, with some studies reporting low no-go P3 amplitudes but normal latencies (Realmuto *et al.*, 1993; Rodríguez Holguín *et al.*, 1999a; Hada *et al.*, 2000), but others the converse pattern (Biggins *et al.*, 1995; Fein & Chang, 2006).

In any event, the lack of association between ERP no-go responses and ERP CR contradicts Hypothesis 5, that ERP CR in the combined sample would be at least partially explained by self-report measures of impulsiveness, CPT commission errors and response speed, and no-go P3 and no-go N2 amplitude and latency. None of the correlations approached significance, and the data are thus inconsistent with theories which suggest that impulsiveness is a vulnerability factor for substance use

disorders (e.g. Sher *et al.*, 2000). However, the present study was very small and cross-sectional, and thus of limited power to detect causal relationships.

There is likewise no indication that relatively heavy social drinking sustained for at least a year had given rise to prefrontal dysfunction and deficits of inhibitory control, as Jentsch and Taylor have argued can occur in chronic substance misuse. It is, of course, possible that drinking histories in the present sample were simply not severe enough to have produced deficits of sufficient magnitude to be detected by the tasks used here. Nevertheless, these participants' alcohol consumption *does* appear to be associated with electrophysiological CR, and this in itself may plausibly be associated with increasing desire to consume alcohol and hence with escalation of drinking behaviour.

3) Subjective and ERP CR and behavioural and ERP impulsivity: Relationships with self-reported Recent and Trait Impulsivity

There was partial support for Hypothesis 5. i), that within the combined sample ERP and subjective CR would correlate more strongly with the self-report index of recent impulsiveness (RIS) than with the corresponding index of trait impulsiveness (TIS). This pattern was indeed observed for the RIS/TIS Motor Impulsivity (MI) subscale: the higher participants' recent MI, the greater their electrophysiological CR (r = 0.47; p = 0.02). This is the first study to have reported an association between recent impulsiveness and cue-reactivity. However, there were no such recent-trait differences for Cognitive Impulsivity (RIS/TIS CI) correlations with ERP CR or for either subscale with subjective CR.

Interestingly, however, subjective CR did correlate significantly with the CI subscale of the RIS, and showed a trend to correlating likewise with TIS-CI. Thus, the higher participants' cognitive impulsivity, the greater their subjective cue-reactivity. This is consistent with the view that cue-reactivity and impulsivity have partially shared biological substrates.

There was likewise a modest correlation between subjective CR and TIS MI (r = -0.21), though it failed to reach significance in the present small sample. However,

there was no hint of association between ERP CR and TIS/RIS CI. These discrepancies may be a genuine reflection of the MI and CI constructs. Containing somewhat abstract items such as 'In the last two weeks I have planned events and activities well ahead of time', the CI subscale may not be as sensitive as the MI subscale to short-term behavioural changes. Thus the MI subscale focuses more on explicit behaviours which are perhaps more likely to change from week to week (e.g. 'In the last two weeks I have encountered problems because I have done things without stopping to think').

The present findings for trait and recent motor impulsiveness are consistent with those revealed in the first study of this thesis in suggesting that recent MI might either mirror or influence the way in which an individual responds to reward-related – or more specifically alcohol-related – stimuli, and that it is more relevant than longer-term 'trait' MI. Thus in Study 1 for participants reporting a recent change in their alcohol consumption, recent MI correlated more strongly than did trait MI with alcohol intake during the previous two weeks.

In terms of behavioural and ERP measures of impulsivity in the CPT (Hypothesis 5. ii)), there was no suggestion that correlations were greater with recent compared to trait impulsivity; thus, this part of the hypothesis was not supported.

Even without applying the Bonferroni correction, only 3 out of 20 correlations (the negative *r*s between TIS CI and NoGo P3 latency and TIS and RIS CI and NoGo N2 amplitude) reached statistical significance; none of these remained significant when the correction *was* applied. Furthermore, one of these (the negative correlation between TIS CI and NoGo latency) was in the opposite direction to that expected. Similarly, two of the observed trends (the positive *r* between TIS CI and P3 NoGo amplitude and the negative *r* between RIS MI and N2 NoGo latency) were in the opposite directions to those expected. Overall, therefore, these findings are conflicting and possibly spurious; further research with larger samples is needed.

The absence of association between any of the TIS and RIS subscales and CPT commission errors might be related to the ceiling effects observed in terms of CPT performance, thereby reducing the spread of scores in the task. The lack of any

association between the TIS and RIS scales which occurred in eleven out of the 20 correlations might be further related to the poor (and often complete lack of) correlations commonly reported between different indices of impulsivity (Dom *et al.*, 2006b). The lack of correlation observed in five out of ten of the correlations between the RIS subscales and the behavioural and ERP impulsivity measures in particular may have additionally been related to the time interval over which RIS items are measured: since this is relatively long at two weeks, this may have rendered it temporally indistinct from the TIS scale, compared to the 'right now' time-scale of the behavioural and ERP measures. Further research is needed to explore whether, compared to its trait equivalent, the RIS shares greater correlations with 'state' (behavioural) impulsivity measures.

Conclusion

In summary, the present study found that a group of heavy social drinkers but not a demographically well-matched group of light drinkers demonstrated greater P3 amplitudes to alcohol-related words than to neutral words. Paralleling this, heavy drinkers but not light drinkers rated the alcohol-related words as more arousing than neutral words. Qualitatively, the heightened electrophysiological responses of the heavy drinkers appeared to reflect a combination of abnormal response to neutral stimuli as well as slightly elevated responses to alcohol-related words. These observations offered partial support for existing reports of cue-reactivity in non-dependent drinkers. However, the light and heavy drinkers did not differ in self-report, behavioural or electrophysiological correlates of impulsiveness. These findings indicate that cue-reactivity in non-dependent drinkers can be observed in the absence of heightened impulsiveness. Interestingly, and consistent with Study 1, recent motor impulsivity was found to be more strongly associated than trait motor impulsivity with ERP cue-reactivity. However, the cross-sectional design and small sample sizes of the study limit the conclusions which can be drawn and further research is needed.

Chapter 4: Exploring the Effects of a Small Dose of Alcohol on Sensitivity to Non-Alcohol-Related and Alcohol-Related Reinforcers, Subjective Cue-Reactivity and Inhibitory Control and Decision-Making in Healthy Social Drinkers and Acutely Abstinent Non-Dependent Problem Drinkers

Abstract

Background: *Previous studies have consistently reported increased craving and attentional bias in heavy social drinkers (HDs) administered small to moderate doses of alcohol. Impairments of inhibitory control have also been reported at these doses. These 'priming' effects have been accounted for principally in terms of the acute selectively disinhibiting effects of alcohol and drinking-induced alterations in mesocorticolimbic (MCL) dopamine (DA) systems such that a) these regions are 'sensitised' to the acute effects of alcohol and b) alcohol-related stimuli are imbued with heightened incentive salience (Field et al., 2010). It is at present unclear whether priming effects are detectable via behavioural testing in more moderate drinkers, whose dopaminergic (DAergic) MCL pathways, relative to those of heavy and problem drinkers, should i) be well-toned (i.e. neither hypofunctioning nor sensitised to acute alcohol effects) and ii) be less reactive to cues associated with alcohol.*

Research and design: *A repeated-measures design examined whether, compared to placebo, a small (sub-sedative) dose of alcohol administered to social drinkers (SDs) would be associated with increases in i) sensitivity to cues with motivational salience; and ii) decision-making and inhibitory control. In addition, eleven problem drinkers (PDs) were assessed under the same conditions to explore i) whether during acute abstinence they would demonstrate less sensitivity than SDs to cues with motivational salience and impairments of inhibitory control and decision-making; and ii) whether their responses would be normalised by a 'priming' dose of alcohol.*

Methods: *All participants completed a modified Stroop task, a cue-elicited craving procedure, the Iowa Gambling Task (IGT), and a Continuous Performance Test (CPT)*

twice: once during acute abstinence and once following alcohol administration. They completed the RIS and TIS at baseline only.

It was further hypothesised that the RIS would predict performance on the experimental indices of reward sensitivity and impulsiveness during acute abstinence, more strongly than the TIS.

Results: *In SDs, a 'priming' dose of alcohol had no discernible effect on sensitivity to cues with motivational salience or on decision-making or inhibitory control. However, on the Stroop task, PDs responded to alcohol priming with an increase in sensitivity to appetitive words, and a decrease in sensitivity to aversive words; there was also a tendency for their cue-elicited craving to be reduced. Neither the RIS nor the TIS predicted any aspect of task performance during acute abstinence.*

Conclusions and limitations: *While SDs did not show effects of priming by alcohol, these data provide tentative evidence that salience attribution processes are dysfunctional in PDs and may be normalised by small doses of alcohol. The lack of effects on inhibitory control and decision-making conflict with previous data but may reflect the small N and low power.*

Introduction and rationale

Neurochemical 'priming' studies have revealed that ingestion of alcohol acutely increases dopaminergic (DAergic) activity within mesocorticolimbic (MCL) circuitry. Such neurochemical reports have been complemented by self-report and behavioural studies showing that alcohol can prime social drinkers' desire to drink (de Wit & Chutuape, 1993; Duka *et al.*, 1999) and increase the likelihood of their choosing an alcohol rather than an alcohol-free beverage (de Wit & Chutuape, 1993). Previous priming studies have tended to administer 2 to 3 units of alcohol to relatively heavy social drinkers; it is thus at present unknown whether in moderate drinkers smaller doses enhance MCL DAergic activity as indicated by their performance in behavioural tests of incentive salience and impulsivity.

There is also consistent evidence that during abstinence alcohol dependent individuals demonstrate an attenuation of activity within and throughout DAergic

MCL circuitry (see Chapter 1, pp. 23-25 and pp. 34-36). While this may reflect homeostatic neuroadaptation to chronic alcohol consumption, it is also possible that constitutionally 'sluggish' MCL system may constitute a vulnerability factor for chronic alcohol consumption and possible dependence. Dysfunctional DAergic MCL circuitry may explain some of the central phenomena of addiction, in particular under-responsiveness to natural reinforcers (or 'anhedonia'), high reactivity to alcohol-related stimuli, and impulsiveness. When addicts are acutely abstinent, it has been argued that their hypodopaminergic state manifests in reduced sensitivity to cues associated with not only drugs but also other reinforcers, and heightened impulsiveness. Relatedly, compulsive drug use may in part be driven by the effect of acute drug ingestion in temporarily elevating DA activity and thus normalising psychological and cognitive functions. Zack *et al*. (2011) note that individuals who do not meet the criteria for physical dependence, but whose drinking is nevertheless dysfunctional ('problem drinkers'; PDs), demonstrate signs of MCL hypodopaminergic function and of psychological dependence (e.g. difficulty in controlling drinking, craving for alcohol, disruption of normal daily activities and responsibilities). Studies of their functioning during abstinence may therefore offer insight into the aetiology of dependence.

If non-dependent PDs develop, or are constitutionally characterised by, underlying hypoactivity in MCL circuitry, they should be relatively more anhedonic and impaired on measures of cue-reactivity and inhibitory control when acutely abstinent. If alcohol retains its ability to induce an increase in MCL DA activity even in dependent drinkers, a priming dose should improve performance deficits observed in abstinence. As yet, no study testing these predictions in drinkers has been published; however, Dawkins *et al*. (2006, 2007b) found that in smokers a small dose of nicotine reversed abnormalities observed during acute abstinence. While corresponding effects are predicted in PDs, it is less clear whether healthy social drinkers will be sensitive to priming doses of alcohol. It is assumed that most such individuals have normally-functioning MCL pathways, and that they will be unaffected by abstinence. However, it may nevertheless be the case that a small

dose of alcohol will produce changes in neural activity that subtly affect performance.

The primary purposes of the present study were thus two-fold: i) to examine the effects of a small 'priming' dose of alcohol on SDs' sensitivity to non-alcohol-related natural reinforcers, reactivity to alcohol-related stimuli and decision-making and inhibitory control; and ii) to examine the effects of acute abstinence and small 'priming' doses of alcohol on these same variables in PDs, in comparison to the SDs.

1) Effects of a dose of alcohol on cognition and motivation in non-dependent social and problem drinkers

1. i) Apparent 'priming' effects of a dose of alcohol in healthy social drinkers

So far, the present thesis has focused principally upon the effect of exteroceptive alcohol-related cues on cognition and motivation, yet the presence of ethanol may likewise be an interoceptive stimulus for conditioned responses such as orienting towards alcohol-associated stimuli or the urge to drink. Thus, Duka and Townshend (2004) found that a dose of alcohol given to social drinkers increased their subsequent alcohol consumption. Stewart, de Wit and Eikelboom (1984) termed such effects 'priming', though it has subsequently been noted that such phenomena can be inconsistent and are often desynchronised (Schoenmakers & Wiers, 2010).

Initially recorded in alcohol-dependent individuals, priming effects are nicely illustrated in a study by Hodgson, Rankin and Stockwell (1979). Severely and moderately dependent alcoholics' craving was recorded after they had consumed a high dose (150 ml of vodka), a low dose (15 ml of vodka) and no dose of alcohol, within a repeated-measures design. Craving was measured via self-report, pulse rate and the time taken to consume an alcoholic drink. Pulse rate was found to increase significantly in both groups after consumption of the high dose compared to both the low dose and no dose. The severely dependent group consumed the drink in fewer sips after the high dose compared to the low dose; this pattern was not observed in moderately dependent participants. Importantly, the severely dependent group also consumed the drink faster following the high dose than in the

other two conditions, whereas this pattern was reversed in the moderately dependent group. A limitation of this study, however, was that participants were informed on each occasion of the drink they were about to receive; thus, expectancy effects may have played a role. Similar findings have also been reported by Ludwig and Wikler (1974) and Bigelow, Griffiths & Liebson (1977), though null effects were reported by Merry (1966), Marlatt, Demming and Reid (1973) and Engle and Williams (1972) (for a review see Stockwell, 1991).

Priming effects have also been reported in non-dependent social drinkers, with increases in subjective craving reported following doses ranging from low (0.3 g of alcohol per kg bodyweight) to high (0.8 g/kg), with subjective craving being larger for larger doses (Schoenmakers, Wiers & Field, 2008; Chutuape, Mitchell & de Wit, 1994; de Wit & Chutuape, 1993; Duka *et al.*, 1999; Rose & Duka, 2006; Schulze & Jones, 2000). However, not all studies have confirmed such effects: Duka and Townshend (2004) and Schulze and Jones (1999) reported craving to be unaffected. Prime effects on other indices of drink desire have also been reported, including 'wanting more alcohol' (Kirk & de Wit, 2000), the consumption of more alcohol (de Wit & Chutuape, 1993; Duka, Tasker & Stephens, 1998), choosing alcohol over an alcohol-free beverage (de Wit & Chutuape, 1993) and choosing alcohol over money (Chutuape *et al.*, 1994). However, Kirk and de Wit (2000) were unable to replicate this latter finding.

Most of the above studies have been in relatively heavy social drinkers, that is, individuals drinking at or above UK recommended weekly limits of 14 units for women and 21 for men (e.g. Duka *et al.*, 1998; Duka & Townshend, 2004; Rose & Duka, 2006; Schoenmakers *et al.*, 2008). Neuroadaptations and alcohol-related associative learning should be strong in such individuals, increasing the likelihood of detecting effects of priming doses on behavioural indices. However, Field *et al.*'s (2010) model predicts that such effects should also be present to a greater or lesser extent in *all* of those with some experience of alcohol consumption.

In those studies which have included lighter and/or more moderate drinkers, these participants have tended to either: i) be part of a sample also including heavier

social drinkers (e.g. Duka *et al.*, 1999; Duka & Townshend, 2004); ii) include a disproportionately large number of individuals who reported regular use of other psychoactive drugs such as marijuana (e.g. Chutuape *et al.*, 1994); or iii) include participants with a regular binge-like pattern of alcohol consumption, that is, frequently consuming at least 4 drinks in a session (e.g. de Wit & Chutuape, 1993). Thus, the existence of explicit priming effects in more moderate drinkers has not been adequately explored to date.

A growing number of studies have indicated that in social drinkers, alcohol also acutely influences less conscious processes, that is, attentional bias. However, this literature is relatively small and data are conflicting. Nevertheless, it appears that the effects of acute alcohol appear to be influenced by i) the dose of alcohol administered, ii) the task administered and iii) the drinking status of participants. In terms of alcohol dose, Duka & Townshend (2004) and Schoenmakers, Wiers & Field (2008) both found a moderate dose of alcohol (0.3 g/kg) to increase attentional bias in the visual probe task. However, Duka & Townshend (2004) found that a higher alcohol dose (0.6 g/kg) did *not* increase attentional bias relative to placebo; thus, attentional bias may peak at moderate doses (0.3-0.4 g/kg) but decline at higher doses. Consistent with this, Schoenmakers & Wiers (2010) reported that in binge-drinkers, there was a negative correlation between the number of drinks consumed immediately prior to testing and the extent of attentional bias as measured by a modified flicker paradigm.

Concerning the task administered, Miller & Fillmore (2011) reported no dose-dependent effect of 0.32 g/kg or 0.64 g/kg doses of alcohol on time spent fixating on alcohol-related compared to neutral images in the visual probe task. However, using the modified Stroop task, Duka & Townshend (2004) observed greater interference at a 0.6 g/kg dose of alcohol than a 0.3 g/kg dose. More recently, Adams *et al.* (2012) have reported that 0.13 g/kg and 0.4 g/kg doses of alcohol (relative to placebo) had no effect on an alcohol Stroop task, but that a moderate dose of alcohol (0.4 g/kg) produced greater attentional bias in a visual probe task. This led Adams *et al.* (2012) to suggest that different indices of attentional bias may be mediated by different underlying mechanisms.

As per research relating to subjective craving effects above, all but one (Adams *et al.*, 2012) of the above attentional bias studies incorporated repeated-measures designs with a single group of (relatively heavy) 'social drinkers'. However, levels of social drinking vary widely and, accordingly, recent studies have compared groups of lighter, more moderate social drinkers to heavier, hazardous drinking groups. Fernie *et al.* (2012) found heavy drinkers' attentional bias, measured via eye movement monitoring during a visual probe task, to be unaffected by a 0.4 g/kg dose of alcohol. In light drinkers, however, attentional bias was greater following alcohol, relative to placebo. Weafer & Fillmore (2013), on the other hand, reported no effect of either 0.45 g/kg or 0.65 g/kg doses of alcohol on visual probe task performance in their light drinkers, but found (similar to Duka & Townshend, 2004) heavy drinkers to show a dose-dependent decrease in attentional bias following alcohol administration. In the study by Adams *et al.* (2012; above), however, attentional bias in neither the alcohol Stroop nor visual probe task varied as a function of drinking status. Thus, it is at present unclear how drinking status and alcohol doses interact to effect implicit priming effects in non-dependent moderate versus heavier drinking groups; further research is needed.

1. ii) The acute effects of alcohol on inhibitory control

As discussed in Chapter 2 (pp. 55-57), a number of studies have reported that a moderate dose of alcohol (0.4-0.45 g/kg, which produces BACs of around 0.06 g%) has a selectively detrimental effect on inhibitory control as measured by tasks such as the Stop Signal Task and the cued Go/No-Go task (Marczinski *et al.*, 2005; de Wit, Crean & Richards, 2000). Similar doses have also been found to impair performance on tasks assessing inhibitory control over attention (Abroms & Fillmore, 2004; Abroms, Gottlob & Fillmore, 2006). It is important to note that at this BAC, the inhibitory control impairment does not tend to be accompanied by either impaired accuracy or slower responding to 'go' cues, suggesting that inhibitory control disruption is specific rather than a global impairment or psychomotor slowing.

Schoenmakers and Wiers (2010) have questioned the extent to which findings from controlled laboratory settings can be generalised to real-world settings where many

factors may influence the motivation to drink. A meta-analysis indicated that alcohol effects on both expectancies and pharmacological responses are greater in 'natural environment' labs than in 'typical' labs (McKay & Schare, 1999). This may reflect the presence of environmental cues normally encountered when drinking socially and participants' relaxation in those participants. Furthermore, the amount of alcohol people tend to drink socially generally exceeds the amounts administered in priming studies.

1. iii) Models of alcohol's acute priming effects

Priming effects in social drinkers (SDs) have been interpreted in terms of the acute effects of alcohol on inhibitory control together with more stable incentive motivational factors. Consistent with the preceding review, Field *et al.* (2010) contend that administration of small to moderate alcohol doses increases implicit appetitive responses to alcohol-related cues and impairs inhibitory control. They argue that these processes may have additive effects on drinking behaviour, such that alcohol-induced disinhibition may make the individual less able to resist alcohol-induced elevations in attentional bias and other appetitive responses elicited by alcohol-related cues.

Weafer and Fillmore (2008) found that a 0.6 g/kg alcohol dose administered to social drinkers increased their commission errors (i.e. failures of inhibitory control) on a Go/No-Go task, and that the degree of impairment, relative to a placebo condition, predicted twenty percent of the variance in *ad libitum* beer consumption in a subsequent bogus 'taste-test'. However, since alcohol-seeking behaviour was tested only after BACs had fallen to baseline levels, it is unlikely that the acute weakening of inhibitory control itself caused the increase in alcohol consumption. Rather, it suggests that drinkers most sensitive to the effects of alcohol are also those most drawn to it. It is possible that the more alcohol-sensitive participants were those with a greater history of social drinking and were therefore a) more sensitised to alcohol's effects on inhibitory control and b) more likely to drink in response to alcohol availability. Unfortunately, although Weafer and Fillmore (2008) found marked individual differences in the magnitude of alcohol impairment of

inhibitory control, they did not examine the relationship between this and habitual drinking levels.

In a double-blind design, Hutchison *et al.* (2001) randomised twenty-six heavy social drinkers to receive either 5 mg of the DA D_2 antagonist olanzapine or placebo before each of two experimental sessions. Participants were administered a moderate alcohol dose in one session and a non-alcoholic beverage in the other, before rating their craving. Alcohol increased craving, but olanzapine significantly attenuated this effect. This study therefore strengthens the theory that DA systems are involved in mediating alcohol priming.

1. iv) Effects of small alcohol doses on subjective craving, attentional bias and inhibitory control

Priming studies have typically administered moderate to large doses of alcohol (i.e. between 0.4 and 0.6 g/kg, or approximately 3.33-5 UK units). The relative lack of research utilising smaller doses might reflect beliefs or even pilot findings that regular drinkers are insensitive to lower doses; however, in the absence of many published studies utilising alcohol doses smaller than 0.4 g/kg it remains an open empirical question whether and to what extent doses below this level can influence craving and attentional bias to alcohol-related stimuli and inhibitory control in moderate social drinkers.

In one of the few existing studies, Jones & Schulze (2000) observed an effect of a very small dose of alcohol – half a unit. Sixty social drinkers consumed either a soft drink or alcohol before completing a modified Stroop task. The alcohol group, but not the placebo group, were slowed in their colour-naming of alcohol-related words relative to alcohol-unrelated words. More recently, however, Adams *et al.* (2012; see p.189) reported no effect of a 0.13 g/kg dose of alcohol (roughly equivalent to 1 unit) on light drinkers' performances on the alcohol Stroop task or the visual probe task. In an earlier study with SDs, however, Schulze & Jones (1999) found no effect of 1 unit of alcohol on desire for alcohol. These findings conform to the notion that priming effects in SDs are dose- and task-dependent; though in the absence of replications no firm conclusions can be drawn.

Whilst Jones and Schulze's (2000) study is interesting, there are limitations to the methodology. Firstly, participants were termed simply 'social drinkers'; the authors did not provide information concerning their average weekly consumption.

Secondly, the Stroop effect was significant only for words with 'positive' alcohol connotations and not for words with 'negative' connotations. At this fine-grained level of analysis, observed effects must be treated very tentatively.

Thirdly, participants appear not to have been blind to the drink they were given. If the observed effect was real, it may therefore have reflected expectancy rather than pharmacological actions. In the absence of studies disguising small doses of alcohol, it therefore remains unclear whether they do in fact directly affect performance on behavioural tasks such as the modified Stroop.

Thus, one of the principal aims of the present study was to replicate and extend the findings of Jones and Schulze (2000) but strengthening various aspects of the methodology. A literature search revealed no studies to have examined effects of doses equivalent to 1 unit or below on inhibitory control. Further research is therefore needed to characterise the effects of small alcohol doses on craving, attentional bias and inhibitory control in moderate social drinkers.

2. Downregulation of MCL DAergic circuitry in chronic drinkers

2. i) Effects of downregulation on responsiveness to 'natural' reinforcers

As detailed in Chapter 1 (pp. 23-25 and pp. 34-36), there is substantial evidence that individuals abusing alcohol demonstrate widespread downregulation of activity in MCL DAergic regions as revealed by behavioural tasks, brain imaging and acute challenge studies. It is not clear whether this hypodopaminergicity is a consequence of, or pre-exists, chronic substance use. In any event, the observation that hypodopaminergicity is observed in heavy chronic drinkers leads to the following hypothesis: if DA D_2 receptors mediate responses to 'natural' reinforcers such as food and sex, drinkers should show reduced sensitivity to such reinforcers when they are acutely abstinent (Volkow *et al*., 2002). This is likely to manifest as 'anhedonia', 'a loss of interest or pleasure in all or almost all usual activities and

pastimes' (Snaith, 1992, p. 134). It is relevant to note here that anhedonia is a common feature of psychiatric disorders including schizophrenia (Blanchard, Horan & Brown, 2001; Mason *et al*., 2004), depression (Klein, 1974), anxiety and adjustment disorders (Silverstone, 1991), suicidal ideation (Oei *et al*., 1990) and successful suicide (Fawcett, 1993), all of which have been associated with underfunctioning DAergic MCL systems (Heinz *et al*., 1994).

Anhedonia has principally been quantified via self-report questionnaires, the most commonly-administered and well-validated measure of which is the Snaith-Hamilton Pleasure Scale (SHPS; Snaith *et al*., 1995). This fourteen-item instrument asks the respondent to rate the extent to which they believe they would enjoy, at the moment of responding, a range of hypothetical real-world scenarios – for example, having a warm bath and eating one's favourite meal. It was initially developed in a large, non-clinical sample, but has subsequently been employed in various psychiatric groups (Janiri *et al*., 2005). Similar self-report instruments include the revised Chapman Physical Anhedonia and Social Anhedonia Scales (PAS & SAS; Chapman, Chapman & Raulin, 1976) and the Fawcett-Clark Pleasure Scale (FCPS; Fawcett *et al*., 1983). The SHPS and PAS have been reported to correlate highly significantly with each other (Loas *et al*., 1997). Visual Analog Scales have also been used, albeit less frequently, to assess hedonic tone (e.g. Janiri *et al*., 2005). Using instruments such as these, a number of studies have provided clear evidence of the presence of anhedonic symptoms in alcohol and other substance-dependent individuals (Gawin & Ellinwood, 1988; Miller, Summers & Gold, 1993; Heinz, Schmidt & Reischies, 1994; Marra *et al.*, 1998; Sarramon *et al.*, 1999; Bovasso, 2001; Shippenberg, Zapata & Chefer, 2007).

2. ii) The potentially 'normalising' effect of a small dose of alcohol in problem drinkers

Because alcohol retains the ability to acutely increase DAergic activity (Di Ciano, Blaha & Philips, 1998), PDs' hypodopaminergicity will remain 'hidden' as long as chronic intake is maintained. Abstinence, however, 'unmasks' the underlying dysfunction and a single dose of alcohol should transiently normalise biological and

psychological responses to cues with motivational salience where these are not themselves alcohol-related.

The effects of abstinence and acute alcohol on responses to alcohol-related cues, however, are harder to predict because there are strong non-biological influences on craving. Thus during abstinence problem drinkers (PDs) are almost certainly preoccupied with the desire for alcohol to attenuate physical and/or psychological discomfort. This is likely to inflate subjective craving and attentional bias to alcohol-related stimuli during acute abstinence, making it difficult to discern additional effects of priming doses (i.e. ceiling effects). It is notable that Powell, Dawkins and Davis (2002) found that in smokers cue-elicited craving was lower during acute abstinence than after they had smoked. However, in a subsequent study Dawkins *et al.* (2007a) failed to replicate this effect. Thus it is currently theoretically and empirically unclear how abstinence and alcohol priming affect responses to alcohol-related cues in PDs.

The effects of acute abstinence and priming doses on executive control in PDs are also unclear. On the one hand, for the reasons previously outlined, a priming dose might be expected to boost DA activity and therefore enhance inhibitory control and decision-making. However, as reviewed by Field *et al.* (2010), even moderate doses of alcohol (e.g. 0.4-0.45 g/kg), which do not lead to global cognitive impairment, selectively impair inhibitory control. Furthermore, Marczinski, Combs and Fillmore (2007), using a 0.65 g/kg alcohol dose, found adverse effects to be more pronounced in heavier/binge drinkers. Thus, it may be the case that executive performance is significantly impaired under both acute abstinence as well as alcohol.

The compromising effects of alcohol withdrawal on physical well-being and, possibly, cognitive faculties, means that investigation of abstinence effects in physically dependent drinkers is difficult. Equally, the ethics of administering a dose of alcohol to long-term abstainers are problematic, given the possibility of inducing relapse. Such research is more straightforward in non-dependent PDs: although they may experience mild withdrawal symptoms during short-term abstinence

(Grüsser, Mörsen & Flor, 2006), these are not dangerous, nor do they have such a detrimental impact on their psychological state as to make them unable to complete an experimental testing procedure. To date, however, few such studies have been performed in this group or in non-physically-dependent users of other substances.

The effects of acute abstinence versus acute satiation on incentive motivation and executive function have been investigated in smokers. Thus, a series of studies by Powell *et al.* are consistent with abstaining smokers having impaired MCL DAergic function, normalised by nicotine consumption (cf. Al-Adawi & Powell, 1997; Powell *et al.*, 2002; Powell, Tait & Lessiter, 2002; Dawkins, Acaster & Powell, 2007; Dawkins & Powell, 2011). In one of the most comprehensive studies, Dawkins *et al*. (2006, 2007b) examined the acute effects of nicotine, given to 145 acutely abstinent smokers, on a battery of measures indexing incentive motivation and executive function. Participants were required to abstain from smoking for twelve hours before being tested on an assessment battery on two occasions: once after having received an experimental dose of nicotine, and once after receiving placebo. Incentive motivation was tapped by the SHPS, the Card-Arranging Reward Responsivity Objective Test (CARROT), the modified Stroop task, a cue-reactivity task, and the 'Incentive Motivational Enhancement of Response Speed' (IMERS) task, which tests the effect of reward on performance speed. Executive function was measured by an antisaccade task, a Continuous Performance Task (CPT), a delayed response spatial working memory task, and a verbal fluency test.

Compared to performance during abstinence (that is, in the placebo condition), nicotine was associated with: higher self-reported pleasure expectations on the SHPS; enhanced responsiveness to financial reward in the CARROT; and greater interference from appetitive words in the modified Stroop task. Furthermore, it was associated with improved inhibitory control as indexed by the antisaccade task, and fewer impulsive responses to filler and 'catch' stimuli (motor errors) in the CPT. It did not, however, affect CPT response bias (an index of impulsive versus cautious decision-making), spatial working memory, or verbal fluency. These findings were

thus generally, though not entirely, consistent with the proposition that dependence is associated with hypofunctioning of MCL circuitry.

Since alcohol, like nicotine and other drugs of abuse, stimulates DA release within MCL circuitry, the present study was designed partly to examine whether low doses of alcohol would produce effects in PDs similar to those reported for nicotine in smokers. As discussed above, however, administration of moderate doses of alcohol (0.4-0.45 g/kg) has been shown to impair the performance of social drinkers on tests of inhibitory control such as Go/No-Go, Continuous Performance and Stop Signal tasks; Loeber and Duka (2009) suggest that this reflects alcohol-induced reduction of frontal lobe activity. The dose used in the present study was therefore selected to be unlikely to produce even subtle sedative effects.

3. Design and Hypotheses of the present study

A number of tests believed to be sensitive to activity within the MCL DA system were administered to participants in two separate but parallel experimental designs. In the first part of the study, a group of healthy social drinkers (SDs) abstained from alcohol for 12 hours before completing a test battery comprising the emotional Stroop task, a cue-reactivity test, the IGT and a modified version of the CPT. They repeated the test battery twice within this single session: once following a small dose of alcohol (0.5 units) and once after placebo. A pilot study indicated that it was impractical to separate the two sessions across different days as a high proportion of participants failed to attend the second session.

Since the MCL DA pathways of healthy SDs should be well-toned, the issue of interest was whether the 'priming' dose of alcohol would produce detectable effects on behavioural performance compared to placebo. Thus, it could be that SDs' systems are functionally at ceiling, such that a priming dose cannot enhance performance; this must be an empirical question, with the potential for different facets of performance to be differentially sensitive.

It has been argued here that priming is most likely in heavier drinkers and particularly in those who have became psychologically dependent. Thus, in the

second part of the study a group of non-physically-dependent problem drinkers (PDs) was tested using the same procedure as for the SDs. PDs with signs of physical dependence were excluded as the 12-hour abstinence period would be associated with overt withdrawal symptoms likely themselves to interfere with test performance. PDs' performance on these tasks, expected to be compromised during acute abstinence, was compared against those of the SDs. Thus, in this part of the study, the SDs acted as a healthy control group. However, difficulty in recruiting and testing suitable PDs meant that the sample was small (n = 11), and analyses were therefore limited in power. This aspect of the study is therefore exploratory and interpretation of findings is necessarily speculative.

The following hypotheses were tested:

In Social Drinkers:

1) The priming dose will:

    a) Increase sensitivity to motivationally significant words, as indexed by colour-naming times and number of errors in the emotional Stroop

    b) Increase cue-elicited craving

    c) Increase risky decision-making on the IGT

    d) Increase impulsive responding on the CPT

2) Heavier social drinkers will show more pronounced priming effects than lighter drinkers, as indicated by the magnitude of alcohol – placebo 'difference' scores on all the above measures

Problem versus Social Drinkers:

3) *Anhedonia:* Acutely abstinent PDs will demonstrate greater anhedonia than SDs

4) *Impulsivity in daily life:* PDs will demonstrate greater impulsiveness than SDs, as evidenced by TIS and SIS subscale scores

5) *Incentive motivation:*

a) Acutely abstinent PDs will show attenuated interference from motivationally salient cues compared i) to SDs and ii) to their own sensitivity to such cues following a small dose of alcohol

b) With levels of baseline craving controlled, PDs will show a proportionally greater increase than SDs in subjective cue-reactivity following a priming dose of alcohol

6) *Decision-making and inhibitory control:* PDs will perform better on the IGT and CPT following a priming dose of alcohol than during acute abstinence, and the magnitude of this improvement will be greater than any shown by SDs

7) *Associations between behavioural measures of incentive motivation and impulsiveness and self-reported Recent and Trait Impulsiveness:* Within the combined sample, performance on the behavioural indices will correlate more highly with RIS scores than with TIS scores

Methods

Participants: Potentially suitable SDs were initially identified via the King's College London (KCL) Mindsearch database of hundreds of individuals (with or without psychiatric diagnoses) who had previously participated in research at KCL and had expressed an interest in future participation. Potential PDs were identified by members of the Drug and Alcohol Misuse Team (DAMT) at Lantern Hall in Croydon. They had been referred to the service in order to cut down or quit alcohol consumption; they were tested prior to their attempt to cut down / quit. As a group, the SDs were matched as far as possible to the PDs in terms of mean age, gender ratio and mean number of years spent in full-time education. SDs were paid £20 for their participation on completion. PDs received a £5 voucher for a well-known supermarket. Both SDs and PDs received reimbursement for travel expenses.

Inclusion/exclusion criteria: In order to minimise the potential for use of other substances (e.g. nicotine, caffeine) to affect the MCL DA system, participants were required not to smoke cigarettes or drink tea, coffee and/or caffeinated soft drinks on the day of the study. In order to maximise absorption of the alcohol dose,

participants were also asked not to eat a meal of high fat content the night or morning before the study. Compliance with these criteria was established via verbal confirmation from all participants.

To be categorised as an SD, men had to report drinking an average of at least 1 and no more than 26 standard units of alcohol per week, and women between 1 and 16 units per week, over the previous twelve months (based upon Cox *et al.*, 1999). SD candidates were asked to complete the Modified Alcohol Use Questionnaire (AUQ; Mehrabian & Russell, 1978) in order to determine their suitability for the study. PDs were excluded if they had a current diagnosis of physical dependence on alcohol or any other addictive drug, as reported by the DAMT.

Problems recruiting PDs: The researcher attended DAMT weekly review meetings for eighteen months to recruit suitable PDs as they presented to the service but before they commenced treatment.

The vast majority of referrals to the DAMT were unsuitable due to their being either physically dependent on alcohol and/or their abuse of other psychoactive drugs. Over the course of the eighteen-month recruitment period, approximately 778 new clients were considered by the team. Of these, 731 (94%) were excluded from the study due to either alcohol-dependence alone and/or other drug abuse (primarily marijuana and/or cocaine). Of the remaining 47, 9 were ineligible due to concerns regarding their mental state (e.g. personality disorder, acute paranoid schizophrenic episode). This left 38 eligible clients, 14 of which the researcher was unable to make contact with. Of the remaining 24, 9 did not wish to participate in the study; 4 agreed to participate but either did not attend for testing (and could not be re-contacted in order to arrange an alternative testing session) or quit the testing procedure prior to its completion. Thus, 11 eligible clients successfully participated in the study.

It is notable that successive and significant cuts were made to the funding of the DAMT's service over the period of participant recruitment (c. April 2009 to November 2010 inclusive). Reflecting this, the largest proportion of participants was recruited in the initial months. Because of the team's decreasing capacity to treat

PDs, they were increasingly referred to other local non-NHS alcohol services. Unfortunately, these were unwilling to be involved in the study.

Drinks administered to participants

The alcohol drink: The alcohol drink contained 0.5 units of alcohol, comprising 12.5 millilitres (ml) of Smirnoff Vodka[8], 37.5 ml of Schweppes Tonic Water[9] and 8 drops of Tabasco Sauce[10].

In people weighing between 140 and 240 pounds (as did all the present participants), 0.5 units of alcohol produces a peak Blood Alcohol Concentration (BAC) of around 8 mg/100 ml in men and 12 mg/100 ml in women (Barbour, 2001). This low dose was used for several inter-related reasons. Firstly, the study was designed to test the hypothesis that a dose of alcohol too low to sedate or intoxicate may nevertheless be sufficient to stimulate (or 'prime') the MCL DA system. In SDs, mild intoxication has been reported at doses of 20 mg/100 ml (Dougherty *et al.*, 2008), but not at the lower level used here. Secondly, such a low dose should not be subjectively detectable; this therefore reduces the risk of expectancy effects. And thirdly, this dose would be metabolised within around half an hour and would therefore not compromise performance in the placebo condition, when this was administered second.

The placebo drink: The placebo drink consisted of 50 ml of Schweppes Tonic Water and 8 drops of Tabasco Sauce.

Manipulation check: At the end of the study, participants were asked, 'Do you have any idea which drink contained alcohol?' If they answered 'Yes', participants were asked: i) to indicate which drink they thought contained alcohol; and ii) how confident they were, by marking a vertical line along a 100-mm VAS anchored by the statements, 'Not at all' and 'Totally'.

[8] The Pierre Smirnoff Co., London, UK

[9] Schweppes Ltd., Uxbridge, UK

[10] McIlhenny Co., Avery Island, CA

Of the 31 participants who responded in full, twenty-seven believed that they could identify which drink contained alcohol; four did not. Only 12 of the 27 (44.44%) were correct in identifying the alcohol drink – that is, accuracy was at chance-level. Those who were correct rated their confidence at 51% on average. There were no differences between problem drinkers and social drinkers in terms of accuracy [χ^2 (1) = 0.14; ns]. Thus, the drinks appear to have been adequately disguised.

ASSESSMENTS

[A] Alcohol-related information: The following instruments were fully described in Chapter 3 (pp. 120-121).

- ***Modified Alcohol Use Questionnaire*** *(AUQ; Mehrabian & Russell, 1978; Appendix 9):* The index used here was the number of units of alcohol consumed in a typical week during the previous 12 months.

- ***Family Tree Questionnaire*** *(FTQ; Mann et al., 1985):* The index used here was whether or not the respondent indicated that they had a first-degree relative with an alcohol use disorder.

[B] Impulsivity measures

- ***Recent and Trait Impulsivity Scales*** *(RIS & TIS; Appendices 12 and 13):* These parallel impulsivity measures are fully described in Chapter 2. In both cases, analyses were conducted on the Cognitive Impulsivity and Motor Impulsivity subscale scores separately.

[C] Mood state

- ***Hospital Anxiety and Depression Scale*** *(HADS; Zigmond & Snaith, 1983; Appendix 17):* The HADS has been used in clinical and general population settings, and correlates well with interview-based measures and other screening questionnaires that identify psychiatric distress (Green & Benzeval, 2011). The HADS has two subscales – one for anxiety, and one for depression, and each has seven items scored on a four-point scale from 0 to 3, so that there is a maximum score of 21 on each subscale. Total scores of more than 8 or more on each subscale

have been shown to have sensitivity and sensitivity of around eighty percent for identifying clinical cases. This validation was principally within clinical settings; however, a community survey showed similar values (Bjelland *et al.*, 2002). The present study administered both the HADS Anxiety and HADS Depression subscales.

[D] Measures of incentive salience/reward motivation

- ***Snaith-Hamilton Pleasure Scale*** *(SHPS; Snaith et al., 1995; Appendix 18):* The SHPS is a well-validated, 14-item self-report scale measuring hedonic tone. The respondent is asked to consider a series of statements concerning hypothetical scenarios generally thought to be pleasurable, and to indicate the extent to which they believe they would enjoy each. Each statement begins with, 'I would enjoy...' (e.g. 'I would enjoy being with my family or close friends') and following Franken *et al.* (2007), the response options are 'Strongly disagree' (4), 'Disagree' (3), 'Agree' (2) and 'Strongly agree' (1). Items are summed to give an overall score ranging from 14 to 56, higher scores indicating greater levels of anhedonia. The SHPS has good test-retest reliability amongst healthy participants over a three-week interval (intra-class correlation coefficient between test and re-test: $r = .70$, $p < .00$; Franken *et al*., 2007).

- ***Modified Stroop test of attentional bias*** *(Appendix 19):* This measures the extent to which attention is 'captured' by various types of motivationally salient stimuli (Powell *et al.*, 2002). Participants must colour-name the ink (red, green, yellow or blue) in which each of eighty-eight words (eight repetitions of eleven different words from the same semantic category) is printed. A card version was used in the present study, with the eighty-eight words presented in four columns. Participants were required to colour-name them sequentially (vertically downwards) and correct themselves if they made an error. Four classes of semantic stimuli (neutral, appetitive, aversive and alcohol-related; e.g. pub, liqueur, wine), matched for word frequency and length, were presented on separate cards in counterbalanced order. As per convention, colour-naming time and number of errors served as dependent variables.

The interference index for each of the latter three word-types is computed by subtracting their colour-naming times / number of errors from the colour-naming times / number of errors in the neutral condition.

- ***Cue-Reactivity (CR):*** Participants rated their desire to drink alcohol: (1) at baseline; (2) after two minutes' exposure to a neutral cue (taking the top off of a bottle of water and sniffing it); and (3) after two minutes' exposure to a bottle of alcohol of their preferred brand (taking the top off of the bottle and sniffing it).

Participants were asked simply, 'How strong is your desire to have a drink right now?', and responded by placing a mark on a 10-centremetre-long Visual Analog Scale (VAS) anchored by the statements 'Not at all' and 'The most I've ever felt'. The score was derived by measuring the distance (in mm) from the 'Not at all' end of the VAS to the point marked by the participant; therefore, higher scores indicated greater desire.

[E] Measures of inhibitory control/decision-making

- ***Computerised Continuous Performance Test*** *(CPT):* Various versions of the CPT have been used to investigate attentional control and response inhibition in a variety of patient groups; the version used here was adapted from Dougherty *et al*. (1999). Five-digit numbers were presented on a computer monitor at a constant rate of two per second for a period of five minutes. Participants were instructed to press the left button of a computer mouse whenever a five-digit sequence was identical to the preceding one ('target' stimuli) but not to respond to other sequences, which comprised 'novel' stimuli (no digits in common with the preceding stimulus) and 'catch' stimuli (in which four of the five digits matched those of the previous stimulus). Each presentation of a target, catch or novel stimulus was separated from the next by three consecutive presentations of the 'filler' sequence '12345', to which participants were likewise instructed *not* to respond. Two fixed sequences were used, with the order counterbalanced across conditions.

'Correct detections' are responses to a target; 'commission errors' (CEs) are responses to catch stimuli; 'random errors' are responses to novel stimuli; and 'motor errors' (MEs) are pre-emptive responses to at least one of the sequence of three filler stimuli. Commission errors are believed to result from an inability to withhold a response until the stimulus has been completely processed and have been reported to be elevated in impulsive populations (Dougherty *et al*., 2000). They have also been associated with impulsivity-related psychopathology (Marsh *et al*., 2002), and they tend to increase following alcohol consumption (Dougherty *et al*., 1999, 2000). Furthermore, high rates of CEs are often observed in normal but impulsive individuals (Swann *et al.*, 2001; Mathias *et al.*, 2002; Dougherty *et al.*, 2003a, 2003b, 2005) and they have been found to correlate significantly with self-report measures of impulsivity (Marsh *et al.*, 2002; Thompson *et al.*, 2006). The present study therefore utilised CE rate as the primary index of impulsivity from the CPT. Given that Dawkins *et al.* (2007b) reported that in smokers, a fewer number of MEs were observed following acute nicotine administration compared to acute abstinence, MEs were included here as a secondary index of impulsivity in the CPT.

- ***Computerised Iowa Gambling Task*** *(IGT; Bechara et al., 1994):* The IGT is a widely-administered instrument which mimics real-life affective decision-making and measures the participant's propensity toward risk-taking. Kasar *et al.* (2010) found individuals with alcohol use disorders to perform worse on this task than otherwise healthy controls.

The task involves 100 card selections from four separate decks (A, B, C and D), presented via a computer monitor. Each selection results in either winning or losing money. Decks A and B usually yield moderate immediate wins (e.g. $110, $130) but occasional heavy losses (e.g. $1250, $1500) and lead to a net loss over repeated selections. They are therefore termed 'high-risk' decks. Decks C and D typically generate smaller wins (e.g. $40, $55) but also occasional smaller penalties (e.g. $50); over time they result in an overall net profit, and they are therefore termed 'low-risk' or 'advantageous' decks. Since participants completed this task twice, two versions were administered. One included the A, B, C and D decks described above,

whilst in the other the 'advantageous' decks were labelled K and N and the 'high-risk' decks L and M.

Net score is calculated by subtracting the number of choices from the risky decks (A and B; L and M) from the number of choices from the safe decks (C and D; K and N). Greater net scores therefore indicate lower risk-taking / good decision-making. For the purposes of data analysis, the task was divided into five blocks, each one consisting of twenty consecutive card choices, in order to quantify the change in decision-making across the course of the task (Bechara *et al.*, 1994).

PROCEDURE

SDs completed the procedure in a testing room at Goldsmiths College whilst PDs completed the study in one of the assessment rooms at Lantern Hall in Croydon. Clinical participants necessarily lived locally to Lantern Hall; presenting for the research study at this location was therefore more convenient. The majority of SDs lived within South-East London and so for them, presenting for the study at Goldsmiths College was more convenient. The experimental procedure itself was identical for the two groups.

Participants were required to have abstained from alcohol for 24 hours and cigarettes, tea, coffee or any highly-caffeinated soft drinks for 3 hours. On arrival for testing, participants provided a breath alcohol sample on a Lion Alcolmeter (Lion Laboratories Ltd., Barry, UK). All participants had a breath alcohol level (BAL) of zero.

Participants were administered the first drink (alcohol or placebo) and instructed to consume it as quickly as possible. Immediately following this, they completed the RIS, BIS-11 and SHPS. Participants were permitted ten minutes and no more in which to complete these questionnaires; if they had not completed them during this time, they did so at the end of the session. If they completed them prior to 10 minutes having elapsed, they had a short break until the ten minutes was reached. Ten minutes was identified as the appropriate interval from consumption of the alcohol to the start of the behavioural tests i) to allow time for alcohol to reach the

bloodstream and ii) because BAC peaks at around 30 minutes (Julien, 2005).[11] Participants then completed the behavioural measures for the first time.

For those participants who had been administered the alcohol drink first, breath alcohol levels (BALs) were taken immediately prior to administration of the second (placebo) drink. This was to ensure that BALs had returned to zero and that there were thus no carry-over effects into the placebo condition. There was then a further interval of 10 minutes during which participants were administered the HADS and TIS. As before, if these were not completed within 10 minutes, they were completed at the end of the session. Likewise if they were completed in under ten minutes, the participant took a short break until the 10 minutes had elapsed. Following this, the behavioural tests were administered for the second time.

Order of drink conditions was counterbalanced within both groups (PDs and SDs). Following the second condition, participants completed any incomplete measures from earlier parts of the procedure. Finally, participants who had been given the alcohol drink second gave another BAL reading to ensure that the alcohol had been metabolised before they left the experimental situation. The participant, but not the experimenter, was blind to the experimental condition. Table 4.1 provides a schematic overview of the order of task administration.

[11] A pilot study had earlier indicated that a single completion of the test battery took about twenty-five to thirty minutes. On average, it takes an adult 1 hour to metabolise one unit of ethanol (Julien, 2005). Thus, consumption of 0.5 units should mean that participants would have some ethanol in their system throughout the duration of one test battery completion. With at least a half-hour interval between the two conditions, given in counterbalanced order, those receiving placebo second would be alcohol-free throughout testing in that condition.

Table 4.1: Schematic overview of design and order of assessments in Study Parts 1 and 2

Start of session	Participant arrives Informed consent Expired breath alcohol measured
Condition I	First drink administered (alcohol or placebo)
	First set of questionnaires administered (duration: 10 mins): • RIS • BIS-11 • SHPS
	First administration of behavioural tests (duration: 25-30 mins): • IGT • Emotional Stroop • CPT • Cue-reactivity procedure
Condition II	Second drink administered (alcohol or placebo)
	Second set of questionnaires administered (duration: 10 mins): • HADS • TIS
	Expired breath alcohol measured*
	Second administration of behavioural tests (duration: 25-30 mins): • IGT • Emotional Stroop • CPT • Cue-reactivity procedure
End of session	Any uncompleted questionnaires from Conditions I and II Expired breath alcohol measured Participant leaves

*If participant had been administered the alcohol drink first.

Data analysis

All statistical analyses were carried out using SPSS version 16.

There were two stages to the analyses. **Stage 1** focused on the SDs only; data were analysed using analysis of variance (ANOVA) with the within-subjects repeated measure of **DRINK TYPE** (placebo vs. alcohol). **Stage 2** compared PDs with SDs: in a mixed-measures ANOVA, **DRINK TYPE** (placebo vs. alcohol) was again the repeated-measures factor, with **DRINKING GROUP** (SDs vs. PDs) an additional between-subjects factor.

Not all PDs completed every test, and for some indices analyses were based on as few as seven participants. Given the exploratory nature of this aspect of the study, conservative corrections for multiple testing have not been applied; however any positive findings have been interpreted cautiously.

Results

1] Does alcohol priming affect test performance in SDs?

Data screening: Prior to analysis, variables were screened for accuracy of data entry, missing values and fit between their distributions and the assumptions of multivariate analysis. There was no evidence of any clear non-linearity or curvilinearity for any variable.

Participant characteristics:

One or two participants had missing data on one or two variables, as shown in Table 4.2.

Table 4.2: Sociodemographic, personality, mood and alcohol-related characteristics of social drinkers

Variable		Social Drinkers (*N* = 23)
Age (years)	Mean (SD) Range	47.13 (9.41) 29.00 – 63.00
Gender (female/male)	F : M	11:12
Years of full-time education	Mean (SD)	12.70 (2.30)
Typical weekly alcohol intake (units per week during previous 12 months)	Mean (SD) Range	8.87 (6.51) 1.00 – 24.45
Family history of alcohol use disorders (presence/absence)	Y : N	7:16
Anxiety (HADS-Anx)[a]	Mean (SD)	5.09 (2.49)
Depression (HADS-Dep)[a]	Mean (SD)	2.82 (2.46)
Anhedonia (SHPS)	Mean (SD)	22.39 (6.46)
Recent Cognitive Impulsivity (RIS-CI)	Mean (SD)	3.57 (1.85)
Recent Motor Impulsivity (RIS-MI)	Mean (SD)	4.26 (2.22)
Trait Cognitive Impulsiveness (TIS-CI)	Mean (SD)	3.87 (1.91)
Trait Motor Impulsiveness (TIS-MI)	Mean (SD)	4.48 (1.83)

[a] *N* = 22.

Hypothesis-testing: Each hypothesis is recapitulated below, followed by the corresponding analysis/analyses.

[A] The effects of alcohol administration upon sensitivity to non-alcohol-related and alcohol-related motivational cues/stimuli

Hypothesis 1 a): The priming dose of alcohol will increase sensitivity to motivationally significant words, as indexed by i) colour-naming times and ii) number of errors in the emotional Stroop

To simplify analyses, new 'interference effect' variables were computed for each motivationally significant word-type (appetitive, aversive and alcohol-related) by subtracting from their colour-naming times / number of errors the colour-naming times / number of errors for neutral words. The derived variables are labelled 'App^{INT}', Av^{INT}' and 'Alc^{INT}'.

In all ANOVAs, there was the repeated-measures factor of DRINK (placebo versus alcohol). In the 'interference' ANOVAs, there was the additional repeated-measures factor of WORD-TYPE (App^{INT} vs. Av^{INT} vs. Alc^{INT}).

i) Colour-naming times

An initial ANOVA tested whether alcohol affected baseline colour-naming time for neutral words. Table 4.3 shows colour-naming times to all four types of words, and the interference effects, for both drink conditions.

Table 4.3: Stroop colour-naming times (s) and 'interference' scores in neutral, appetitive, aversive and alcohol-related word conditions in social drinkers after placebo and alcohol

Drink administered	Variable	Social Drinkers (*N* = 21) Mean (SD)
Placebo	*Neutral*	66.57 (13.29)
	Appetitive	67.29 (12.15)
	Aversive	66.86 (11.55)
	Alcohol-related	69.71 (11.68)
	App^{INT}	0.71 (7.52)
	Av^{INT}	0.29 (6.74)
	Alc^{INT}	3.14 (8.71)
Alcohol	*Neutral*	67.76 (12.03)
	Appetitive	69.24 (12.94)
	Aversive	68.00 (12.00)
	Alcohol-related	70.52 (13.20)
	App^{INT}	1.48 (5.12)
	Av^{INT}	0.24 (8.75)
	Alc^{INT}	2.76 (6.66)

Neutral condition: One participant was identified as a univariate outlier and excluded from analysis, leaving 21 participants. The main effect of DRINK was non-significant [F (1, 20) = 0.32; ns].

Interference scores: One participant did not provide complete data, and another was excluded owing to their being a univariate outlier, leaving 21 participants for analysis. The main effect of DRINK was non-significant [F (1, 20) = 0.00; ns], as was

the main effect of WORD-TYPE [*F* (2, 40) = 1.63; ns]. And the DRINK by WORD-TYPE interaction [*F* (2, 40) = 0.19; ns].

ii) Number of errors

An initial ANOVA tested whether alcohol affected baseline errors to neutral words. Table 4.4 shows number of errors in all four types of words, and the interference effects, for both drink conditions.

Table 4.4: Stroop errors and 'interference' scores in neutral, appetitive, aversive and alcohol-related word conditions in social drinkers after placebo and alcohol

Drink administered	Variable	Social Drinkers Mean (SD)
Placebo	*Neutral*[a]	1.14 (1.67)
	Appetitive[a]	1.27 (2.03)
	Aversive[a]	1.55 (1.90)
	Alcohol-related[a]	1.27 (1.42)
	App^{INT}[b]	-0.19 (1.44)
	Av^{INT}[b]	0.29 (1.49)
	Alc^{INT}[b]	0.00 (1.87)
Alcohol	*Neutral*[a]	1.77 (1.95)
	Appetitive[a]	1.41 (1.50)
	Aversive[a]	2.50 (2.63)
	Alcohol-related[a]	1.45 (1.68)
	App^{INT}[b]	-0.38 (1.53)
	Av^{INT}[b]	0.71 (2.67)
	Alc^{INT}[b]	-0.29 (1.98)

[a]*N* = 22; [b]*N* = 21.

Neutral condition: The main effect of DRINK was non-significant [*F* (1, 21) = 1.60; ns].

Interference Scores: One participant did not provide complete data and another, being a univariate outlier, was excluded from analysis, leaving 21 participants. The main effect of DRINK was non-significant [*F* (1, 20) = 0.00; ns] as was the DRINK by WORD-TYPE interaction [*F* (2, 40) = 1.18; ns]. The main effect of WORD-TYPE was significant [*F* (2, 40) = 3.78; *p* = 0.03]; however, as this was not in itself of theoretical interest, it was not explored further.

Overall, therefore, the hypothesis was not supported.

Hypothesis 1 b): The priming dose of alcohol will increase cue-elicited craving

Data were missing for one participant.

Table 4.5: Subjective desire for alcohol following presentation of a) participants' preferred alcoholic drink and b) a bottle of water in SDs after placebo and alcohol

Drink administered	Drink presented	Social Drinkers (*N* = 22) Mean (SD)
Placebo	*Water*	13.77 (20.06)
	Alcohol	22.75 (25.35)
Alcohol	*Water*	12.86 (23.07)
	Alcohol	26.86 (24.98)
Grand mean (collapsed across drink administered)	*Water*	13.32 (20.85)
	Alcohol	24.81 (24.42)

No participants were identified as univariate outliers. The main effect of DRINK was non-significant [F (1, 21) = 1.23; ns]. As can be seen in Table 4.5 and Figure 4.1, the main effect of CUE-TYPE was significant [F (1, 21) = 26.11; p = 0.00; η_p^2 = 0.55].

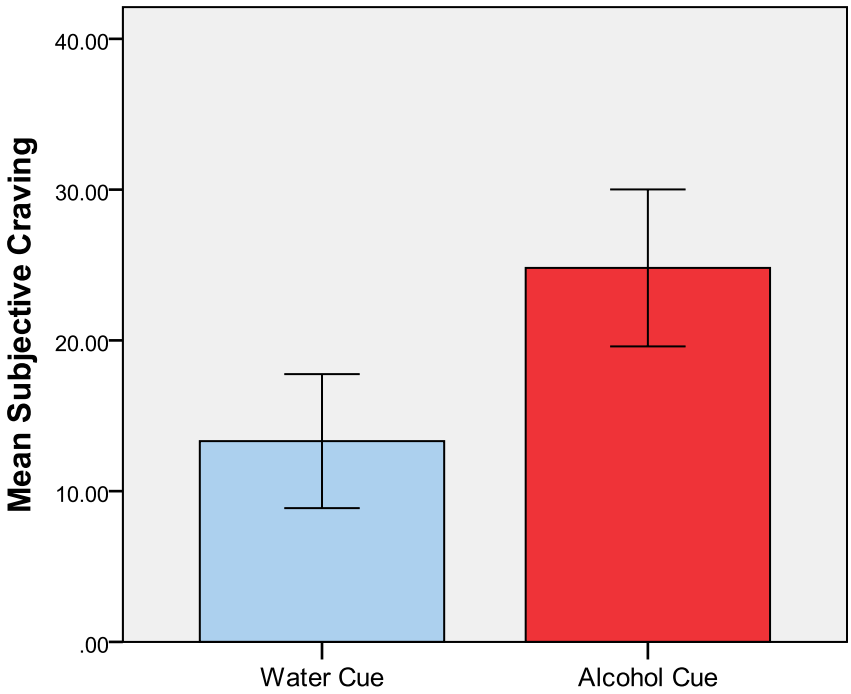

Figure 4.1: Mean (+/- 1 SE) subjective craving in SDs following presentation of neutral and alcohol cues

The data were thus not consistent with the hypothesis.

[B] The effects of alcohol administration upon measures of decision-making and inhibitory control

<u>Hypothesis 1 c):</u> A priming dose of alcohol will increase risky decision-making on the IGT

Participants' scores in each block of the IGT were analysed via a repeated-measures ANOVA, with the within-subjects factors of DRINK (placebo versus alcohol) and IGT BLOCK (1 vs. 2 vs. 3 vs. 4 vs. 5). For these analyses, there were 23 SDs. Table 4.6 shows IGT performance in each block, in SDs after placebo and alcohol.

Table 4.6: IGT score in each block, and net score, in SDs after placebo and alcohol drink administration

Drink administered	IGT Block	Social Drinkers (*N* = 23) Mean (SD)
Placebo	*1*	-4.52 (5.73)
	2	1.65 (8.46)
	3	2.52 (9.67)
	4	2.17 (8.16)
	5	1.74 (7.87)
	Total	3.57 (29.85)
Alcohol	*1*	-1.48 (4.94)
	2	0.17 (8.86)
	3	2.00 (9.93)
	4	2.43 (8.70)
	5	0.61 (10.40)
	Total	3.74 (28.85)

There were no univariate outliers. There was no main effect of DRINK on net score [F (1, 22) < 0.001; ns], meaning that the hypothesis was not supported. As expected, there was a main effect of IGT BLOCK [F (4, 88) = 5.34; p < 0.01], reflecting improved performance across successive blocks.

<u>Hypothesis 1 d):</u> A priming dose of alcohol will increase impulsive responding on the CPT

One participant failed to complete the CPT under both drink conditions, leaving an *N* of 22.

Table 4.7: Number of correct detections, commission errors and motor errors in SDs after placebo and alcohol

Drink administered	Variable	Social Drinkers (*N* = 22) Mean (SD)
Placebo	*Correct detections (/ 25)*	19.91 (4.16)
	Commission errors (/ 25)	5.23 (4.51)
	Motor errors (/ 25)	1.68 (1.84)
Alcohol	*Correct detections (/ 25)*	20.09 (3.70)
	Commission errors (/ 25)	5.23 (4.00)
	Motor errors (/ 25)	1.45 (1.71)

Participants' Commission Errors and Motor Errors were analysed via separate repeated-measures ANOVAs. In neither were there any univariate outliers.

<u>Commission Errors:</u> The main effect of DRINK was non-significant [*F* (1, 21) = 0.00; ns].

<u>Motor Errors:</u> The main effect of DRINK was non-significant [*F* (1, 21) = 0.50; ns].

Again, these findings are not consistent with the hypothesis.

[C] Associations between habitual level of alcohol intake and measures of non-alcohol-related and alcohol-related reward responsiveness and measures of inhibitory control and decision-making

<u>Hypothesis 2:</u> Heavier drinkers will show more pronounced priming effects than lighter drinkers, as indicated by the magnitude of alcohol – placebo 'difference' scores on all the above measures

New 'difference' variables were created for all the preceding indices by subtracting participants' performances under the placebo condition from their performances during the alcohol condition. Spearman correlations (1-tailed) were then performed

with mean number of units of alcohol consumed per week during the previous twelve months.

Table 4.8: Spearman correlations (*p* value; 1-tailed) between habitual alcohol intake and difference scores for behavioural measures of non-alcohol-related and alcohol-related reward sensitivity and decision-making and inhibitory control in SDs

Variable	Correlation with mean alcohol consumption (units per week) during previous 12 months
Stroop Interference Scores[a]	
Colour-naming times:	
• *Appetitive words:*	0.01 (ns)
• *Aversive words:*	0.12 (ns)
• *Alcohol-related words:*	0.01 (ns)
Numbers of errors:	
• *Appetitive words:*	0.03 (ns)
• *Aversive words:*	-0.21 (ns)
• *Alcohol-related words:*	0.21 (ns)
Cue-elicited craving[a]	-0.15 (ns)
IGT net score[b]	-0.05 (ns)
CPT commission errors[a]	0.22 (ns)
CPT motor errors[a]	-0.16 (ns)

[a]*N* = 22; [b]*N* = 23.

Thus, Hypothesis 2 was not supported.

2] Are the effects of alcohol priming more pronounced in PDs than SDs?

Data screening: Prior to analysis, variables were screened for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis. There was no evidence of any clear non-linearity or curvilinearity for any variable.

Participant characteristics:

One or two participants had missing data on one or two variables, as shown in Table 4.9.

Table 4.9: Sociodemographic, personality, mood and alcohol-related characteristics of social versus problem drinkers

Variable		Social Drinkers (*n* = 23)	Problem Drinkers (*n* = 11)	Social vs. Problem Drinkers		
				t/χ^2 value	*p* value	*d*
Age (years)	Mean (SD)	47.13 (9.41)	47.36 (12.56)	-0.06	ns	-
Gender (female/male)	F : M	11:12	5:6	-0.02	ns	-
Years of full-time education	Mean (SD)	12.70 (2.30)	12.00 (2.28)	0.83	ns	-
*Typical weekly alcohol intake (units per week during previous 12 months)**	Mean (SD)	8.87 (6.51)	81.02 (30.57)	-7.74	< 0.01	4.15
	Range	1.00 – 24.45	42.00 – 133.96			
Family history of alcohol use disorders (presence/absence)[a]	Y : N	7:16	8:2	-6.91	0.01	
Anxiety (HADS-Anx)[b]	Mean (SD)	5.09 (2.49)	9.36 (4.92)	-3.34	0.00	1.30
Depression (HADS-Dep)[b]*	Mean (SD)	2.82 (2.46)	6.27 (5.08)	-2.13	0.05	1.01
Anhedonia (SHPS)	Mean (SD)	22.39 (6.46)	25.55 (6.90)	-1.30	ns	-
Recent Cognitive Impulsivity (RIS-CI)	Mean (SD)	3.57 (1.85)	4.82 (2.48)	-1.65	0.11	0.62
Recent Motor Impulsivity (RIS-MI)	Mean (SD)	4.26 (2.22)	5.55 (1.63)	-1.71	0.10	0.65
Trait Cognitive Impulsiveness (TIS-CI)	Mean (SD)	3.87 (1.91)	5.36 (2.46)	-1.94	0.06	0.54
Trait Motor Impulsiveness (TIS-MI)	Mean (SD)	4.48 (1.83)	5.64 (2.11)	-1.64	0.11	0.62

P values are two-tailed;

*Levene's test for equality of error variance significant at $p < 0.05$; equal variances therefore not assumed;

[a] = *n* (PDs) = 10; *n* (SDs) = 23;

[b] = *n* (PDs) = 11; *n* (SDs) = 22.

One problem drinker did not give his age; the remaining 10 were aged between 25 and 62 years. The twenty-three social drinkers were aged between 29 and 60 years. As evident from the table, the two groups did not differ in mean age, gender ratio, or mean years of full-time education. Reflecting the differences in alcohol

consumption explicit in categorisation as a problem or social drinker, there was a highly significant difference between the groups for self-reported weekly alcohol intake.

PDs self-reported greater symptoms of anxiety and depression than SDs; there were no differences between the groups in terms of anhedonia, however.

Fifteen individuals reported having a first-degree relative with a 'possible' or 'definite' history of alcohol problems ('Family History Positive' or FHP) and 18 reported having no such relatives ('Family History Negative' or FHN). One PD failed to provide any information. PDs were more likely to be FHP than SDs, consistent with being familialy more predisposed towards alcohol use disorders.

In order to explore whether this difference in family history might explain any observed differences between the groups on experimental indices, relevant ANOVAs were re-run covarying FAMHIST (yes vs. no). Since one PD did not provide family history information, this meant that in the latter analyses, there were 10 PDs versus 23 SDs. Detailed results from these analyses are reported only if FAMHIST altered the original main effect of group, or of any interactions involving group.

Hypothesis-testing: Each hypothesis is recapitulated below, followed by the corresponding analysis/analyses.

[A] Anhedonia

***Hypothesis 3:* Acutely abstinent PDs will demonstrate greater anhedonia than SDs**

An independent-measures *t*-test was performed to compare problem and social drinkers' SHPS scores. As shown in Table 4.9 (p. 190), the groups did not differ and the hypothesis was therefore not supported.

[B] Impulsiveness in daily life

<u>Hypothesis 4:</u> PDs will demonstrate greater impulsiveness than SDs, as manifested in TIS and RIS subscale scores

Independent-measures *t*-tests compared problem and social drinkers' TIS and RIS subscale scores. As shown in Table 4.9, there were trends for PDs to score more highly than SDs on all of the SIS and TIS subscales.

[C] The effects of alcohol administration upon sensitivity to non-alcohol-related and alcohol-related motivational cues/stimuli

<u>Hypothesis 5 a):</u> Acutely abstinent PDs will show attenuated interference from motivationally salient cues compared i) to SDs and ii) to their own sensitivity to such cues following a dose of alcohol

Analysis of the Stroop task focused on the 'interference effect' variables ('App^{INT}', Av^{INT}' and 'Alc^{INT}') for colour-naming times and number of errors, as described on p. 177.

<u>i) Colour-naming times</u>

An initial ANOVA compared the two groups on their colour-naming times for the neutral words only, in the placebo and alcohol conditions.

Table 4.10: Emotional Stroop: Colour-naming times and interference effects in social and problem drinkers after placebo and alcohol

Drink administered	Variable	Social Drinkers	Problem Drinkers
Placebo	*Neutral*[a]	66.57 (13.29)	69.00 (15.27)
	Appetitive[a]	67.29 (12.15)	68.00 (12.04)
	Aversive[a]	66.86 (11.55)	74.33 (14.97)
	Alcohol-related[a]	69.71 (11.68)	71.44 (16.73)
	App^{INT}[b]	0.71 (7.52)	-1.30 (7.63)
	Av^{INT}[b]	0.29 (6.74)	5.10 (9.60)
	Alc^{INT}[b]	3.14 (8.71)	1.10 (10.89)
Alcohol	*Neutral*[a]	67.76 (12.03)	64.56 (11.09)
	Appetitive[a]	69.24 (12.94)	67.11 (12.32)
	Aversive[a]	68.00 (12.00)	64.56 (9.04)
	Alcohol-related[a]	70.52 (13.20)	68.00 (8.09)
	App^{INT}[b]	1.48 (5.12)	2.20 (6.00)
	Av^{INT}[b]	0.24 (8.75)	0.50 (6.85)
	Alc^{INT}[b]	2.76 (6.66)	2.70 (5.56)

[a] = *n* (SDs) = 21; *n* (PDs) = 9;

[b] = *n* (SDs) = 21; *n* (PDs) = 10.

Neutral condition: Two univariate outliers (1 PD; 1 SD) were excluded from the ANOVA, leaving 21 SDs and 9 PDs. There was no main effect of either GROUP [F (1, 29) = 0.25; ns] or DRINK [F (1, 29) = 0.58; ns], nor a GROUP x DRINK interaction [F (1, 29) = 1.89; ns].

Interference scores: One univariate outlier (an SD) was excluded from the ANOVA, leaving 21 SDs and 10 PDs. Table 4.11 overleaf shows the results.

Table 4.11: Emotional stroop colour-naming times: Main and interaction effects

Main effects	***F***	***df***	***p***	η_p^2
GROUP	0.04	1, 29	ns	-
DRINK	0.01	1, 29	ns	-
WORD-TYPE	0.91	2, 58	ns	-
Interaction effects				
GROUP x DRINK	0.00	1, 29	ns	-
GROUP x WORD-TYPE	1.29	2, 58	ns	-
DRINK x WORD-TYPE	2.91	2, 58	0.06	0.09
GROUP x DRINK x WORD-TYPE	2.80	2, 58	0.11	0.07

As can be seen, no main effects or interaction effects reached significance, though there was a weak trend towards a three-way GROUP x DRINK x WORD-TYPE interaction and a strong trend towards a DRINK x WORD-TYPE interaction. These are illustrated graphically in Figure 4.2.

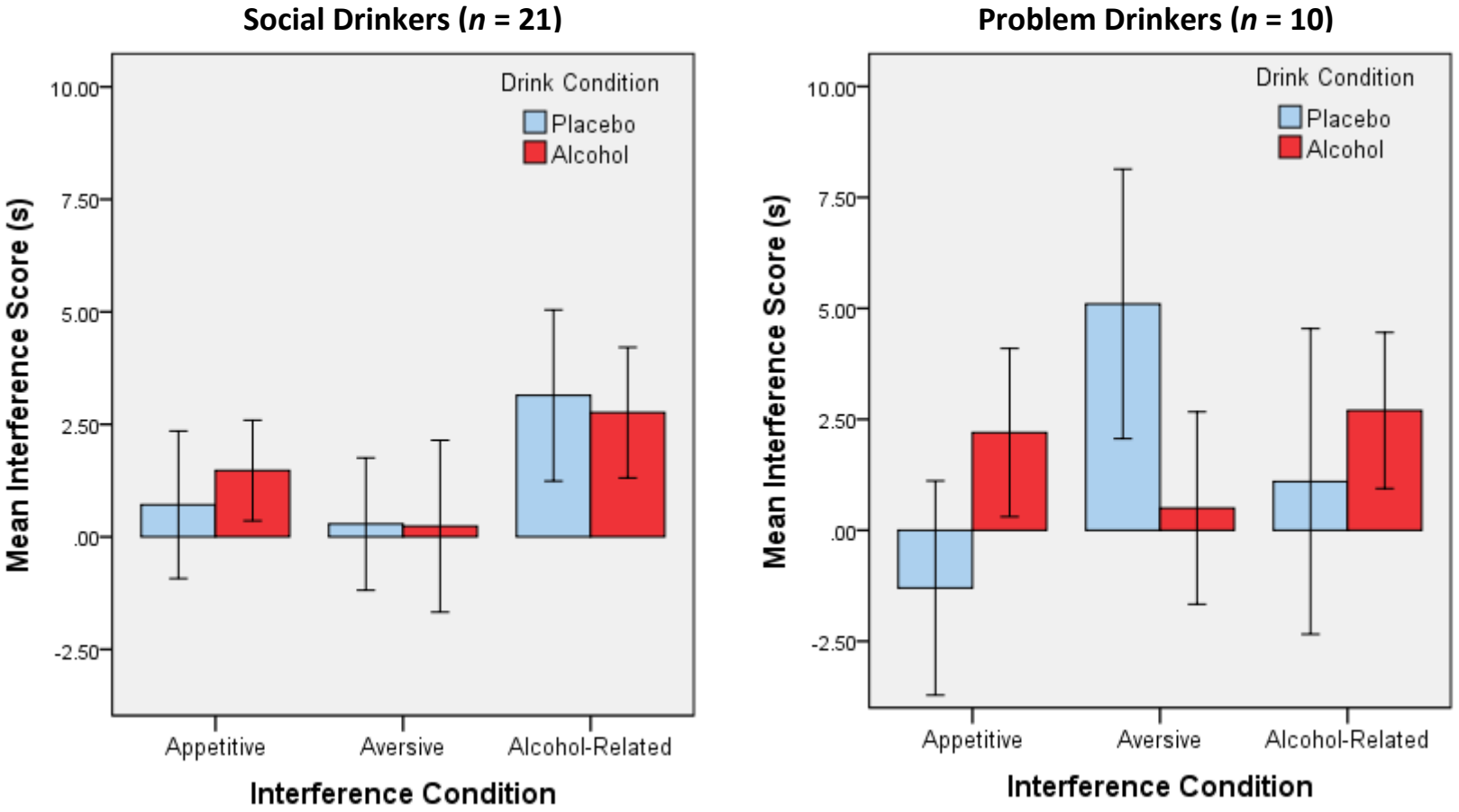

Figure 4.2: Interference effects for colour-naming times in the motivational word conditions of the Stroop task, under placebo and alcohol, for SDs (*n* = 21; left panel) and PDs (*n* = 10; right panel)

There was thus a tendency for the PDs to show a more erratic pattern, showing greater interference from appetitive and alcohol-related words following a priming dose of alcohol than after placebo, but the reverse effect for aversive words. Differences between the conditions were much less pronounced in the SDs.

This apparent difference between the responses of the two groups was explored further by running separate ANOVAs for each group. In the SDs, the DRINK x WORD-TYPE interaction was non-significant [F (2, 40) = 0.19; ns]. In the PDs, however, the DRINK x WORD-TYPE interaction demonstrated a suggestion of a trend towards significance [F (2, 18) = 2.62; p = 0.10; η_p^2 = 0.23].

Exploratory paired-samples t-tests were used to explore the source of the trend in PDs. After placebo drink administration, colour-naming time for aversive words was greater than for appetitive words [t (9) = -2.92; p = 0.02; d = 0.92]; there was also a trend for the greater colour-naming time of aversive words compared to alcohol-related words [t (9) = 1.98; p = 0.08; d = 0.63]. However, there were no differences following administration of alcohol.

Holding word-type constant, there were no differences between the placebo and alcohol administration conditions within any of the Stroop interference variables.

ii) Numbers of errors

One univariate outlier (a PD) was excluded from the ANOVA, leaving 9 PDs and 22 SDs.

An initial ANOVA compared the two groups on their numbers of errors for the neutral words only, in the placebo and alcohol conditions.

Table 4.12: Emotional Stroop: Numbers of errors and interference effects in social and problem drinkers after placebo and alcohol

Drink administered	Variable	Social Drinkers (*n* = 22)	Problem Drinkers (*n* = 9)
Placebo	*Neutral*	1.14 (1.67)	3.67 (4.12)
	Appetitive	1.27 (2.03)	1.78 (1.92)
	Aversive	1.55 (1.90)	4.56 (4.50)
	Alcohol-related	1.27 (1.42)	3.11 (4.57)
	App^{INT}	0.14 (2.08)	-1.89 (2.42)
	Av^{INT}	0.41 (1.56)	0.89 (2.26)
	Alc^{INT}	0.14 (1.93)	-0.56 (2.07)
Alcohol	*Neutral*	1.77 (1.95)	2.78 (3.46)
	Appetitive	1.41 (1.50)	3.22 (4.60)
	Aversive	2.50 (2.63)	2.44 (3.47)
	Alcohol-related	1.45 (1.68)	2.78 (3.46)
	App^{INT}	-0.36 (1.50)	0.44 (2.79)
	Av^{INT}	0.73 (2.60)	-0.33 (1.41)
	Alc^{INT}	-0.32 (1.94)	0.00 (2.24)

Neutral condition: The main effect of GROUP demonstrated a strong trend towards significance [F (1, 29) = 3.59; p = 0.07; η_p^2 = 0.11], reflecting the greater number of errors by PDs than SDs. The main effect of DRINK was non-significant [F (1, 29) = 0.11; ns], as was the GROUP x DRINK interaction [F (1, 29) = 1.10; ns].

Interference scores:

Table 4.13: Main and interaction effects for 2 (GROUP: SDs vs. PDs) x 2 (DRINK: placebo vs. alcohol) x 3 (WORD-TYPE: App^{INT} vs. Av^{INT} vs. Alc^{INT}) mixed-measures ANOVA upon emotional Stroop numbers of errors

Main effects	***F***	***df***	***p***	η_p^2
GROUP	0.64	1, 29	ns	-
DRINK	0.15	1, 29	ns	-
WORD-TYPE	3.70	2, 58	0.03	0.11
Interaction effects				
GROUP x DRINK	0.74	1, 29	ns	-
GROUP x WORD-TYPE	0.24	2, 58	ns	-
DRINK x WORD-TYPE	2.79	2, 58	0.07	0.09
GROUP x DRINK x WORD-TYPE†	7.03	2, 58	0.00	0.20

† η_p^2 = 0.20.

As shown in the table and Figure 4.3, the GROUP x DRINK x WORD-TYPE interaction was significant [F (2, 58) = 7.03; p = 0.00; η_p^2 = 0.20], and the DRINK x WORD-TYPE interaction demonstrated a strong trend towards significance [F (2, 58) = 2.79; p = 0.07; η_p^2 = 0.09]. There was a main effect of WORD-TYPE [F (2, 58) = 3.70; p = 0.03]; however, as this was not of particular theoretical interest, it was not explored further. No other main effects and interaction effects were significant.

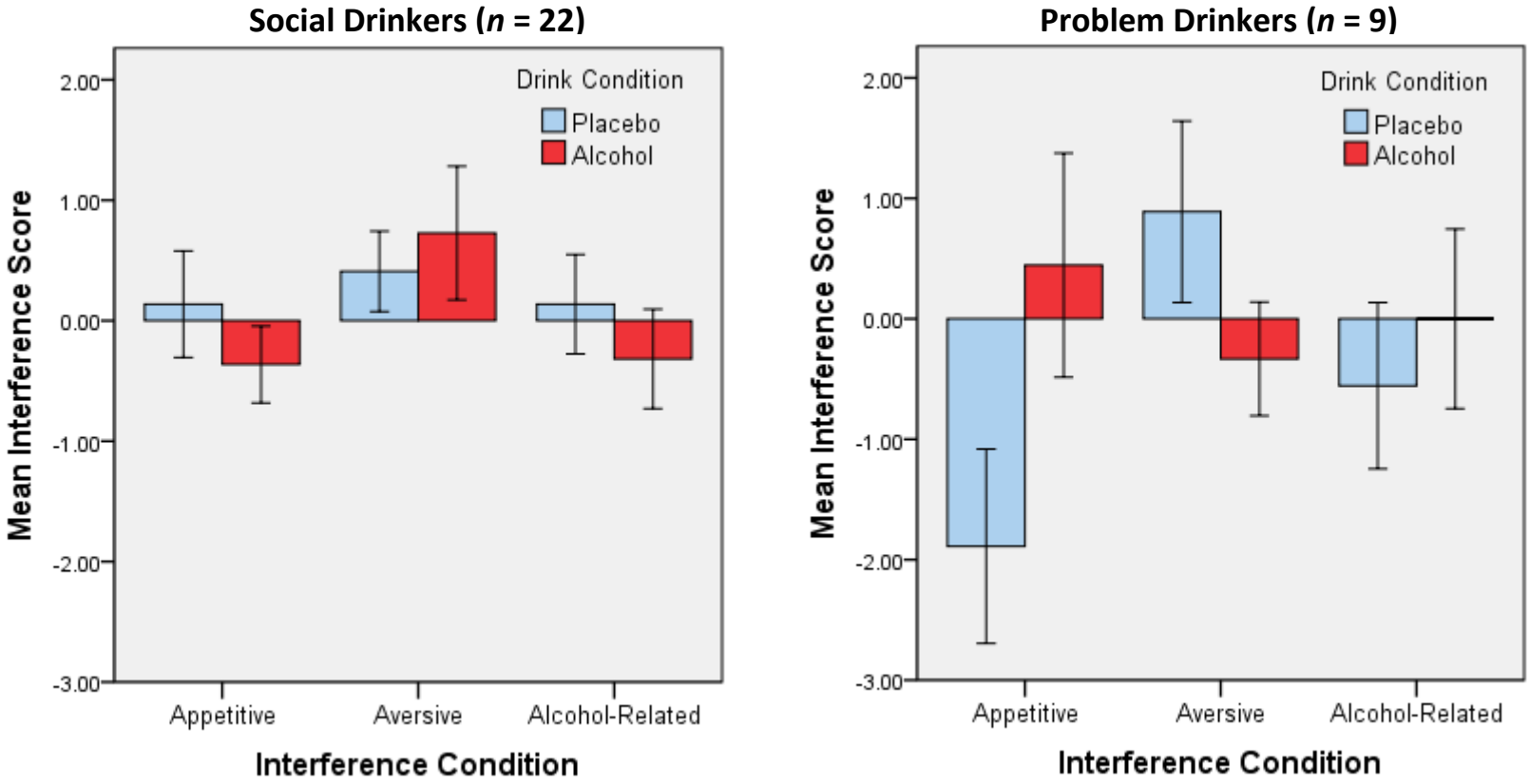

Figure 4.3: Interference effects for numbers of errors in the motivational word conditions of the Stroop task, under placebo and alcohol, for SDs (*n* = 22; left panel) and PDs (*n* = 9; right panel)

It appears that alcohol tended to increase interference by appetitive-related words in the PDs, but to reduce it in the SDs. The PDs show the reverse pattern for aversive words. This apparent difference between the responses of the two groups was explored further by running separate ANOVAs within each group. In the SDs, the DRINK x WORD-TYPE interaction was non-significant [F (2, 42) = 1.67; ns]. In the PDs, however, the DRINK x WORD-TYPE interaction demonstrated a very strong trend towards significance [F (2, 16) = 3.30; p = 0.06; η_p^2 = 0.29].

Paired-samples t-tests were used to further explore the source of this near-significance in PDs. After placebo drink administration, more errors occurred during aversive words than appetitive words [t (8) = -2.58; p = 0.03; d = 0.86] and alcohol-related words [t (8) = 2.87; p = 0.02; d = 0.95]. However, there were no differences following administration of alcohol.

Holding word-type constant, there were no differences between the placebo and alcohol administration conditions within any of the Stroop interference variables. These findings mirror those observed with respect to colour-naming times.

Family history of AUDs: When a mixed-measures ANOVA was repeated with FAMILY HISTORY as an additional independent-measures factor, the GROUP x DRINK by WORD-TYPE interaction remained significant [F (2, 54) = 4.63; p = 0.01; η_p^2 = 0.15].

Thus, overall, even though Hypothesis 5 a) was not supported, there was some evidence for dysfunctional processing of motivationally salient cues in PDs.

<u>Hypothesis 5 b):</u> With level of baseline craving controlled, PDs will show a proportionally greater increase in subjective cue-reactivity following a priming dose of alcohol than will SDs

For these analyses, there were 11 PDs and 22 SDs. No participants were identified as univariate outliers. Table 4.14 shows scores of the two groups in the cue-reactivity test.

Table 4.14: Cue-elicited craving: means and standard deviations (s.d.s) for craving following exposure to alcohol and water, in SDs and PDs, under placebo and alcohol conditions

Drink administered	Drink presented	Social Drinkers (*n* = 22)	Problem Drinkers (*n* = 11)
Placebo	*Water*	13.77 (20.06)	13.41 (15.63)
	Alcohol	22.75 (25.35)	30.68 (28.25)
Alcohol	*Water*	12.86 (23.07)	20.09 (27.36)
	Alcohol	26.86 (24.98)	23.32 (30.47)

Table 4.15 shows the results of the ANOVA, which had the between-subjects factor of GROUP (SDs vs. PDs) and the within-subjects factors of DRINK (placebo vs. alcohol) and CUE-TYPE (water vs. alcohol).

Table 4.15: Cue-elicited craving: main and interaction effects

Main effects	***F***	***df***	***p***	η_p^2
GROUP	0.11	1, 31	ns	-
DRINK	0.20	1, 31	ns	-
CUE-TYPE	29.57	1, 31	0.00	0.49
Interaction effects				
GROUP x DRINK	0.46	1, 31	ns	-
GROUP x CUE-TYPE	0.10	1, 31	ns	-
DRINK x CUE-TYPE	1.46	1, 31	ns	-
GROUP x DRINK x CUE-TYPE†	6.54	1, 31	0.02	0.17

† $\eta_p^2 = 0.17$.

A main effect of CUE-TYPE reflected greater subjective craving following presentation of the alcohol cue than the neutral cue [F (1, 31) = 29.57; $p < 0.01$; $\eta_p^2 = 0.49$] (see Figure 4.4).

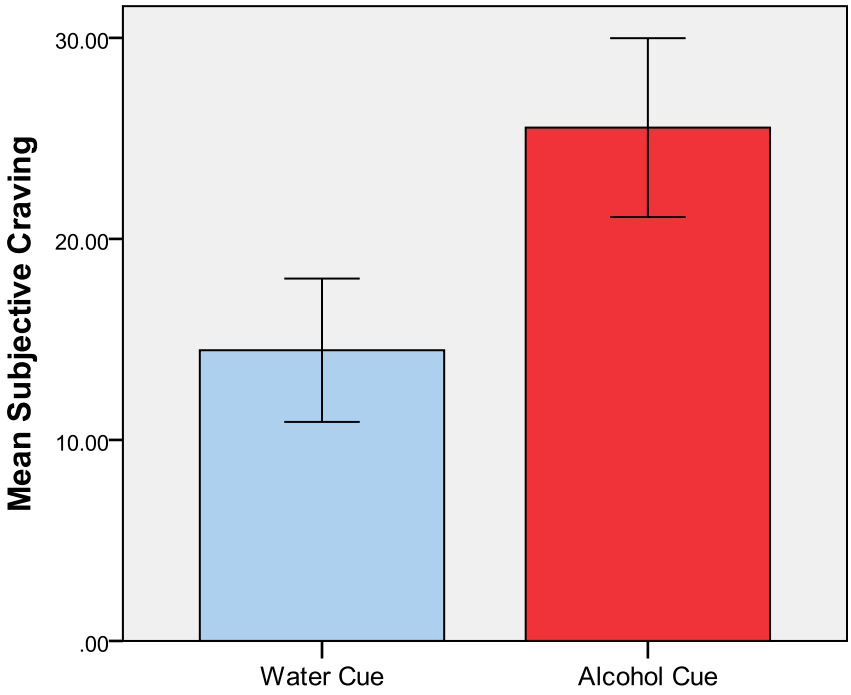

Figure 4.4: Mean (+/- 1 SE) subjective craving in response to water and alcohol stimuli

This was qualified by a 3-way (GROUP x DRINK x CUE-TYPE) interaction [F (1, 31) = 6.54; p = 0.02; η_p^2 = 0.17], illustrated in Figure 4.5, in which PDs show stronger craving in the placebo condition than after alcohol priming whilst SDs showed the converse pattern.

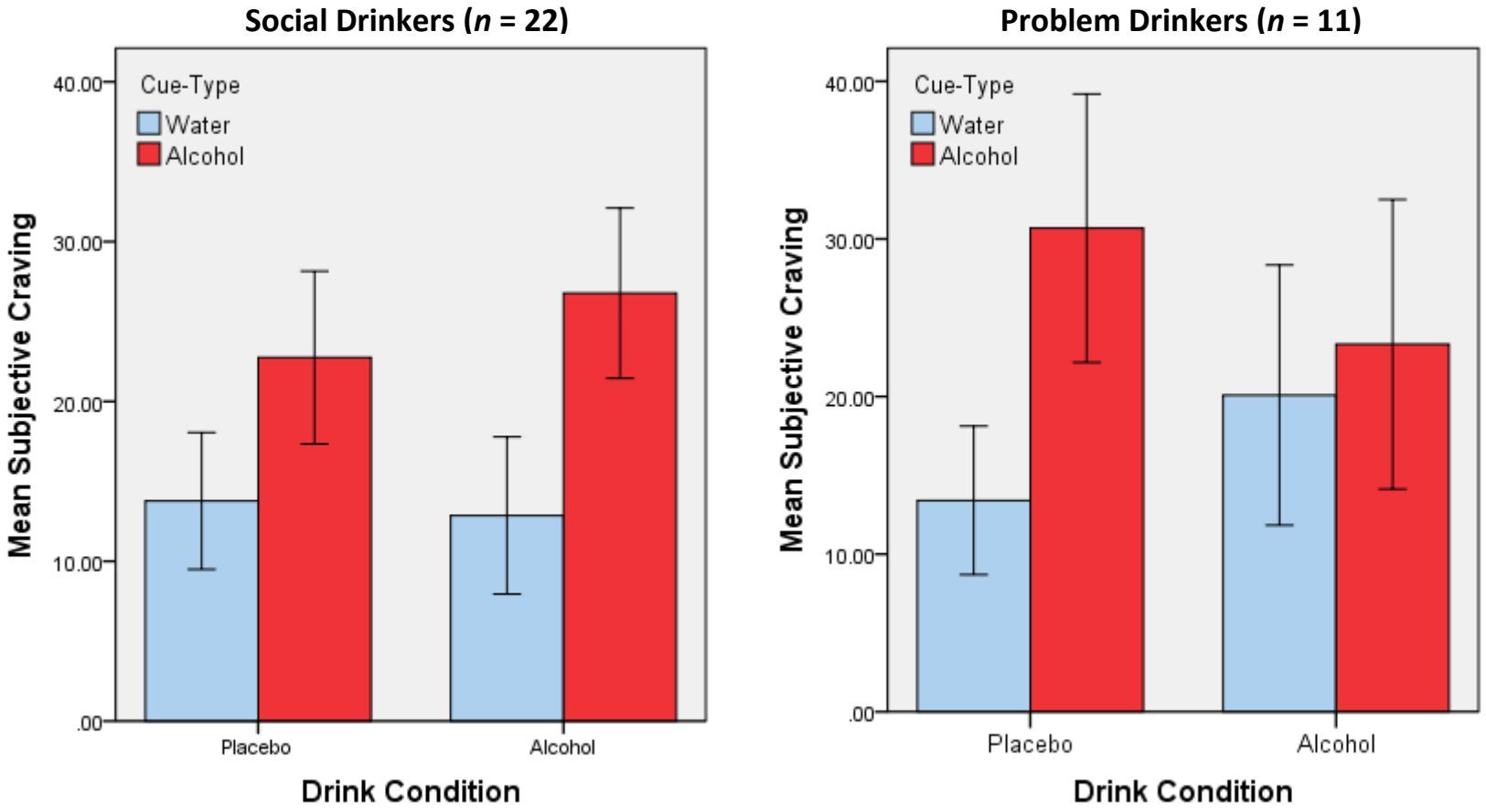

Figure 4.5: Mean (+/- 1 SE) subjective craving in response to water and alcohol stimuli, under placebo and alcohol, in SDs (*n* = 22; left panel) and PDs (*n* = 11; right panel)

In order to explore the source of the significant GROUP x DRINK x CUE-TYPE interaction, DRINK x CUE-TYPE ANOVAs were performed in PDs and SDs separately. These 2-way interactions were significant in PDs [F (1, 10) = 6.89; p = 0.03; η_p^2 = 0.41] but not SDs [F (1, 21) = 1.23; ns].

Repeated-measures t-tests explored the source of the significant interaction in PDs. In the placebo drink condition, subjective craving was greater after the alcohol cue than the neutral cue [t (10) = -3.01; p = 0.01; d = 0.91]; in the alcohol drink condition, there was no difference in subjective craving as a function of cue-type [t (10) = -1.45; ns].

Family history of AUDs: When a mixed-measures ANOVA was repeated with FAMILY HISTORY as an additional independent-measures factor, the GROUP by DRINK by CUE-TYPE interaction remained significant [F (1, 29) = 8.50; p = 0.01; η_p^2 = 0.23].

The data did thus not on balance support Hypothesis 5 b).

[D] The effects of alcohol administration upon measures of decision-making and inhibitory control

<u>Hypothesis 6:</u> PDs will perform better on the IGT and CPT following a priming dose of alcohol than during acute abstinence, and the magnitude of this improvement will be greater than any shown by SDs

<u>a) IGT</u>

Over a third of the PDs (n = 4) failed to provide complete IGT data due to their experiencing significant problems with the task. This left only 7 PDs, so these analyses are highly tentative. The PD and SD groups remained matched for age [t (28) = -1.54; ns], gender ratio [χ^2 (1) = 0.05; ns] and number of years of full-time education [t (28) = 0.02; ns].

Table 4.16 shows mean scores.

Table 4.16: Means and s.d.s for IGT score by block, and net score, in SDs and PDs, after placebo and alcohol drink administration

Drink administered	IGT Block	Social Drinkers (*n* = 23)	Problem Drinkers (*n* = 7)
Placebo	*1*	-4.52 (5.73)	1.14 (5.64)
	2	1.65 (8.46)	-1.14 (1.57)
	3	2.52 (9.67)	3.14 (7.47)
	4	2.17 (8.16)	6.00 (6.53)
	5	1.74 (7.87)	3.71 (8.36)
	Total	3.57 (29.85)	12.86 (12.85)
Alcohol	*1*	-1.48 (4.94)	0.29 (2.14)
	2	0.17 (8.86)	-0.86 (5.01)
	3	2.00 (9.93)	1.71 (8.44)
	4	2.43 (8.70)	3.71 (7.43)
	5	0.61 (10.40)	-3.14 (9.51)
	Total	3.74 (28.85)	1.71 (25.73)

Table 4.17 shows the results of the ANOVA, which had the between-subjects factor of GROUP (SDs vs. PDs) and the within-subjects factors of DRINK (placebo vs. alcohol) and IGT BLOCK (1 vs. 2 vs. 3 vs. 4 vs. 5).

Table 4.17: IGT performance: main and interaction effects

Main effects	***F***	***df***	***p***
GROUP	0.14	1, 28	ns
DRINK	0.63	1, 28	ns
IGT BLOCK	3.63	4, 112	0.01
Interaction effects			
GROUP x DRINK	0.67	1, 28	ns
GROUP x IGT BLOCK	1.42	4, 112	ns
DRINK x IGT BLOCK[a]	0.80	3.27, 91.55	ns
GROUP x DRINK x IGT BLOCK	0.49	4, 112	ns

[a]Greenhouse-Geisser statistic used due to violation of sphericity.

A main effect of IGT BLOCK reflected, as would be expected, improved performance as the task progressed [F (4, 112) = 3.63; p = 0.01; η_p^2 = 0.12]. As can be seen from the table, no other main or interaction effects were significant.

Hypothesis 6 a) was therefore not supported.

b) CPT

The 4 PDs who failed to complete the IGT likewise had difficulty with, and failed to complete, the CPT. These analyses are therefore again very tentative.

Table 4.18: Means and s.d.s for number of correct detections, commission errors and motor errors, in SDs and PDs, under placebo and alcohol

Drink administered	Variable	Social Drinkers (*n* = 22)	Problem Drinkers (*n* = 7)
Placebo	*Correct detections*	19.91 (4.16)	17.57 (3.91)
	Commission errors	5.23 (4.51)	6.71 (4.50)
	Motor errors	1.68 (1.84)	3.86 (4.74)
Alcohol	*Correct detections*	20.09 (3.70)	18.57 (4.35)
	Commission errors	5.23 (4.00)	5.71 (2.98)
	Motor errors	1.45 (1.71)	3.29 (2.69)

Commission Errors and Motor Errors were analysed in separate 2 x 2 mixed-measures ANOVAs.

Commission Errors: There were no univariate outliers. There was no main effect of DRINK [F (1, 27) = 1.02; ns] or GROUP [F (1, 27) = 0.32; ns], nor any GROUP by DRINK interaction [F (1, 27) = 1.02; ns].

Motor Errors: One PD was identified as a univariate outlier, but was retained in the analysis due to the low PD sample size. There was no main effect of DRINK [F (1, 27) = 0.54; ns], nor a GROUP x DRINK interaction [F (1, 27) = 0.10; ns], though the main effect of GROUP was significant [F (1, 27) = 5.10; p = 0.03; η_p^2 = 0.16]. This reflected more motor errors by PDs.

Hypothesis 6 b) was therefore not supported.

[E] Associations of behavioural measures of incentive motivation and impulsiveness with Trait and Recent Impulsiveness

<u>Hypothesis 7:</u> Within the combined sample, performance on the behavioural indices will correlate more highly with RIS scores than with TIS scores

The RIS and TIS were correlated, using Spearman correlations, with the placebo performance indices from the emotional Stroop, cue-reactivity, Iowa Gambling and Continuous Performance Tasks in the combined sample (*N*s = between 29 and 33).

Dunn and Clark's (1969) Z_1^* statistic was then used for each behavioural index, to test whether the magnitude of their correlations with the RIS and TIS subscale scores differed. Table 4.19 shows all correlations, with uncorrected *p* values, and then the comparison between RIS and TIS correlations.

Table 4.19: Spearman correlations for TIS and RIS subscale scores with experimental indices in the placebo condition, in the combined sample of SDs and PDs; and comparisons of the magnitude of RIS and TIS correlations with each index

Variable	Cognitive Impulsiveness			Motor Impulsiveness		
	TIS (*r*)	**RIS** (*r*)	**TIS vs. RIS** (*p*)	**TIS** (*r*)	**RIS** (*r*)	**TIS vs. RIS** (*p*)
Stroop Interference[a]						
Colour-naming times:						
• *Appetitive words:*	-0.06	-0.14	ns	-0.28†	-0.18	ns
• *Aversive words:*	0.33*	0.20	ns	0.23†	0.10	ns
• *Alcohol-related words:*	0.08	-0.08	ns	-0.36*	-0.45**	ns
Numbers of errors:						
• *Appetitive words:*	-0.20	-0.28†	ns	-0.22	-0.27†	ns
• *Aversive words:*	0.38*	0.34*	ns	0.33*	0.12	ns
• *Alcohol-related words:*	-0.02	-0.08	ns	-0.14	-0.18	ns
Cue-elicited craving[b]	0.01	-0.03	ns	0.10	0.19	ns
IGT net score[c]	-0.39*	-0.27†	ns	0.00	-0.14	ns
CPT commission errors[d]	0.41*	0.29†	ns	0.25†	0.27†	ns
CPT motor errors[d]	-0.13	-0.12	ns	0.30†	0.21	ns

[a] = *N* = 32; [b] = *N* = 33; [c] = *N* = 30; [d] = 29;

** p ≤ 0.01 level; *p ≤ 0.05; † trend - p ≤ 0.10. All tests one-tailed.

Although there are some correlations between the questionnaire indices of impulsivity and the behavioural indices, there is no clear or consistent tendency for these to be greater for the RIS than the TIS. This hypothesis is therefore not supported.

It is of some interest, however, that more cognitively impulsive individuals were more prone to making maladaptive reward-oriented responses on the IGT, and to making more commission errors on the CPT. They were also rather more error-prone in colour-naming aversive words on the Stroop task.

Discussion

The discussion first considers results from the SDs only, and then the analyses comparing PDs and SDs. Particular foci include: the extent to which the reward sensitivity data are congruent with Robinson and Berridge's (1993; 2000) models of incentive salience; the findings pertaining to inhibitory control, decision-making and impulsiveness contextualised in relation to addiction theories which emphasise impairments in frontal regions (e.g. Jentsch & Taylor, 1999); and the implications of the TIS and RIS data.

1) Social Drinkers

The present sample of moderate social drinkers, none of whom reported either regular use of other psychoactive drugs or regular binge-drinking, demonstrated no evidence of priming or disinhibition following ingestion of half a unit of alcohol. The present study adopted only a single-blind design. However, when asked to identify which drink contained alcohol, correct identification occurred only at chance-level. Furthermore, confidence levels amongst those who had correctly identified the alcohol drink were only around fifty percent. Thus, the results of the present study probably cannot be attributed to expectancy effects.

1. i) Lack of priming effects

Hypothesis 1 a), which predicted that the priming dose of alcohol would increase sensitivity to motivationally significant words, was not supported. This appears to

contradict the finding of Jones and Schulze (2000) that half a unit of alcohol produced greater levels of Stroop interference for alcohol-related words. However, differences in the design of the two studies limit direct comparisons. Whereas the present study used as stimuli the generic names of well-known alcoholic drinks (e.g. 'wine', 'beer'), Jones and Schulze's (2000) stimuli had a more implicit and tangential relationship with alcohol, with connotations which could be considered either appetitive (e.g. 'peaceful', 'sexy') or aversive (e.g. 'clumsy', 'thoughtless'). Also, they did not disguise their alcoholic and placebo drinks, meaning that it is impossible to separate pharmacological effects from those pertaining to expectancy; interestingly, expectancy can itself elicit increases in DA (Heinz *et al.*, 2009) though effects on word-processing could be purely cognitive in origin.

At any rate, the effect of an alcohol dose on attentional bias remains unclear. There could be important dose-related relationships, with no effects at small doses (as here), greater ones at moderate doses and possibly a reduction at large doses. Thus, Duka and Townshend (2004) and Schoenmakers *et al.* (2008) both reported a priming effect of a 0.3 g/kg dose (higher than the present dose of approximately 0.06 g/kg), whilst Duka and Townshend (2004) additionally found that a 0.6 g/kg dose did *not* elevate attentional bias relative to placebo. This led Fernie *et al.* (2012) to speculate that attentional bias peaks at moderate but declines at higher doses. It is unclear why this might be, or even whether this is a genuine pattern at present (given the relatively small number of studies); further research is needed.

Correlational analyses produced no indication of an association between social drinkers' habitual alcohol intake and attentional bias in the Stroop task. This finding is in contrast to the studies of Weafer and Fillmore (2013) and Fernie *et al.* (2012), both of which reported effects of alcohol doses on attentional bias to be moderated by social drinking status – though the two studies reported somewhat conflicting findings. To recapitulate, whilst Weafer and Fillmore (2013) reported a dose-dependent increase in attentional bias after 0.45 g/kg and 0.65 g/kg doses of alcohol in heavy social drinkers but not moderate drinkers, Fernie *et al.* (2012) found that, compared to placebo, a 0.4 g/kg alcohol dose increased attentional bias in moderate but not heavy social drinkers. Similar to the present findings, Adams *et*

al. (2012) found no effect of social drinking status on attentional bias in the visual probe task or the modified Stroop following 0.13 g/kg and 0.40 g/kg alcohol doses. Conflicting findings aside, some important methodological differences limit comparison between the present study and those previous. Firstly, the positive findings reported by Weafer and Fillmore (2013) and Fernie *et al.* (2012) were observed for the visual probe task, as opposed to the emotional Stroop used here. This is important as the effects of alcohol on attentional bias seem to vary as a function of the task used; Adams *et al.* (2012) found an effect of alcohol in the visual probe task but not the modified Stroop. Secondly, the previous three studies all divided their participants into heavy and moderate/lighter social drinking groups, whereas the present study used a single group of moderate social drinkers. It may be that the necessarily lower and narrower range of alcohol consumption exhibited by the present sample, and crucially, the presumably lower levels of incentive salience this group would have attributed to alcohol-related stimuli, reduced the chances for effects of alcohol on attentional bias.

Thirdly, and perhaps most importantly, the present study administered a comparatively smaller dose than Weafer and Fillmore (2013), Fernie *et al.* (2012) and Adams *et al.* (2012). Although a limitation of the present study was its failure to take BACs at pre- and post-test following consumption of the alcohol dose, peak BAC following the half unit administered here would nevertheless have been expected to have been around 8 mg/100 ml in men and 12 mg/100 ml in women (Barbour, 2001). By comparison, the larger doses of alcohol administered in recent studies comparing heavier / hazardous drinkers to lighter, moderate drinking groups on attentional bias following alcohol produced peak BACs substantially higher than those expected here. For example, the doses of 0.45 g/kg and 0.65 g/kg administered by Weafer & Fillmore (2012) – typical of the doses given in such research – produced average peak BACs of 60 mg/100 ml and 80 mg/100 ml, respectively. Though Fernie *et al.* (2012) did not report BACs, participants were administered a 0.40 g/kg dose; thus, peak BACs should have been similar to those of Weafer & Fillmore's (2012) 0.45 g/kg dose. Adams *et al.* (2012) administered doses of 0.13 g/kg and 0.40 g/kg; the former would have produced peak BACs of around

15 mg/100 ml in men and 24 mg/100 ml in women. Adams *et al.* (2012) found no effect of either dose on modified Stroop performance; in a visual probe task, however, attentional bias increased in both light and heavy drinking participants under the 0.40 g/kg dose. Taken together with the present findings, it appears that small doses of alcohol (i.e. those producing peak BACs equal to and less than 15 mg/100 ml in men and 24 mg/100 ml in women) do not influence attentional bias (as measured via modified Stroop or visual probe task) in social drinking groups. On balance, therefore, Jones & Schulze's (2000) finding of attentional bias (only to alcohol-related words with positive connotations) in social drinkers following half a unit appears spurious. The effects of doses which produce BACs of around 60 mg/100 ml and above on attentional bias in heavier and more moderate social drinkers appear conflicting and further research is needed.

The second hypothesis (1 b), which predicted that the priming dose would increase SDs' cue-elicited craving, was also unsupported. Interestingly, Schulze and Jones (2000) reported that doses 'up to' a maximum of 1 unit (in a bogus taste test) significantly increased SDs' craving, relative to placebo. Although some participants (27%) did not finish the drink, it is likely that on average the alcohol dose consumed was larger than that used here. Again, the interpretation of their findings is seriously compromised by the fact that they did not disguise the alcohol and placebo drinks. A final important difference between that study and this one is that Schulze and Jones measured subjective craving via the Desires for Alcohol Questionnaire (DAQ; Love *et al.*, 1998), whereas the present study used a VAS. Whilst it is possible that the DAQ has greater sensitivity to changes in subjective CR, it did not detect effects of 1 unit of alcohol in an earlier study by Schulze and Jones (1999).

As noted in the Introduction of this chapter, previous studies have suggested that subjective CR may increase with increasing alcohol doses (e.g. Chutuape *et al.*, 1994; Duka *et al.*, 1999; Rose & Duka, 2006). The results of the present study may imply a starting threshold somewhere between the 0.5 units (approximately 0.06 g/kg; producing peak BACs of around 8 mg/100 ml (men) to 12 mg/100 ml (women) used here and the lowest dose of 0.3 g/kg (which should produce peak BACs of

around 37.5 mg/100 ml in men and 60 mg/100 ml in women) at which effects have been reported in social drinkers. Further research is needed to clarify this situation.

Although there was no effect of alcohol priming, subjective craving did increase following presentation of the alcohol cue, relative to presentation of the neutral cue. In the Stroop task, however, greater interference was *not* observed for alcohol-related compared to neutral words. This may well reflect the relative lack of significance that alcohol has for normal social drinkers. This is not inconsistent with the ability of explicit cues to elicit conscious associations of relaxation and enjoyment, and elevated desire to have a drink. However, Stroop interference effects from alcohol-related words have been reported in social drinkers elsewhere (e.g. Bauer & Cox, 1998; Ryan, 2002a), and further research is needed to determine whether inconsistency in findings relates to particular methodological or sample characteristics. In any event, it is evidently not a robust phenomenon in SDs.

To summarise, then, in the present sample of moderate social drinkers, doses of alcohol of half a unit did not precipitate pharmacological effects sufficient to produce increases in either implicit craving, measured via attentional bias, or explicit, subjective craving.

1. ii) Lack of disinhibiting effects of the priming dose

Hypotheses 1 c) and d), that the priming dose would increase risky decision-making on the IGT and impulsive responding on the CPT, were not supported. There was no indication whatsoever that the 'priming' dose had had any effect in either case.

A literature review revealed no previous studies of the effects of alcohol on the IGT. However, a number of previous studies have reported disinhibiting effects of alcohol in SDs as measured via the Stop Signal Task (e.g. Dougherty *et al.*, 2008), Go/No-Go task (e.g. Marczinski *et al.*, 2005) and Continuous Performance Task (e.g. Dougherty *et al.*, 2008). However, the smallest dose at which these studies tend to report inhibitory control failures is 0.40 g/kg – broadly equivalent to 3.33 units. Few published studies have investigated the potentially disinhibiting effects of smaller doses. Dougherty *et al.* (1999) have reported disinhibition on the CPT at 0.2 g/kg

(broadly equivalent to 1.7 units); however, these same authors later reported that 0.2 g/kg did *not* affect CPT performance (Dougherty *et al.*, 2008). It therefore remains unclear at what dosage inhibitory control failures begin to emerge.

Different doses appear to affect different impulsivity indices in different ways. Dougherty *et al.* (2008) examined performance on a CPT, SST and delay discounting task after placebo and doses of 0.2, 0.4, 0.6 and 0.8 g/kg alcohol across five experimental days, with task performance being assessed at 0.5 hours (h) before, and 0.25, 1.00 and 2.00 h after alcohol administration. The two larger doses, but not the lower ones, increased disinhibition in the CPT across time and at peak breath alcohol concentration (BrAC). Disinhibition increased over time regardless of the alcohol dose size in the SST and delay discounting task, with no differences among dose conditions, nor any difference from placebo, at peak BrAC. Few, if any other studies, have administered multiple doses and multiple performance measures; more are needed to illuminate potentially complex relationships between alcohol dose and different facets of impulsivity.

1. iii) Results of the present study in the context of priming theory

Field *et al.*'s (2010) model of alcohol's priming effects posits an interaction of the acutely disinhibiting effects of alcohol with underlying and enduring incentive salience attributions to alcohol and associated stimuli. Thus a reduction in inhibitory control increases the emergence of appetitive responses to alcohol-related stimuli. Whilst the present findings suggest that in this sample of SDs, frontal inhibitory control mechanisms were not adversely affected by alcohol, the fact that alcohol cue exposure elicited subjective craving suggests that they did make incentive salience attributions. It is possible that a larger dose would have magnified their cue-reactivity through disinhibiting effects, and further research varying the dose level would be interesting in this regard.

It is interesting to contrast the findings of craving and attentional bias at doses at or less than 1 unit (e.g. Schulze & Jones, 2000; Jones & Schulze, 2000) with the apparent absence of effects on inhibitory control at similar doses. It may be that measures of inhibitory control are simply less sensitive to real but subtle effects of

low doses. Alternatively, low doses may induce no disinhibition but nevertheless exert direct effects on reward centres and thus promote responding to reward-associated stimuli. A third possibility concerns expectancy effects. The negative results of the present study, contrasting with the positive findings in the non-blinded studies by Jones & Schulze, are consistent with the priming effects observed being a product of expectancy. In 'real-life' drinking situations people tend to be aware of the alcoholic content of their beverage, raising the distinct possibility that any priming they experience is to some extent cognitively driven.

In order to distinguish between these possible factors, future studies could include indices of both incentive motivation and inhibitory control, administer doses of alcohol varying between 0.5 to 3 or 4 units, and manipulate expectancies/beliefs about alcohol content (c.f. Marlatt's work using the 'balanced placebo' design; e.g. Marlatt, Demming & Reid, 1973; Rohsenow & Marlatt, 1981). Though some studies have adopted elements of this approach (e.g. Dougherty *et al.*, 2008; Guillot *et al.*, 2011), they have typically not included indices of reward responsiveness. In so doing, the progressive effects of increasing doses could be better explored and mapped. In an ideal world of substantial resources and large sample sizes, brain imaging would also be used to study the effects of these manipulations on MCL DAergic circuitry. However, such a complex study involving so many manipulations would be rather impractical as hundreds of participants would be needed in order to give sufficient power.

1. iv) Sample characteristics

The social drinkers recruited here were generally moderate in their consumption, drinking less than 10 units per week on average. Priming studies have more typically recruited heavy social drinkers who, as suggested by Field *et al.* (2010), may be sensitised to the disinhibiting effects of alcohol. This could reflect dysregulations in their MCL DA systems which render them more sensitive than the present moderate social drinkers to the effects of the small alcohol dose used here. There was no evidence of any tendency for heavier SDs to show more pronounced priming effects than lighter drinkers, even though the sample varied in their consumption

between 1 and 24 units per week. However, with a fairly modest *N* of 23, there was little statistical power to detect such a relationship.

2) Problem versus Social Drinkers

Problem drinkers (PDs) were sufficiently psychologically dependent to be seeking treatment, they normally drank throughout the day and during the testing session they (unusually for them) were 12 hours abstinent.

2. i) Reward Sensitivity: Self-reported anhedonia

Hypothesis 3, that abstaining PDs would demonstrate greater anhedonia than SDs as manifested in higher SHPS scores, was not supported. This may imply that the relevant brain circuitry was not compromised during acute abstinence, or that any disturbance was relatively mild and was not experienced subjectively. However, the lack of difference is surprising given (a) that PDs were acutely abstinent and therefore likely to be experiencing disturbed affect as well as putatively reduced dopaminergic tone, and (b) that PDs tend to be exposed to various stressful life circumstances as either cause or consequence of their heavy drinking, and in clinical studies have been found to present with low mood (Mossberg, Liljeberg & Borg, 1985; Tómasson & Vaglum, 1995). This suggests that the present sample was atypical. In comparative terms they were not anhedonic, as indicated by SHPS scores which (a) approximated to those reported in healthy adults (Franken, Rassin & Muris, 2007) and (b) were lower than those reported in other addict groups (Dawkins *et al.*, 2006) and people with depression (Franken *et al.*, 2007; Nakonezny *et al.*, 2010). By contrast, however, their anxiety and depression scores on the HADS were on average around 30% and 100% higher than published norms (Crawford *et al.,* 2001), and were also significantly higher than those of the SDs tested here. Thus the SHPS did not detect anhedonia despite the presence, as expected, of other forms of affective disturbance. However, it is important to note that anhedonia is only one aspect of depressed mood: for example, schizophrenic and traumatic brain injury (TBI) patients have both been reported to demonstrate anhedonic symptoms without meeting criteria for depressive disorder (Rao *et al.*, 2007). Anhedonia may thus be correlated with – but separable from – depression. The above

notwithstanding, the present PDs' lack of anhedonia is inconsistent with neurobiological models (e.g. Robinson & Berridge, 1993, 2000) positing dysfunctional MCL DA activity and reward sensitivity in addicted individuals during early abstinence.

One potentially relevant difference between the SHPS and the HADS as employed here was in relation to their reference time-frames, the former relating here to how respondents felt 'right now', and those of the former to 'in the last week'. Thus, it is possible that the mood of this small sample was better than usual on the day of testing – either by chance, or perhaps in response to the social context of engaging with the researcher or to anticipation of consuming alcohol during and/or after the assessment.

2. ii) Reward sensitivity: The emotional Stroop task

There was partial support for Hypothesis 5 a), that compared to SDs, PDs' sensitivity to motivationally significant words, as indexed by colour-naming times and number of errors in the modified Stroop, would be more strongly influenced by a priming dose of alcohol. As predicted, for PDs but not SDs there were trends for alcohol to heighten interference from appetitive words and decrease sensitivity to aversive words; it had no effect on responsiveness to alcohol-related words in either group. Several caveats must be borne in mind, however. Firstly, although there was a strong GROUP by DRINK by WORD-TYPE interaction for the number of Stroop errors, only a (relatively weak) trend for this interaction was observed in relation to colour-naming times. Post-hoc analyses for colour-naming times did, however, support a pattern of alcohol increasing interference from appetitive words, decreasing interference to aversive words, whilst having no effect (relative to placebo) on responsiveness to alcohol-related words. Secondly, the GROUP by DRINK by WORD-TYPE effects notwithstanding, there was no overall main effect of alcohol priming, nor did this interact with GROUP. Thus, the alcohol dose influenced PDs' relative sensitivity to the different forms of affective stimuli rather than having a general effect or one which affected responses to alcohol-related cues in particular. The third caveat concerns the small number of PDs and the fact that the

Bonferroni correction was not applied to post-hoc analyses due to their exploratory nature. It is possible therefore that the findings are spurious; although interesting, they should be considered tentative and in need of replication in an independent sample.

PDs' reduced responsivity to appetitive words during acute abstinence is congruent with models of alcohol addiction (Robinson & Berridge, 1993, 2000; Goldstein & Volkow, 2002) which posit down-regulation of reward pathways and hence attenuated responses to non-drug-related rewarding stimuli which can be transiently reversed by alcohol. That is, the under-responsivity of DAergic MCL pathways is exposed during acute abstinence; and the DAergic 'boost' of alcohol 'normalises' sensitivity to natural reinforcers. Dawkins *et al*. (2006) reported similar results with smokers.

This appears to conflict with the finding that PDs and SDs did not differ in terms of self-reported anhedonia. This discrepancy might reflect differences between self-report and behavioural forms of measurement (i.e. the former can be subject to conscious or unconscious biases whereas the latter are more objective). Thus, for instance, demand characteristics may have led the PDs to report what they considered to be a 'normal' anticipation of enjoyment rather than their actual feelings. Alternatively, these findings may reflect a progressive reduction in incentive salience which parallels increasingly dysfunctional MCL DAergic activity. Thus subtle changes which are detected by behavioural tests may not impinge on subjective experience (anhedonia) until a certain threshold is reached.

During abstinence, PDs demonstrated slightly greater attentional bias than SDs towards aversive words; however, following alcohol administration, PDs' bias disappeared whilst in SDs it increased. It is possible that PDs were experiencing mild withdrawal symptoms during abstinence and that this made them sensitive to mood-congruent aversive stimuli. Consistent with this, PDs reported greater anxiety (a symptom of withdrawal) than SDs at baseline.

PDs' interference from alcohol-related words did not differ between placebo and alcohol conditions. No previous studies have compared Stroop interference in those

with an AUD under abstinence and after alcohol ingestion. In smokers, however, Munafò *et al.* (2003), Rusted *et al.* (2000) and Dawkins *et al.* (2006) have all similarly reported no effects of nicotine ingestion. However, Johnsen *et al.* (1997) did report increased interference from smoking cues following nicotine administration compared to acute abstinence. Then again, other studies using similar paradigms have reported greater attentional bias towards smoking-associated stimuli during abstinence (e.g. Gross, Jarvik & Rosenblatt, 1993; Waters *et al.*, 2003). These mixed findings may reflect the complexity of substance-associated Stroop tasks in addicted groups. During acute abstinence, the drinker is likely to be preoccupied with thoughts relating to alcohol and drinking. This is likely to give rise to 'semantic priming' – the preferential processing of stimuli related to recent cognitive content. This effect would oppose any concomitant abstinence-related *reduction* in neurobiological 'appetitive priming' (i.e. impaired sensitivity to appetitive stimuli in general). The converse might apply after alcohol ingestion: that is, those with an AUD may be less likely to think about alcohol and drinking, thereby reducing semantic priming, whilst the DAergic 'boost' triggered by alcohol ingestion will tend to elevate appetitive priming. Since it is likely that the relative impact of these two salience attribution mechanisms are a function of such variables as length of abstinence, dose of alcohol, alcohol expectations and level of dependence, virtually any pattern of results could arise. The same is not true, however, for appetitive cues which are not substance-related, since abstinence is most unlikely to give rise to semantic priming for stimuli other than those related to the individual's preferred drug.

It is also possible that the suggestion raised by Field and Christiansen (2012; see p. 31) may be relevant here. To recapitulate, these authors have argued that since drinkers often tend to drink only a certain brand of beer, for example, they will probably be most responsive to words related to that brand, less so to those related to other beer brands and potentially not at all responsive to words associated with cider, wine or spirits. One could argue that such an effect may be strongest in problem and physically-dependent drinkers (compared to heavy / hazardous drinkers) due to the progressively compulsive nature of addiction; that is, such

drinkers tend to drink very high volumes of only a certain brand and type of alcohol. It may make sense for future studies using the alcohol Stroop task to include only words considered relevant to the participant's habitual drinking habits. Indeed, it may be considered rather strange that this is not already the *status quo*, particularly when one considers that those with panic disorder, for example, tend to be presented specifically with words synonymous with 'anxiety' and not with words associated with other forms of affective status. This of course is the logic underlying most CR procedures in which the participant is exposed to the sight and smell of their preferred alcoholic beverage.

2. iii) Cue-elicited craving

Hypothesis 5 b) was that PDs' cue-elicited craving would be more strongly influenced than that of SDs by a priming dose of alcohol. Unexpectedly, PDs showed greater cue-elicited craving in the placebo (abstinent) than the alcohol priming condition; this was opposite to the predicted effects. There was no interaction effect in SDs.

The pattern of findings in PDs further illustrates the problems arising from the dual-route model of CR discussed earlier in relation to the alcohol Stroop task. That is, the observed cue-reactivity in the placebo condition could reflect semantic priming being elevated during abstinence, whilst the small priming dose is hypothesised to trigger craving via a pharmacological DA 'boost'. The lack of any interaction effect in SDs and the unexpected pattern in PDs can both be explained by the dual route model, but of course this model is intrinsically irrefutable.

It is notable that exposure to direct alcohol-related stimuli triggered craving in SDs, reflecting previous observations in relation both to cue-elicited craving (e.g. McCusker & Brown, 1990; Walitzer & Sher, 1990; Greeley *et al.*, 1993) as well as behavioural and/or (electro)physiological CR (e.g. McCusker & Brown, 1990; Walitzer & Sher, 1990; Bauer & Cox, 1998; Cox *et al.*, 1999; Jones & Schulze, 2000; Sharma *et al.*, 2001; Ryan, 2002a; Chapter 3 of the present thesis). Lusher *et al.* (2004) have suggested that alcohol-related stimuli acquire motivational salience long before dependence develops. The lack of an overall difference between the

groups in subjective craving found here may suggest that salience attribution plateaus quite early in the development of drinking behaviour.

Family history of AUDs did not add further explanatory value. However, its ability to do so was limited by a) the lack of difference between groups in CR; b) the small sample; and c) the fact that the PDs were twice as likely to have a family history than the SDs and base rate in PDs was so high (80%). The index used to measure this variable, the Family Tree Questionnaire (FTQ; Mann *et al.*, 1985), is a self-report questionnaire, and clearly cannot provide any direct information concerning an individual's genetics; thus, the present finding does not preclude the influence of genetic factors.

2. iv) Impulsiveness

Hypothesis 4 was that PDs would demonstrate greater impulsiveness than SDs, as manifested in TIS and RIS subscale scores, and in IGT net score and CPT commission and motor errors change variables. There was partial support for this. Self-reported levels of impulsivity tended to be higher in PDs than SDs, consistent with the characteristically chaotic and disorganised personal lives often observed in addicts. In contrast, for the three experimental indices of impulsiveness, the groups differed only with respect to motor errors in the CPT. That is, PDs made three times more responses to the 'to be ignored' filler stimuli. However the difference was not affected by whether or not participants had consumed alcohol or placebo.

Alternatively, the discrepancies between the different experimental indices may be related to the multi-faceted nature of impulsiveness and/or differential sensitivity of those indices. These issues are detailed in Chapter 2 (pp. 52-53). Indeed, the present findings are in line with other reports of only weak to moderate correlations, if any, between different measures of impulsiveness (Dom *et al.*, 2006b; Reynolds *et al.*, 2006a).

2. v) Inhibitory control and decision-making during acute abstinence and following alcohol administration

Hypothesis 6 a) predicted that compared to SDs, PDs' decision-making, as manifested in the IGT net score, would be impaired during acute abstinence and 'normalised' following the priming dose of alcohol. This was not supported: acutely abstinent PDs were not impaired in terms of their decision-making abilities. No previous study has investigated the IGT in non-dependent drinkers, though deficits have been reported in physically dependent drinkers (Mazas *et al.*, 2000; Bechara *et al.*, 2001; Dom *et al.*, 2006a; Vicenzi *et al.*, 2006; Loeber *et al.*, 2009a, 2009b). Perhaps the arguably more diverse (relative to the CPT) set of decision-making skills required by the IGT makes performance relatively robust against transient alterations in MCL DA activity in those without physical dependence. Alternatively, it is of course possible that the absence of a deficit in the present PDs may simply relate to the small sample size (N = 7) and consequent lack of power. Though both Vuchinuch and Simpson (1998) and Field *et al.* (2007) have reported delay aversion in non-dependent heavy and problem drinkers via a delay discounting task (a theoretical 'cousin' of the IGT), there are few other comparable studies; further research is therefore needed.

Hypothesis 6 b) was that PDs' inhibitory control, as manifested in CPT Commission Errors (CEs) and Motor Errors (MEs), would be impaired during acute abstinence and 'normalised' following acute alcohol administration, to a greater extent than in SDs. Although this pattern was not in fact found, PDs committed more MEs than SDs across both drink conditions.

As with the IGT, few published studies have examined whether non-dependent drinkers show impaired inhibitory control in the CPT. Those which *have*, have tended to report (positive) correlations between level of consumption and impairment (e.g. Newman & Kosson, 1986; Colder & Connor, 2002). Thus, the findings for MEs are consistent with such previous reports.

It may be argued that the half unit of alcohol was simply not able to produce alterations in MCL DA measurable via behavioural performance. However, the fact

that the drink administered was found to significantly interact with group and word-type factors in the Stroop and CR tasks indicates that the half unit was able to produce meaningful changes in MCL DA.

It is interesting to compare the CPT findings here with those of Dawkins *et al.* (2007b) in smokers, where MEs were elevated during acute abstinence and reduced following nicotine administration. In both studies MEs proved more sensitive than other CE indices to between-groups or between-conditions differences. This may be significant with regards to addicts' failure to exercise sufficient levels of control over their drug-taking behaviour. However, it is not clear why nicotine priming in smokers, but not alcohol priming in drinkers, influenced the level of MEs. There are several possible explanations. Most simply, perhaps the small number of PDs here was key. Alternatively, it is possible that a combination of the disinhibiting effects of alcohol, together with a greater sensitivity to these effects in PDs compared to SDs, had the simultaneous effects that a) the greater level of MEs was maintained in PDs whilst b) MEs were unaffected in SDs. Further research is needed to examine such speculations.

Overall, therefore, the findings concerning behavioural measures of executive control only partly supported previous observations of prefrontal deficits in non-dependent substance-abusing groups.

3) Recent versus trait Impulsiveness

Hypothesis 7 was that recent impulsivity (RIS) scores would correlate more strongly than would trait impulsiveness (TIS) scores with behavioural indices of reward responsiveness and impulsivity, in the placebo (abstinent) condition. This was not supported.

The lack of difference can probably be accounted for via recourse to the small sample size. As demonstrated in Chapter 2 (p. 93), correlations between the corresponding TIS and RIS subscales of cognitive impulsivity and motor impulsivity subscales were strong (i.e. they ranged from 0.57 to 0.80), meaning that it was unlikely that anything other than a very large difference in sensitivity to the

behavioural indices of impulsivity would have been detected in a sample of such modest size. However, these analyses were, as stated in the methods section of this chapter, run on an exploratory basis given the small *N*; thus, in order to properly test the hypothesis a much larger sample would be needed. Another possibility is that the RIS is flawed in that its time-scale of the previous two weeks is too broad. This may have had the effect that no meaningful temporal differentiation existed between the TIS and RIS. This limitation of the RIS has been discussed in Chapter 2 (p. 97).

Conclusion

In conclusion, the present study found no evidence that a small priming dose of alcohol had any priming or disinhibitory effects in SDs; nor that their habitual level of alcohol consumption predicted their sensitivity to priming effects on behavioural indices. When compared to these SDs, however, a group of acutely abstinent PDs demonstrated dysfunctional reward-related processing in a modified Stroop task and in a cue-reactivity procedure; these appeared to normalise somewhat following alcohol priming. The same was not true for behavioural indices of impulsivity. Finally, there was no evidence that Recent Impulsivity was more associated with behavioural measures of reward responsivity and impulsivity than Trait Impulsivity.

Chapter 5: General Discussion

Overview

The present thesis consisted of three studies. The first was concerned with the development and initial validation of a new questionnaire to measure recent impulsivity – the Recent Impulsivity Scale (RIS). The second and third studies were primarily concerned with examining whether and to what extent phenomena typically observed in alcohol dependence syndrome (ADS) – notably heightened cue-reactivity (CR) and impulsiveness, putatively reflecting attenuated activity within the mesocorticolimbic (MCL) dopamine (DA) system – were present in samples of non-physically-dependent heavy social drinkers (HDs) and problem drinkers (PDs), respectively, compared to controls. These latter studies also sought to explore relationships with the newly-developed RIS. This chapter will discuss the principal findings, implications, methodological issues and future research questions raised by the studies of this thesis.

1) Development and Validation of the Recent Impulsivity Scale

The items for an initial version of the Recent Impulsivity Scale (RIS) were devised by converting those of existing trait-based questionnaires and relating them to a 'previous two weeks' time-frame. Factor analyses of the RIS and a Trait equivalent (the TIS), administered to first-year psychology undergraduate students, revealed two factors; these were named 'Cognitive Impulsivity' and 'Motor Impulsivity'.

The sensitivity and construct validity of the RIS were explored throughout the three studies of this thesis. The following evidence in support of its validity was found. In Study 1: i) it correlated less strongly with an established trait measure, the BIS-11 (Patton, Stanford & Barratt, 1995) than did the TIS, consistent with it being affected by factors other than an underlying stable trait; ii) there was a trend for the RIS-MI subscale to show less temporal stability (test-retest correlation) than the TIS-MI subscale; iii) the TIS and RIS CI subscales were more highly correlated in stable drinkers than in 'increasing' or 'decreasing' drinkers, consistent with an effect of alcohol consumption on recent (but also trait) impulsivity; and iv) there was a

significant positive correlation between recent change in recent MI and recent alcohol intake.

In Study 2, there was a strong trend for electrophysiological (ERP) cue-reactivity (CR) to correlate more strongly with RIS-MI than with TIS MI. On the other hand, RIS scores did not correlate more strongly than scores with other self-report and behavioural indices of interest. To some extent the lack of differences reflects the strong inter-correlations between the TIS and RIS subscales and the modest sample sizes in Studies 2 and 3, which were rather low-powered for correlational analyses; thus, only very large effect sizes could have been detected (for a full discussion of issues related to low power, see 'Problems associated with low power and small sample sizes' on p. 279). Clearly, further research with larger sample sizes is needed.

There were notable differences in the patterns observed for the Motor Impulsivity (MI) and Cognitive Impulsivity (CI) subscales. With respect to MI, Study 1 revealed that for participants whose recent alcohol intake was atypical, recent alcohol intake correlated significantly with recent change in MI but not CI. Similarly, there was a strong trend for RIS-MI but not RIS-CI to correlate with electrophysiological cue-reactivity. These findings are consistent with MI being more strongly influenced than CI by (or influential on) recent alcohol use. In relation to this it is notable that the items of the MI subscale are more clearly behaviour-oriented than those of the CI (e.g. the top-loading MI item was 'I have encountered problems because I did things without stopping to think' whilst the top-loading CI item was 'I have planned work tasks and activities in my free time carefully'). This behavioural orientation may make the MI more sensitive to change in as much as recent actions are probably more salient and memorable than recent thoughts and intentions, which are intrinsically more ephemeral and abstract. Consistent with this, there was a tendency for recent MI, but not recent CI, to be more unstable than its 'trait' counterpart (i.e. RIS-MI showed lower test-retest stability than TIS-MI). These findings suggest that MI may be more sensitive than CI to short-term fluctuations, or that the RIS index of MI is more sensitive than that of CI.

The two-week timeframe over which RIS items are judged make it an index of recent/'short-term' impulsivity rather than of impulsivity at that particular moment in time. It is difficult to think of behavioural indicators with sufficient base-rate frequency to make meaningful judgements over shorter timescales (e.g. 'today' or 'right now'). However, this does mean that scores are likely to index something between traditional trait questionnaires and behavioural 'state' measures. Given this, the failure of the RIS to correlate significantly more strongly than the TIS with behavioural measures is not surprising, especially given the small sample sizes and limited statistical power.

Implications of findings concerning the Recent Impulsivity Scale

Mixed findings and small sample sizes notwithstanding, the present results give some encouragement to the view that state impulsivity is a meaningful construct which can be measured via a self-report questionnaire. Although various authors have previously referred to SI as being indexed by behavioural indices such the Stop Signal, Go/No-Go, Continuous Performance and Delay Discounting Tasks (e.g. de Wit, Enggasser & Richards, 2002; Shiels *et al.*, 2009; Strakowski *et al.*, 2010), until now self-report measures have been confined to trait impulsiveness.

The concept of State Impulsivity raises many interesting questions for further research. For example, what is the typical time course over which changes in SI take place? What is the 'normal' scale of such changes? Are certain people more susceptible to SI changes? Such questions could be addressed by administering the SIS and TIS to a large number of respondents repeatedly over a period of several months.

Measuring and understanding SI may eventually prove important for expanding our understanding of alcohol misuse and/or addiction. As discussed in Chapter 2 (pp. 65-67), a number of studies have reported that alcohol acutely reduces inhibitory control (e.g. Fillmore & Vogel-Sprott, 1998, 1999; Rose & Duka, 2008). Field *et al.* (2010) have contended that alcohol-induced disinhibition may make the individual less able to resist the appetitive responses elicited by alcohol-related cues, and thus to drink more. Relatedly, some people may be particularly susceptible to state-

based changes in impulsivity, perhaps because they have genotypes which render their mesolimbic circuitry more reactive to agonist stimulation (e.g. Guiramand *et al.*, 1995; Gardner, Hall & Strange, 1996; Fraeyman & Vermis, 2003). It may be that the acutely disinhibiting effects of alcohol consumption are particularly potent in such individuals, putting them at increased risk of continued and problematic alcohol consumption in individual drinking sessions and chronically.

2) Behavioural indices of appetitive responding and impulsiveness in heavy / problem drinkers versus lighter social drinkers

Studies 2 and 3 compared groups of non-physically-dependent but heavy or problem drinkers with lighter social drinkers, in relation to indices of reward-responsiveness, inhibitory control, decision-making and impulsivity.

Appetitive Responding

It is notable that the presentation of alcohol or associated stimuli increased subjective craving in both the heavy and light drinkers (HDs & LDs) in Study 2 and also in the problem drinkers (PDs) and social drinkers (SDs) tested in Study 3. Thus, the presentation of alcohol-related words in Study 2 and the holding and smelling of preferred alcoholic beverages in Study 3 both resulted in increases in the urge to drink independent of participants' drinking status. Acutely abstinent PDs reported greater increases in subjective craving following exposure to the alcohol cue than did the SDs, but after consumption of the priming dose of alcohol there was no difference in CR between the groups. Thus, consistent with previous observations (e.g. Walitzer & Sher, 1990), subjective cue-elicited craving is experienced by even relatively low levels of drinking experience. Thus the LDs in Study 2 reported an average weekly intake of only 2 units. It seems unlikely that alcohol and associated stimuli have acquired strong conditioned incentive salience in such light drinkers; it may rather be that their self-reported desire to drink when prompted by such cues reflects widely-held beliefs about the enjoyment and relaxation which alcohol offers. It is interesting in this regard that though the electrophysiological (P3) index of cue-reactivity used in Study 2 was stronger to alcohol-related words than to

neutral words in HDs than in LDs, there were no differences in terms of subjective craving in response to the alcohol-related and household-related words.

Similar absences of group differences have also been found in other studies comparing non-dependent heavy and light drinkers (e.g. Johnsen *et al.*, 1994; Stetter *et al.*, 1994; Cox, Yeates & Regan, 1999). It may be that at heavier or more problematic levels of alcohol consumption between-groups differences would emerge; further prospective research is needed and it would be particularly interesting to examine whether any temporal patterns differ between subjective and behavioural or physiological indices.

That HDs and PDs showed dysfunctional reward-related processing in the objective indices of electrophysiological response and the emotional Stroop task may suggest that such 'unconscious' reward-related processing is a general feature of relatively heavy or problematic alcohol intake. It is notable, however, that neither HDs' nor PDs' responses to alcohol-related stimuli were in themselves abnormal. Thus in Study 2 HDs demonstrated an attenuated P3 response to neutral household-related stimuli rather than a heightened P3 to alcohol-related stimuli. Similarly, in Study 3 acutely abstinent PDs demonstrated somewhat abnormal responses to non-alcohol-related appetitive and aversive cues rather than to alcohol-related cues. After a priming dose of alcohol, PDs' colour-naming tended to normalise. This suggests that excessive alcohol intake may be associated more with reduced interest in non-alcohol-related stimuli than with elevated interest in alcohol. However, other published studies using behavioural indices of CR *have* found HDs or PDs to show abnormally strong responses to alcohol-related stimuli specifically (e.g. Herrmann *et al.*, 2001). Whilst there is no obvious explanation for these differences in findings between studies, there are many potentially relevant differences in the methodologies – for example, sample characteristics, specific features of cue-reactivity tasks and protocols. All studies to date have also had relatively small sample sizes (tens, rather than hundreds) and findings from some could therefore be spurious. When more comparable studies using the same tasks have been carried out a meta-analysis might enable underlying patterns and influences to be detected.

In any event, the apparent greater sensitivity of behavioural and EEG indices than of self-reported cue-reactivity to differences in drinking history could reflect the involvement of cognitive processes in the latter but not the former. This is somewhat in keeping with Tiffany's (1990; Tiffany & Conklin, 2000) model of craving, which contends that experienced substance users preferentially and automatically (i.e. unconsciously) process substance-related stimuli (as well as presumably demonstrating (electro)physiological correlates of such unconscious processes). It is only in circumstances in which drug-procurement or -taking is impeded that more conscious processes become activated (aimed at obtaining the substance). Thus whilst such conscious processes may, as discussed above, have been present in both heavier and lighter drinkers, only the former group would have been expected to – and indeed only they *did* – demonstrate evidence of somewhat abnormal unconscious processes.

Inhibitory control, decision-making and impulsivity

Study 2 found no evidence that HDs were more impulsive than LDs, on any of a battery of self-report and behavioural measures (RIS and TIS CI and MI subscales, 'commission' errors (CEs; responses to distractor stimuli) in the Continuous Performance Task (CPT) and electrophysiological correlates of impulsivity during CPT performance). On the other hand, Study 3 found PDs to be more impulsive than SDs, as indicated both by the self-report measures (RIS and TIS CI and MI subscales) and CPT motor errors – that is, when the participant fails to withhold responding to the to-be-ignored 'filler' stimuli. However, the groups did not differ in either CPT CEs or rational decision-making in the Iowa Gambling Task (IGT).

The apparent inconsistency between tasks may reflect findings elsewhere of small or non-existent correlations between different impulsivity indices (e.g. Dom *et al.*, 2006b). However the findings of Studies 2 and 3 offer some support for the thesis that impulsivity/inhibitory control deficits increase with heavier levels of habitual alcohol consumption. That the drinking levels of the SDs in Study 3 (average unit consumption (AUC)/week was 8.87) were rather more similar to the LDs of Study 2 (AUC/week was 2.13) than the HDs (AUC/week was 44.26) is consistent with this

idea. So, in Study 2 the heavier drinkers *did not* show greater impulsivity than lighter drinkers; but in Study 3 PDs were, on some indices, more impulsive than SDs. Comparisons here are restricted to the RIS and TIS CI and MI subscales and CPT CEs (all of which were administered in both studies 2 and 3; only Study 3 included both CPT commission *and* motor errors). There were also differences in the average ages of participants in the two studies, as those in Study 2 were principally aged between 18 and 23 (mean age was 22 years) whereas those in Study 3 were between 25 and 63 and had a mean age of 47. This could be relevant in that patterns of heavy alcohol consumption may have a greater effect on the still-developing late-adolescent brain than that of the adult (e.g. Crews & Boettiger, 2009). However, there was no difference between the studies in terms of the gender ratio of participants (χ^2 (1) = 0.37; ns). Overall, these findings are at least in keeping with Jentsch and Taylor's (1999) contention that inhibitory control deficits develop over a period of chronic alcohol consumption. A limitation of their model is its lack of explanation of the processes which underpin and maintain the initial phase of alcohol consumption. It may be, however, that to some extent elevated impulsivity pre-dates and is a vulnerability factor for excessive and uncontrolled drinking (e.g. Sher, Bartholow & Wood, 2000; Habeych *et al.*, 2006; Rubio *et al.*, 2008).

A significant methodological limitation of Study 3 was its small sample size and the fact that only 7 PDs completed the CPT and IGT tasks. These data must therefore be treated very tentatively and indeed the inclusion of the PD group was from the outset exploratory. The data do, however, suggest that further research in larger samples may be justified. Few studies to date have studied impulsivity and inhibitory control deficits in non-physically-dependent drinkers, and to gain greater understanding of their development and causal role in dependence it will be necessary to conduct longitudinal studies following a large cohort from adolescence (i.e. when participants are relatively 'alcohol-naive') through to adulthood, when a proportion will have developed alcohol use disorders. Such studies are time-consuming and costly, however. In the meantime further cross-sectional studies could usefully compare matched samples drinking at several 'bands' of severity on a

range of impulsivity indices. This might clarify whether impulsivity-related features tend to increase between particular bands.

Family history of alcohol use disorders

Study 2 HD and LD groups did not differ in number of first-degree relatives with a definite or suspected alcohol use disorder (AUD). Although in Study 3 the PDs had a greater proportion of first-degree relatives with an AUD, this variable did not explain between-group (PD vs. SD) differences on any measure. Although the sample was small this suggests that abnormalities in task performance were not a result of familial transmission but were likely to relate to their chronic drinking patterns *per se*. This is consistent with evidence that chronic alcohol intake is able to bring about dysfunction within MCL DAergic pathways (Diana *et al.*, 1992a, 1992b; Rossetti, Hmaidan & Gessa, 1992; Shen & Chiodo, 1993; Weiss *et al.*, 1996).

Wider implications of the present thesis concerning reward responsivity and impulsiveness

Overall, the findings of Studies 2 and 3 indicate that even in the absence of physical dependence heavy social drinkers and problem drinkers can show differential responsiveness towards alcohol and associated stimuli and/or attenuated responses to non-alcohol-related rewarding stimuli. Thus elements of the present data are consistent with Robinson and Berridge's (1993, 2000) incentive sensitisation model of addiction which posits that with increasing consumption, drugs and associated stimuli develop incentive motivational properties: that is, they grab attention and become attractive and 'wanted'. Combined with impaired executive control and decision-making, this can explain the core symptoms of addiction. That Study 2 found evidence of alcohol cue-reactivity in the absence of impulsiveness in a sample of light and heavier social drinkers, whereas the PDs in Study 3 demonstrated dysfunctional reward processing as well as impulsivity, may suggest that impulsivity is a critical factor in the transition to problematic drinking. However, since these studies were cross-sectional rather than prospective they were unable to address issues of causality.

An interesting question is whether there are differences in the degree to which these phenomena are demonstrated by light, moderate and heavy social drinkers, hazardous drinkers, problem drinkers and dependent drinkers. To the extent that they are a consequence of cumulative alcohol consumption, they should develop progressively and therefore manifest more strongly with increasing severity of alcohol use disorder. If, however, pre-existing abnormalities in reward sensitivity predispose to heavier substance use, they may be present to similar levels in heavy, hazardous and problem drinkers. The same or similar issues apply to impulsivity, and it is presently unclear whether CR and impulsivity develop in parallel or differently. As previously noted, longitudinal or large-scale cross-sectional studies will be needed if these questions are to be addressed with high statistical power.

In an ideal world it would be desirable to include physiological and brain imaging assessments in such studies to try and better characterise non-dependent heavy drinking. It would be of particular interest to examine whether such individuals demonstrate abnormal levels of DA D_2 receptors in the striatum and PFC, as has been found in physically-dependent drinkers (e.g. Volkow *et al.*, 1993, 2001; London *et al.*, 2000; Robinson *et al.*, 2001). To date, no studies have examined this directly, though Kubota *et al.* (2001) found heavy social drinkers to be at a significantly increased risk of frontal lobe shrinkage. More recently, Yan and Li (2009) and Bednarski *et al.* (2012) have reported heavy social drinkers to demonstrate abnormalities in amygdala, caudate and superior frontal cortex, brain regions linked to successful performance in the Stop Signal Task.

Whether or not there is a continuum in the development of cue-reactivity and impulsivity, it is certainly important to consider the role they may play in triggering or maintaining 'real-world' drinking behaviour.

Problems associated with low statistical power and small sample size

The studies of the present thesis – in particular, Studies 2 and 3 – were relatively low-powered since they were performed using rather small sample sizes. This is somewhat problematic given the issues known to be associated with low statistical power (Button *et al.*, 2013). These problems can be broadly divided into two

categories: i) problems that are mathematically expected, even if the research is perfect in all other respects; and ii) problems which tend to co-occur with low-powered studies, or which often become worse in small, low-powered studies.

With regards to the first category, low statistical power is associated with three principal mathematical problems. Firstly, low statistical power reduces the chances of finding an effect when it genuinely exists: all other things being equal, low-powered studies return more false negatives than high-powered studies. Thus, if a series of studies in a given area only have a power of 20%, when there are 100 genuine non-null effects to be discovered in that area, such studies would only be expected to discover 20 of them.

Secondly, the lower the power, the lower the probability that an observed effect passing the required significance threshold (such as $p < 0.05$, for example) actually reflects a true effect. This probability is termed the 'positive predictive value' (PPV) of a claimed discovery. The formula which links the PPV to power is:

$$PPV = ([1 - \beta] \times R) / ([1 - \beta] \times R + \alpha)$$

where $(1 - \beta)$ is the power, β is the type II error, α is the type I error and R is the pre-study odds that a probed effect is non-null. This formula means that, with a given pre-study odds R, the lower the power and the higher the type I error, the lower the PPV. This can be illustrated if we consider the example of a scientific field in which one in five of the effects tested are expected to be genuinely non-null (i.e. $R = 1 / (5 - 1) = 0.25$). If we claim to have discovered an effect at $p < 0.05$, and the studies have 20% power, then $PPV = 0.20 \times 0.25 / (0.20 \times 0.25 + 0.05) = 0.05 / 0.10 = 0.05$; thus, just half of the claims for discoveries would be correct. With 80% power, on the other hand, $PPV = 0.80 \times 0.25 / (0.80 \times 0.25 + 0.05) = 0.20 / 0.25 = 0.80$; thus, 80% of discovery claims would be correct.

Thirdly, even when an under-powered study returns a genuine effect, the magnitude of this effect is likely to be over-estimated; a scenario referred to as the 'winner's curse'. This tends to occur whenever claims of discovery are based on thresholds of statistical significance, such as $p < 0.05$, for example. Effect inflation is

worst for small, low-powered studies since such studies can only detect large effects. For example, if an effect is medium-sized, only those small studies which over-estimate the size of the effect will surpass the threshold for discovery. To illustrate, suppose that a genuine association exists with an odds ratio of 1.20 and a small, low-powered study with 20% power is conducted to detect this effect. In any study, the measurements of the variables and outcomes of interest are open to sampling variation and random error. Thus, although on average such small studies would return an odds ratio of 1.20, due to random errors a single study may find an odds ratio smaller than 1.20 (e.g. 1.00) or larger than 1.20 (e.g. 1.60). Due to the small sample size, odds ratios of 1.00 or 1.20 would not attain statistical significance. Nominal significance would be attained, however, in the third case in which the odds ratio was found to be 1.60. Thus, the winner's curse refers to the researcher making the discovery being, in fact, cursed by an inflated effect.

In terms of the second category of additional biases associated with low power, there are three chief problems. Firstly, studies of low power are more likely to provide a wide range of effect magnitude estimates. Termed 'vibration of effects', this refers to the scenario whereby varying estimates of the magnitude of an effect are obtained as a function of the analytical options implemented. Such options refer to the definition of the variables of interest, the statistical model used, the use (or not) of adjustments for particular potential confounders, and so on. The range of potential results consequent of vibration of effects is wider in small studies, relative to larger studies; this is because, broadly, results in the latter tend to be more uncertain and will thus be more sensitive to analytical changes.

Secondly, smaller, under-powered studies are more likely to be affected by publication bias and selective reporting of outcomes. That is, negative results in larger studies – often more widely-known, their results being eagerly anticipated – cannot be easily explained in terms of low power; reviewers and editors may thus be more willing to publish the study. On the other hand, a small 'negative' study is generally considered inconclusive or uninformative, and has a reduced chance of publication.

Thirdly, smaller studies may have a poorer design quality than larger studies. The former may be more opportunistic, their data collection and analysis possibly proceeding with relatively little planning. In contrast, the greater funding and personnel resources associated with larger studies tend to mean that their designs are examined more carefully prior to data collection, and that their analyses and reporting is more structured.

It is important at this juncture to note that the small sample sizes and low power of the studies within the present thesis are anything but particular; indeed, low power and small sample sizes are endemic within psychology and its associated fields. For example, Button *et al.* (2013) estimate that median statistical power across neuroscience research in general is just 21%, and that this figure is between 18 and 31% in the specific area of animal model studies, and that it is only 8% in the field of neuroimaging studies. This may mean that a substantial proportion of 'statistically significant' research findings are in fact spurious.

Summary and Conclusion

Firstly, the present thesis developed and piloted a self-report questionnaire to measure State Impulsivity. Preliminary validation and tests of the measure's sensitivity to alcohol consumption was limited by sample sizes that were relatively small for correlational analyses. Nevertheless, there was support for the reality of state variations in impulsivity, and for its measurability. This has potentially important implications for understanding acute alcohol effects and the development of alcohol use disorders.

Two cross-sectional studies examined differences between non-physically-dependent but heavy drinkers and lighter social drinkers on a range of self-report, behavioural and physiological measures of reward responsivity and impulsivity. Compared to light drinkers, heavy social drinkers demonstrated electrophysiological cue-reactivity to alcohol-related words, though they did not show elevated impulsivity. In acutely abstinent PDs there was some evidence of both dysfunctional reward responsivity and impulsivity compared to social drinkers. These findings are consistent with existing models of addiction (e.g. Robinson & Berridge, 1993, 2000;

Jentsch & Taylor, 1999) and may suggest a continuum along which abnormalities develop in parallel with alcohol use disorder severity. However, the small sample sizes and attendant low power of Studies 2 and 3 act as a caveat to such conclusions. Longitudinal studies are needed to test these propositions further.

References

Abroms, B. D. & Fillmore, M. T. (2004). Alcohol-induced impairment of inhibitory mechanisms involved in visual search. Experimental and Clinical Psychopharmacology, 12 (4), 243-250.

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.

Adams, S., Ataya, A. F., Attwood, A. S. & Munafò, M. R. (2012). Effects of acute alcohol consumption on alcohol-related cognitive biases in light and heavy drinkers are task-dependent. Journal of Psychopharmacology, 26 (2), 245-253.

Adolphs, R., Bechara, A., Kaufman, O., Kawasaki, H., Bakken, H., Damasio, H., Granner, M. & Howard, M., III. (2000). Single unit responses in human orbitofrontal cortex: decision-making on a gambling task. Journal of Cognitive Neuroscience, 53 (Supplement), 57B.

Ahmadi, A., Pearlson, G. D., Meda, S. A., Dager, A., Potenza, M. N., Rosen, R., Austad, C. S., Raskin, S. A., Fallahi, C. R., Tennen, H., Wood, R. M. & Stevens, M. C. (2013). Influence of alcohol use on neural response to Go/No-Go task in college drinkers. Neuropsychopharmacology, Epub. ahead of print.

Ainslie, G. (1975). Specious reward: a behavioural theory of impulsiveness and impulse control. Psychological Bulletin, 82 (4), 463-496.

Akine, Y., Kato, M., Muramatsu, T., Umeda, S., Mimura, M., Asai, Y., Tanada, S., Obata, T., Ikehira, H., Kashima, H. & Suhara, T. (2007). Altered brain activation by a false recognition task in young abstinent patients with alcohol dependence. Alcoholism: Clinical and Experimental Research, 31 (9), 1589-1597.

Al-Adawi, S. & Powell, J. (1997). The influence of smoking on reward responsiveness and cognitive functions: a natural experiment. Addiction, 92 (12), 1773-1782.

Algom, D., Chajut, E. & Lev, S. (2004). A rational look at the emotional Stroop phenomenon: a generic slowdown, not a Stroop effect. Journal of Experimental Psychology, 133 (3), 323-338.

American Psychiatric Association (1995). Diagnostic and Statistical Manual of Mental Disorders (4th Ed.). Washington, DC: American Psychiatric Association.

Annis, H. M. (1982). Situational Confidence Questionnaire. Ontario, Canada: Addiction Research Foundation.

Aron, A. R., Robbins, T. W. & Poldrack, R. A. (2004). Inhibition and the right inferior frontal cortex. Trends in Cognitive Sciences, 8 (4), 170-177.

Ataya, A. F., Adams, S., Mullings, E., Cooper, R. M., Attwood, A. S. & Munafò, M. R. (2012). Internal reliability of measures of substance-related cognitive bias. Drug and Alcohol Dependence, 121 (1-2), 148-151.

Baayen, H. R., Piepenbrock, R. & Gulikers, L. (1995). The CELEX Lexical Database (CD-ROM). Philadelphia: Linguistic data consortium, University of Pennsylvania.

Bailey, C. P., Andrews, N., McKnight, A. T., Hughes, J. & Little, H. J. (2000). Prolonged changes in neurochemistry of dopamine neurones after chronic ethanol consumption. Pharmacology, Biochemistry, and Behaviour, 66 (1), 153-161.

Balakrishnan, R., Allender, S., Scarborough, P., Webster, P. & Rayner, M. (2009). The burden of alcohol-related ill-health in the United Kingdom. Journal of Public Health, 31 (3), 366-373.

Baker, F., Johnson, M. W. & Bickel, W. K. (2003). Delay discounting in current and never-before cigarette smokers: similarities and differences across commodity, sign and language. Journal of Abnormal Psychology, 112 (3), 382-392.

Barbour, A. D. (2001). Simplified estimation of Widmark “r” values by the method of Forrest. Science and Justice, 41 (1), 53-54.

Bauer, D. & Cox, W. M. (1998). Alcohol-related words are distracting to both alcohol abusers and non-abusers in the Stroop colour-naming task. Addiction, 93 (10), 1539-1542.

Bechara, A., Damasio, A. R., Damasio, H. & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. Cognition, 50 (1-3), 7-15.

Bechara, A., Damasio, H., Tranel, D. & Anderson, S. W. (1998). Dissociation of working memory from decision making within the human prefrontal cortex. Journal of Neuroscience, 18 (1), 428-437.

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.

Bechara, A., Dolan, S. & Hindes, A. (2002). Decision-making and addiction (part II): myopia for the future or hypersensitivity to reward? Neuropsychologia, 40 (10), 1690-1705.

Beck, A. T., Steer, R. A. & Carbin, M. G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. Clinical Psychology Review, 8 (1), 77-100.

Bednarski, S. R., Erdman, E., Luo, X., Zhang, S., Hu, S. & Li, C. S. (2012). Neural processes of an indirect analog of risk taking in young nondependent adult alcohol drinkers-an fMRI study of the stop signal task. Alcoholism: Clinical and Experimental Research, 36 (5), 768-779.

Bekker, E. M., Kenemans, J. L. & Verbaten, M. N. (2004). Electrophysiological correlates of attention, inhibition, sensitivity and bias in a continuous performance task. Clinical Neurophysiology, 115 (9), 2001-2013.

Bickel, W. K. & Marsch, L. A. (2001). Toward a behavioural economic understanding of drug dependence: delay discounting processes. Addiction, 96 (1), 73-86.

Bigelow, G. E., Griffiths, R. R. & Liebson, I. A. (1977). Pharmacological influences on human ethanol self-administration. Advances in Experimental Medicine and Biology, 85B, 523-538.

Biggins, C. A., MacKay, S., Poole, N. & Fein, G. (1995). Delayed P3a in abstinent elderly male chronic alcoholics. Alcoholism: Clinical and Experimental Research, 19 (4), 1032-1042.

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.

Bjork, J. M., Hommer, D. W., Grant, S. J. & Danube, C. (2004). Impulsivity in abstinent alcohol-dependent patients: relation to control subjects and type 1-/type-2-like traits. Alcohol, 34 (2-3), 133-150.

Blanchard, J. J., Horan, W. P. & Brown, S. A. (2001). Diagnostic differences in social anhedonia: a longitudinal study of schizophrenia and major depressive disorder. Journal of Abnormal Psychology, 110 (3), 363-371.

Blum, K., Noble, E. P., Sheridan, P. J., Montgomery, A., Ritchie, T., Jagadeeswaran, P., Nogami, H., Briggs, A. H. & Cohn, J. B. (1990). Allelic association of human dopamine D2 receptor gene in alcoholism. The Journal of the American Medical Association, 263 (15), 2055-2060.

Bobova, L., Finn, P. R., Rickert, M. E. & Lucas, J. (2009). Disinhibitory psychopathology and delay discounting in alcohol dependence: personality and cognitive correlates. Experimental and Clinical Psychopharmacology, 17 (1), 51-61.

Boettiger, C. A., Mitchell, J. M., Tavares, V. C., Robertson, M., Joslyn, G., D'Esposito, M. & Fields, H. L. (2007). Immediate reward bias in humans: fronto-parietal

networks and a role for the catechol-O-methyltransferase 158 (Val/Val) genotype. Journal of Neuroscience, 27 (52), 14383-14391.

Bokura, H., Yamaguchi, S. & Kobayashi, S. (2001). Electrophysiological correlates for response inhibition in a go/nogo task. Clinical Neurophysiology, 112 (12), 2224-2232.

Bolla, K. I., Eldreth, D. A., London, E. D., Kiehl, K. A., Mouratidis, M., Contoreggi, C., Matochik, J. A., Kurian, V., Cadet, J. L., Kimes, A. S., Funderburk, F. R. & Ernst, M. (2003). Orbitofrontal cortex dysfunction in abstinent cocaine abusers performing a decision-making task. Neuroimage, 19 (3), 1085-1094.

Bolla, K. I., Eldreth, D. A., Matochik, J. A. & Cadet, J. L. (2005). Neural substrates of faulty decision-making in abstinent marijuana users. Neuroimage, 26 (2), 480-492.

Botvinick, M. M., Cohen, J. D. & Carter, C. S. (2004). Conflict monitoring and anterior cingulate cortex: an update. Trends in Cognitive Sciences, 8 (12), 539-546.

Bovasso, G. B. (2001). Cannabis abuse as a risk factor for depressive symptoms. American Journal of Psychiatry, 158 (12), 2033-2037.

Bowirrat, A. & Oscar-Berman, M. (2005). Relationship between dopaminergic neurotransmission, alcoholism, and reward deficiency syndrome. American Journal of Medical Genetics. Part B, Neuropsychiatric Genetics, 132B (1), 29-37.

Braithwaite, V., Duncan-Jones, P., Bosly-Craft, R. & Goodchild, M. (1984). A psychometric investigation of the usefulness of the EASI-III Temperament Survey in the Australian general population. Australian Journal of Psychology, 36 (1), 85-95.

Brandeis, D. & Lehmann, D. (1986). Event-related potentials of the brain and cognitive processes: approaches and applications. Neuropsychologia, 24 (1), 151-168.

Breier, A., Su, T. P., Saunders, R., Carson, R. E., Kolachana, B. S., de Bartolomeis, A., Weinberger, D. R., Weisenfeld, N., Malhotra, A. K., Eckelman, W. C. & Pickar, D. (1997). Schizophrenia is associated with elevated amphetamine-induced synaptic dopamine concentrations: evidence from a novel position emission tomography method. Proceedings of the National Academy of Sciences of the United States of America, 94 (6), 2569-2574.

British Beer and Pub Association (2004). The Statistical Handbook 2004. London: Brewing Publications.

Bruin, K. J., Wijers, A. A. & van Staveren, A. S. (2001). Response priming in a go/nogo task: do we have to explain the go/nogo N2 effect in terms of response activation rather than inhibition? Clinical Neurophysiology, 112 (9), 1660-1671.

Buss, A. H. & Plomin, R. (1984). Temperament: Early Developing Personality Traits. Hillsdale, New Jersey: Erlbaum.

Button, K. S., Ioannidis, J. P. A., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S. J. & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. Nature Reviews Neuroscience, 14 (5), 365-376.

Cabinet Office (2003). Alcohol misuse: How Much Does it Cost? London: Cabinet Office.

Cangemi, S., Giorgi, I., Bonfiglio, N. S., Renati, R. & Vittadini, G. (2010). Impulsiveness and time perception in alcohol dependent patients in alcoholic rehabilitation treatment. Giornale Italiano di Medicina del Lavoro ed Ergonomia, 32 (Supplement B), B23-28.

Carlson, S. R., Johnson, S. C. & Jacobs, P. C. (2010). Disinhibited characteristics and binge-drinking among university student drinkers. Addictive Behaviours, 35 (3), 242-251.

Carretie, L., Martin-Loeches, M., Hinojosa, J. A. & Mercado, F. (2001). Emotion and attention interaction studied through event-related potentials. Journal of Cognitive Neuroscience, 13 (8), 1109-1128.

Carter, B. L. & Tiffany, S. T. (1999). Meta-analysis of cue-reactivity in addiction research. Addiction, 94 (3), 327-340.

Carver, C. S. & White, T. L. (1994). Behavioral inhibition, behavioural activation, and affective responses to impending reward and punishment: the BIS/BAS scales. Journal of Personality and Social Psychology, 67 (2), 319-333.

Chanraud, S., Martelli, C., Delain, F., Kostogianni, N., Douaud, G., Aubin, H. J., Reynaud, M. & Martinot, J. L. (2007). Brain morphometry and cognitive performance in detoxified alcohol-dependents with preserved psychosocial functioning. Neuropsychopharmacology, 32 (2), 429-438.

Chapman, L. J., Chapman, J. P. & Raulin, M. L. (1976). Scales for physical and social anhedonia. Journal of Abnormal Psychology, 85 (4), 374-382.

Chen, A. C., Porjesz, B., Rangaswamy, M., Kamarajan, C., Tang, Y., Jones, K. A., Chorlian, D. B., Stimus, A. T. & Begleiter, H. (2007). Reduced frontal lobe activity in subjects with high impulsivity and alcoholism. Alcoholism: Clinical and Experimental Research, 31 (1), 156-165.

Christiansen, P., Cole, J. C., Goudie, A. J. & Field, M. (2012). Components of behavioural impulsivity and automatic cue approach predict unique variance in hazardous drinking. Psychopharmacology, 219 (2), 501-510.

Chutuape, M. A. D., Mitchell, S. H. & de Wit, H. (1994). Ethanol preloads increase ethanol preference under concurrent random-ratio schedules in social drinkers. Experimental and Clinical Psychopharmacology, 2 (4), 310-318.

Clark, C. P., Brown, G. G., Eyler, L. T., Drummond, S. P., Braun, D. R. & Tapert, S. F. (2007). Decreased perfusion in young alcohol-dependent women as compared with age-matched controls. The American Journal of Drug and Alcohol Abuse, 33 (1), 13-19.

Coffey, S. F., Gudleski, G. D., Saladin, M. E. & Brady, K. T. (2003). Impulsivity and rapid discounting of delayed hypothetical rewards in cocaine-dependent individuals. Experimental and Clinical Psychopharmacology, 11 (1), 18-25.

Cohen, J. & Cohen, P. (2003). Applied Multiple Regression / Correlation Analysis for the Behavioural Sciences. Hillsdale, New York: Lawrence Erlbaum Associates.

Colder, C. R. & O'Connor, R. (2002). Attention biases and disinhibited behaviour as predictors of alcohol use and enhancement reasons for drinking. Psychology of Addictive Behaviours, 16 (4), 325-332.

Comerchero, M. D., Katayama, J. & Polich, J. (1997). P3a and P3b from auditory and visual stimuli. Psychophysiology, 34, S27.

Comrey, A. L. & Lee, H. B. (1992). A First Course in Factor Analysis (2nd Ed.). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Conners, C. K., Epstein, J. N., Angold, A. & Klaric, J. (2003). Continuous performance test performance in a normative epidemiological sample. Journal of Abnormal Child Psychology, 31 (5), 555-562.

Cooney, N. L., Gillespie, R. A., Baker, L. H. & Kaplan, R. F. (1987). Cognitive changes after alcohol cue exposure. Journal of Consulting and Clinical Psychology, 55 (2), 150-155.

Copersino, M. L., Serper, M. R., Vadhan, N., Goldberg, B. R., Richarme, D., Chou, J. C., Stitzer, M. & Cancro, R. (2004). Cocaine craving and attentional bias in cocaine-dependent schizophrenic patients. Psychiatry Research, 128 (3), 209-218.

Courchesne, E., Hillyard, S. A. & Galambos, R. (1975). Stimulus novelty, task relevance and the visual evoked potential in man. Electroencephalography and Clinical Neurophysiology, 39 (2), 131-143.

Cox, W. M., Blount, J. P. & Rozak, A. M. (2000). Alcohol abusers' and nonabusers' distraction by alcohol and concern-related stimuli. The American Journal of Drug and Alcohol Abuse, 26 (3), 489-495.

Cox, W. M., Yeates, G. N. & Regan, C. M. (1999). Effects of alcohol cues on cognitive processing in heavy and light drinkers. Drug and Alcohol Dependence, 55 (1-2), 85-89.

Crabbe, J. C. (2002). Genetic contributions to addiction. Annual Review of Psychology, 53, 435-462.

Craig, R., Mindell, J. & Hirani, V. (2009). Health Survey for England 2008. Volume 1: Physical Activity and Fitness. London: NHS Information Centre.

Crawford, J. R., Henry, J. D., Crombie, C. & Taylor, E. P. (2001). Normative data for the HADS from a large non-clinical sample. British Journal of Clinical Psychology, 40 (Part 4), 429-434.

Crews, F. T. & Boettiger, C. A. (2009). Impulsivity, frontal lobes and risk for addiction. Pharmacology, Biochemistry, and Behaviour, 93 (3), 237-247.

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N. & Lang, P. J. (2000). Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. Biological Psychology, 52 (2), 95-111.

Cyders, M. A. (2011). Impulsivity and the sexes: measurement and structural invariance of the UPPS-P Impulsive Behaviour Scale. Assessment [Epub ahead of print].

Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 351 (1346), 1413-1420.

Dao-Castellana, M. H., Samson, Y., Legault, F., Martinot, J. L., Aubin, H. J., Crouzel, C., Feldman, L., Barrucand, D., Rancurel, G., Féline, A. & Syrota, A. (1998). Frontal dysfunction in neurologically normal chronic alcoholic subjects: metabolic and neuropsychological findings. Psychological Medicine, 28 (5), 1039-1048.

Dawkins, L., Acaster, S. & Powell, J. H. (2007a). The effects of smoking and abstinence on experience of happiness and sadness in response to positively

valenced, negatively valenced, and neutral film clips. Addictive Behaviours, 32 (2), 425-431.

Dawkins, L. & Powell, J. (2011). Effects of nicotine and alcohol on affective responses to emotionally toned film clips. Psychopharmacology, 216 (2), 197-205.

Dawkins, L., Powell, J. H., West, R., Powell, J. & Pickering, A. (2006). A double-blind placebo-controlled experimental study of nicotine: I—effects on incentive motivation. Psychopharmacology, 189 (3), 355-367.

Dawkins, L., Powell, J. H., West, R., Powell, J. & Pickering, A. (2007b). A double-blind placebo-controlled experimental study of nicotine: II—effects on response inhibition and executive functioning. Psychopharmacology, 190 (4), 457-467.

Demir, B., Uçar, G., Uluğ, B., Ulusoy, S., Sevinç, I. & Batur, S. (2002a). Platelet monoamine oxidase activity in alcoholism subtypes: relationship to personality traits and executive functions. Alcohol and Alcoholism, 37 (6), 597-602.

Demir, B., Uluğ, B., Lay Ergün, E. & Erbaş, B. (2002b). Regional cerebral blood flow and neuropsychological functioning in early and late onset alcoholism. Psychiatry Research, 115 (3), 115-125.

Department of Health (1995). Sensible Drinking: the Report of an Inter-Departmental Working Group. London: Department of Health.

De Wit, H. (2009). Impulsivity as a determinant and consequence of drug use: a review of underlying processes. Addiction Biology, 14 (1), 22-31.

De Wit, H. & Chutuape, M. A. (1993). Increased ethanol choice in social drinkers following ethanol preload. Behavioural Pharmacology, 4 (1), 29-36.

De Wit, H., Crean, J. & Richards, J. B. (2000). Effects of d-amphetamine and ethanol on a measure of behavioural inhibition in humans. Behavioural Neuroscience, 114 (4), 830-837.

De Wit, H., Enggasser, J. L. & Richards, J. B. (2002). Acute administration of d-amphetamine decreases impulsivity in healthy volunteers. Neuropsychopharmacology, 27 (5), 813-825.

Diana, M., Brodie, M., Muntoni, A., Puddu, M. C., Pillolla, G., Steffensen, S., Spiga, S. & Little, H. J. (2003). Enduring effects of chronic ethanol in the CNS: basis for alcoholism. Alcoholism: Clinical and Experimental Research, 27 (2), 354-361.

Diana, M., Pistis, M., Carboni, S., Gessa, G. L. & Rossetti, Z. L. (1992a). Profound decrement of mesolimbic dopaminergic neuronal activity during ethanol withdrawal syndrome in rats: electrophysiological and biological evidence. Proceedings of the National Academy of Sciences of the United States of America, 90 (17), 7966-7969.

Diana, M., Pistis, M., Muntoni, A., Rossetti, Z. L. & Gessa, G. L. (1992b). Marked decrease of A10 dopamine neuronal dopamine firing during ethanol withdrawal syndrome in rats. European Journal of Pharmacology, 221 (2-3), 403-404.

Di Ciano, P., Blaha, C. D. & Philips, A. G. (1998). The relation between dopamine oxidation currents in the nucleus accumbens and conditioned increases in motor activity in rats following repeated administration of cocaine or *d*-amphetamine. European Journal of Neuroscience, 10 (3), 1113-1120.

Dickman, S. (1990). Functional and dysfunctional impulsivity: personality and cognitive correlates. Journal of Personality and Social Psychology, 58 (1), 95-102.

Dien, J. & Santuzzi, A. M. (2005). Application of repeated-measures ANOVA to high-density ERP data-sets: a review and tutorial. In Handy, T. C. (Ed.), Event-Related Potentials: a Methods Handbook (pp. 57-82). Cambridge: the MIT press.

Dom, G., De Wilde, B., Hulstijn, W., van den Brink, W. & Sabbe, B. (2006a). Behavioural aspects of impulsivity in alcoholics with and without a cluster-B personality disorder. Alcohol and Alcoholism, 41 (4), 412-420.

Dom, G., D'haene, P., Hulstijn, W. & Sabbe, B. (2006b). Impulsivity in abstinent early- and late-onset alcoholics: differences in self-report measures and a discounting task. Addiction, 101 (1), 50-59.

Donchin, E. (1981). Surprise!... Surprise? Psychophysiology, 18 (5), 493-513.

Doran, N., Spring, B. & McChargue, D. (2007). Effect of impulsivity upon craving and behavioural reactivity to smoking cues. Psychopharmacology, 194 (2), 279-288.

Dougherty, D. M., Bjork, J. M., Harper, R. A., Marsh, D. M., Moeller, F. G., Mathias, C. W. & Swann, A. C. (2003a). Behavioural impulsivity paradigms: a comparison in hospitalised adolescents with disruptive behaviour disorders. Journal of Child Psychology and Psychiatry, 44 (8), 1145-1157.

Dougherty, D. M., Bjork, J. M., Harper, R. A., Mathias, C. W., Moeller, F. G. & Marsh, D. M. (2003b). Validation of the Immediate and Delayed Memory Tasks in hospitalised adolescents with disruptive behaviour disorders. Psychological Record, 53 (4), 509-532.

Dougherty, D. M., Marsh, D. M., Mathias, C. W. & Swann, A. C. (2005). Bipolar disorder and substance abuse: the conceptualisation and role of impulsivity. Psychiatric Times, 22, 32-35.

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.

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 behavioural measures of impulsivity. Drug and Alcohol Dependence, 96 (1-2), 111-120.

Dougherty, D. M., Mathias, C. W., Marsh, D. M., Moeller, F. G. & Swann, A. C. (2004). Suicidal behaviours and drug abuse: impulsivity and its assessment. Drug and Alcohol Dependence, 76 (Supplement), S93-S105.

Dougherty, D. M., Moeller, F. G., Steinberg, J. L., Marsh, D. M., Hines, S. E. & Bjork, J. M. (1999). Alcohol increases commission error rates for a continuous performance test. Alcoholism: Clinical and Experimental Research, 23 (8), 1342-1351.

Drobes, D. J. & Thomas, S. E. (1999). Assessing craving for alcohol. Alcohol Research and Health, 23 (3), 179-186.

Drummond, D. C., Oyefeso, N., Phillips, T., *et al.* (2005). Alcohol Needs Assessment Research Project (ANARP): the 2004 National Alcohol Needs Assessment for England. London: Department of Health.

Drummond, D., Tiffany, S. T., Glautier, S. E. & Remington, B. E. (1995). Addictive Behaviour: Theory and Practice. London: John Wiley & Sons.

Duka, T., Jackson, A., Smith, D. C. & Stephens, D. N. (1999). Relationship of components of an alcohol interoceptive stimulus to induction of desire for alcohol in social drinkers. Pharmacology, Biochemistry, and Behaviour, 64 (2), 301-309.

Duka, T., Tasker, R. & Stephens, D. N. (1998). Alcohol choice and outcome expectancies in social drinkers. Behavioural Pharmacology, 9 (7), 643-653.

Duka, T. & Townshend, J. M. (2004). The priming effect of alcohol pre-load on attentional bias to alcohol-related stimuli. Psychopharmacology, 176 (3-4), 353-361.

Duka, T., Townshend, J. M., Collier, K. & Stephens, D. N. (2003). Impairment in cognitive functions after multiple detoxifications in alcoholic inpatients. Alcoholism: Clinical and Experimental Research, 27 (10), 1563-1572.

Dunn, O. J. & Clark, V. A. (1969). Correlation coefficients measured on the same individuals. Journal of the American Statistical Association, 64 (325), 366-377.

Easdon, C., Izenberg, A., Armilio, M. L., Yu, H. & Alain, C. (2005). Alcohol consumption impairs stimulus- and error-related processing during a Go/No-Go Task. Cognitive Brain Research, 25 (3), 878-883.

Ehlers, C. L., Phillips, E., Sweeny, A. & Slawecki, C. J. (2003). Event-related potential responses to alcohol-related stimuli in African-American young adults: relation to family history of alcoholism and drug usage. Alcohol and Alcoholism, 38 (4), 332-338.

Eimer, M. (1993). Effects of attention and stimulus probability on ERPs in a go/nogo task. Biological Psychology, 35 (2), 123-138.

Eisenberg, D. T., Mackillop, J., Modi, M., Beauchemin, J., Dang, D., Lisman, S. A., Lum, J. K. & Wilson, D. S. (2007). Examining impulsivity as an endophenotype using a behavioural approach: a DRD2 Taql A and DRD4 48-bp VNTR association study. Behavioural and Brain Functions, 3 (2).

Engle, K. B. & Williams, T. K. (1972). Effect of an ounce of vodka on alcoholics' desire for alcohol. Quarterly Journal of Studies on Alcohol, 33 (4), 1099-1105.

Epping-Jordan, M. P., Watkins, S. S., Koob, G. F. & Markou, A. (1998). Dramatic decreases in brain reward function during nicotine withdrawal. Nature, 393 (6680), 76-79.

Erblich, J. & Earleywine, M. (1995). Drinking does not impair memory during intoxication: support for the attention-allocation model. Journal of Studies on Alcohol, 56 (4), 444-448.

Esposito-Smythers, C., Spirito, A., Rizzo, C., McGeary, J. E. & Knopik, V. S. (2010). Associations of the DRD2 TaqlA polymorphism with impulsivity and substance use: preliminary results from a clinical sample of adolescents. Pharmacology, Biochemistry, and Behaviour, 93 (9), 306-312.

Eysenck, S. B. G., Pearson, P. R., Easting, G. & Allsopp, J. P. (1985a). Age norms for impulsiveness, venturesomeness and empathy in adults. Personality and Individual Differences, 6 (5), 613-619.

Eysenck, S. B. G., Eysenck, H. J. & Barratt, P. (1985b). A revised version of the Psychoticism scale. Personality and Individual Differences, 6 (1), 21-29.

Falkenstein, M., Hoormann, J. & Hohnsbein, J. (1999). ERP components in go/nogo tasks and their relation to inhibition. Acta Psychologica, 101 (2-3), 267-291.

Fawcett, J. (1993). The morbidity and mortality of clinical depression. International Clinical Psychopharmacology, 8 (4), 217-220.

Fawcett, J., Clark, D. C., Scheftner, W. A. & Gibbons, R. D. (1983). Assessing anhedonia in psychiatric patients. Archives of General Psychiatry, 40 (1), 79-84.

Feil, J., Sheppard, D., Fitzgerald, P. B., Yücel, M., Lubman, D. I. & Bradshaw, J. L. (2010). Addiction, compulsive drug seeking and the role of frontostriatal mechanisms in regulating inhibitory control. Neuroscience and Biobehavioural Reviews, 35 (2), 248-275.

Fein, G. & Chang, M. (2006). Visual P300s in long-term abstinent chronic alcoholics. Alcoholism: Clinical and Experimental Research, 30 (12), 2000-2007.

Fernie, G, Cole, J. C., Goudie, A. J. & Field, M. (2010). Risk-taking but not response inhibition or delay discounting predict alcohol consumption in social drinkers. Drug and Alcohol Dependence, 112 (1-2), 54-61.

Fernie, G., Christiansen, P., Cole, J. C., Rose, A. K. & Field, M. (2012). Effects of 0.4 g/kg alcohol on attentional bias and alcohol-seeking behaviour in heavy and moderate social drinkers. Journal of Psychopharmacology, 26 (7), 1017-1025.

Field, M. & Christiansen, P. (2012). Commentary on, 'Internal reliability of measures of substance-related cognitive bias'. Drug and Alcohol Dependence, 124 (3), 189-190.

Field, M., Christiansen, P., Cole, J. & Goudie, A. (2007). Delay discounting and the alcohol Stroop in heavy drinking adolescents. Addiction, 102 (4), 579-586.

Field, M. & Cox, W. M. (2008). Attentional bias in addictive behaviours: a review of its development, causes, and consequences. Drug and Alcohol Dependence, 97 (1-2), 1-20.

Field, M., Mogg, K. & Bradley, B. P. (2004). Cognitive bias and drug craving in recreational cannabis users. Drug and Alcohol Dependence, 74 (1), 105-111.

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.

Fields, S., Leraas, K., Collins, C. & Reynolds, B. (2009). Delay discounting as a mediator of the relationship between perceived stress and cigarette smoking status in adolescents. Behavioural Pharmacology, 20 (5-6), 455-460.

Fillmore, M. T. & Vogel-Sprott, M. (1998). Behavioural impairment under alcohol: cognitive and pharmacokinetic factors. Alcoholism: Clinical and Experimental Research, 22 (7), 1476-1482.

Fillmore, M. T. & Vogel-Sprott, M. (1999). An alcohol model of impaired inhibitory control and its treatment in humans. Experimental and Clinical Psychopharmacology, 7 (1), 49-55.

Fisk, A. D. & Scerbo, M. W. (1987). Automatic and control processing approach to interpreting vigilance performance: a review and reevaluation. Human Factors, 29 (6), 653-660.

Flannery, B. A., Roberts, A. J., Cooney, N., Swift, R. M., Anton, R. F. & Rohsenow, D. J. (2001). The role of craving in alcohol use, dependence, and treatment. Alcoholism: Clinical and Experimental Research, 25 (2), 299-308.

Fraeyman, N. H. & Vermis, K. (2003). Cellular activity of dopamine DA2 receptor splice variants and mutants. Pharmacological Research, 48 (5), 535-540.

Franken, I. H. A. (2003). Drug craving and addiction: integrating psychological and neuropsychopharmacological approaches. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 27 (4), 563-579.

Franken, I. H., Dietvorst, R. C., Hesselmans, M., Franzek, E. J., van de Wetering, B. J. & Van Strien, J. W. (2008). Cocaine craving is associated with electrophysiological brain responses to cocaine-related stimuli. Addiction Biology, 13 (3-4), 386-392.

Franken, I. H., Kroon, L. Y. & Hendriks, V. M. (2000). Influence of individual differences in craving and obsessive cocaine thoughts on attentional processes in cocaine abuse patients. Addictive Behaviours, 25 (1), 99-102.

Franken, I. H. A., Rassin, E. & Muris, P. (2007). The assessment of anhedonia in clinical and non-clinical populations: further validation of the Snaith-Hamilton Pleasure Scale (SHPS). Journal of Affective Disorders, 99 (1), 83-89.

Franken, I. H. A., Stam, C. J., Hendriks, V. M. & van den Brink, W. (2003). Neurophysiological evidence for abnormal cognitive processing of drug cues in heroin dependence. Psychopharmacology, 170 (2), 205-212.

Gaeta, H., Friedman, D., Ritter, W. & Cheng, J. (1998). An event-related potential study of age-related changes in sensitivity to stimulus deviance. Neurobiology of Aging, 19 (5), 447-459.

Gardner, B., Hall, D. A. & Strange, P. G. (1996). Pharmacological analysis of dopamine stimulation of [35S]-GTP gamma S binding via human D2short and D2long dopamine receptors expressed in recombinant cells. British Journal of Pharmacology, 118 (6), 1544-1550.

Gawin, F. H. & Ellinwood, E. H. Jr. (1988). Cocaine and other stimulants. Actions, abuse, and treatment. New England Journal of Medicine, 318 (18), 1173-1182.

Genkina, O. A. & Shostakovich, G. S. (1987). Cortical evoked activity in the process of elaborating a conditioned connection using an unrecognisable word. Fiziologia Cheloveka, 13 (3), 369-378.

George, D. & Mallery, P. (2003). SPSS for Windows Step By Step: a Simple Guide and Reference. 11.0 Update (4th Ed.). Boston: Allyn & Bacon.

George, M. S., Anton, R. F., Bloomer, C., Teneback, C., Drobes, D. J., Lorberbaum, J. P., Nahas, Z. & Vincent, D. J. (2001). Activation of prefrontal cortex and anterior thalamus in alcoholic subjects on exposure to alcohol-specific cues. Archives of General Psychiatry, 58 (4), 345-352.

Goldstein, R. Z. & Volkow, N. D. (2002). Drug addiction and its underlying neurobiological basis: neuroimaging evidence for the involvement of the frontal cortex. American Journal of Psychiatry, 159 (10), 1642-1652.

Goldstein, R. Z. & Volkow, N. D. (2011). Dysfunction of the prefrontal cortex in addiction: neuroimaging findings and clinical implications. Nature Reviews. Neuroscience, 12 (11), 652-669.

Goudriaan, A. E., Oosterlaan, J., de Buers, E. & van den Brink, W. (2006). Neurocognitive functions in pathological gambling: a comparison with alcohol dependence, Tourette syndrome and normal controls. Addiction, 101 (4), 534-547.

Grace, A. A. (2000). The tonic/phasic model of dopamine system regulation and its implications for understanding alcohol and psychostimulant craving. Addiction, 95 (Supplement 2), S119-S128.

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.

Gray, J. A., Young, A. M. & Joseph, M. H. (1997). Dopamine's role. Science, 278 (5343), 1548-1549.

Greeley, J. D., Swift, W., Prescott, J. & Heather, N. (1993). Reactivity to alcohol-related cues in heavy and light drinkers. Journal of Studies on Alcohol, 54 (3), 359-368.

Green, M. J. & Benzeval, M. (2011). Ageing, social class and common mental disorders: longitudinal evidence from three cohorts in the West of Scotland. Psychological Medicine, 41 (3), 565-574.

Gross, T. M., Jarvik, M. E. & Rosenblatt, M. R. (1993). Nicotine abstinence produces content-specific Stroop interference. Psychopharmacology, 110 (3), 333-336.

Grønbæk, M. (2011). The positive and negative health effects of alcohol – and the public health implications. Journal of Internal Medicine, 265 (4), 407-420.

Grüsser, S. M., Mörsen, C. P. & Flor, H. (2006). Alcohol craving in problem and occasional alcohol drinkers. Alcohol and Alcoholism, 41 (4), 421-425.

Guillot, C. R., Fanning, J. R., Bullock, J. S., McCloskey, M. S. & Berman, M. E. (2011). Effects of alcohol on tests of executive functioning in men and women: a dose response examination. Experimental and Clinical Psychopharmacology, 18 (5), 409-417.

Guiramand, J., Montmayeur, J. P., Ceraline, J., Bhatia, M. & Borrelli, E. (1995). Alternative splicing of the dopamine D2 receptor directs specificity of coupling to G-proteins. The Journal of Biological Chemistry, 270 (13), 7354-7358.

Gunnarsson, M., Petter Gustavsson, J., Tengstrom, A., Franck, J. & Fahlke, C. (2008). Personality traits and their associations with substance use among adolescents. Personality and Individual Differences, 45 (5), 356-360.

Habeych, M. E., Folan, M. M., Luna, B. & Tarter, R. E. (2006). Impaired oculomotor response inhibition in children of alcoholics: the role of attention deficit hyperactivity disorder. Drug and Alcohol Dependence, 82 (1), 11-17.

Hada, M., Porjesz, B., Begleiter, H. & Polich, J. (2000). Auditory P3a assessment of male alcoholics. Biological Psychiatry, 48 (4), 276-286.

Hair Jr, J. F., Black, W. C., Babin, B. J. & Anderson, R. E. (2008). Multivariate Data Analysis: a Global Perspective (7th Ed.). United States of America: Pearson Education.

Hallman, J., von Knorring, A. L., von Knorring, L. & Oreland, L. (1990). Clinical characteristics of female alcoholics with low platelet monoamine oxidase activity. Alcoholism: Clinical and Experimental Research, 14 (2), 227-231.

Hamilton, K. R., Sinha, R. & Potenza, M. N. (2012). Hazardous drinking and dimensions of impulsivity, behavioural approach and inhibition in adult men and women. Alcoholism: Clinical and Experimental Research, 36 (6), 958-966.

Handy, T. C. (2005). Event-Related Potentials: a Methods Handbook. London, England: the MIT Press.

Hansenne, M. (2000). The P300 cognitive event-related potential. II. Individual variability and clinical application in psychopathology. Clinical Neurophysiology, 30 (4), 211-231.

Heil, S. H., Johnson, M. W., Higgins, S. T. & Bickel, W. K. (2006). Delay discounting with currently using and currently abstinent cocaine-dependent outpatients and non-drug-using matched controls. Addictive Behaviours, 31 (7), 1290-1294.

Heinz, A., Beck, A., Grüsser, S. M., Grace, A. A. & Wrase, J. (2009). Identifying the neural circuitry of alcohol craving and relapse vulnerability. Addiction Biology, 14 (1), 108-118.

Heinz, A., Lichtenberg-Kraag, B., Baum, S. S., Graf, K., Kruger, F., Dettling, M. & Rommelspacher, H. (1995). Evidence for prolonged recovery of dopaminergic transmission after detoxification in alcoholics with poor treatment outcome. Journal of Neurotransmission, General Section, 102 (2), 149-157.

Heinz, A., Schmidt, L. G. & Reischies, F. M. (1994). Anhedonia in schizophrenic, depressed, or alcohol-dependent patients—neurobiological correlates. Pharmacopsychiatry, 27 (Supplement 1), S7-S10.

Heinz, A., Siessmeier, T., Wrase, J., Hermann, D., Klein, S., Grüsser, S. M., Flor, H., Braus, D. F., Buchholz, H. G., Gründer, G., Schreckenberger, M., Smolka, M. N., Rösch, F., Mann, K. & Bartenstein, P. (2004). Correlation between dopamine D(2) receptors in the ventral striatum and central processing of alcohol cues and craving. American Journal of Psychiatry, 161 (10), 1783-1789.

Heinze, M., Wölfling, K. & Grüsser, S. M. (2007). Cue-induced auditory evoked potentials in alcoholism. Clinical Neurophysiology, 118 (4), 856-862.

Henges, A. L. & Marczinski, C. A. (2012). Impulsivity and alcohol consumption in young social drinkers. Addictive Behaviours, 37 (2), 217-220.

Herrmann, M. J., Weijers, H. G., Wiesbeck, G. A., Aranda, D., Böning, J. & Fallgatter, A. J. (2000). Event-related potentials and cue-reactivity in alcoholism. Alcohol: Clinical and Experimental Research, 24 (11), 1724-1729.

Herrmann, M. J., Weijers, H. G., Wiesbeck, G. A., Böning, J. & Fallgatter, A. J. (2001). Alcohol cue-reactivity in heavy and light social drinkers as revealed by event-related potentials. Alcohol and Alcoholism, 36 (6), 588-593.

Hodgson, R., Rankin, H. & Stockwell, T. (1979). Alcohol dependence and the priming effect. Behaviour Research and Therapy, 17 (4), 379-387.

Holdstock, L., King, A. C. & de Wit, H. (2000). Subjective and objective responses to ethanol in moderate/heavy and light social drinkers. Alcoholism: Clinical and Experimental Research, 24 (6), 789-794.

Hutchison, K. E., Swift, R., Rohsenow, D. J., Monti, P. M., Davidson, D. & Almeida, A. (2001). Olanzapine reduces urge to drink after drinking cues and a priming dose of alcohol. Psychopharmacology, 155 (1), 27-34.

Hyman, S. E. & Malenka, R. C. (2001). Addiction and brain: the neurobiology of compulsion and its persistence. Nature Reviews, Neuroscience, 2 (10), 695-703.

Janiri, L., Martinotti, G., Dario, T., Reina, D., Paparello, F., Pozzi, G., Addolorato, G., Di Giannantonio, M. & De Risio, S. (2005). Anhedonia and substance-related symptoms in detoxified substance-dependent patients: a correlation study. Neuropsychobiology, 52 (1), 37-44.

Jentsch, J. D. & Taylor, J. R. (1999). Impulsivity resulting from frontostriatal dysfunction in drug abuse: implications for the control of behaviour by reward-related stimuli. Psychopharmacology, 146 (4), 373-390.

Jodo, E. & Inoue, K. (1990). Effects of practice on the P300 in a go/nogo task. Electroencephalography and Clinical Neurophysiology, 76 (3), 249-257.

Jodo, E. & Kayama, Y. (1992). Relation of a negative ERP component to response inhibition in a go/no-go task. Electroencephalography and Clinical Neurophysiology, 82 (6), 477-482.

Johnsen, B. H., Laberg, J. C., Cox, W. M., Vaksdal, A. & Hugdahl, K. (1994). Alcoholic subjects' attentional bias in the processing of alcohol-related words. Psychology of Addictive Behaviours, 8 (2), 111-115.

Johnsen, B. H., Thayer, J. F., Laberg, J. C. & Asbjornsen, A. E. (1997). Attentional bias in active smokers, abstinent smokers, and nonsmokers. Addictive Behaviours, 22 (6), 813-817.

Johnson, R. (1986). A triarchic model of P300 amplitude. Psychophysiology, 23 (4), 367-384.

Johnson, R. (1995). Event-related potential insights into the neurobiology of memory systems. In Boller, F., & Grafman, J. (Eds.), Handbook of Neuropsychology Vol. 10 (pp. 135-163). Amsterdam: Elsevier.

Jones, A., Guerrieri, R., Fernie, G., Cole, J., Goudie, A. & Field, M. (2011). The effects of priming restrained versus disinhibited behaviour on alcohol-seeking in social drinkers. Drug and Alcohol Dependence, 113 (1), 55-61.

Jones, B. T. & Schulze, D. (2000). Alcohol-related words of positive affect are more accessible in social drinkers' memory than are other words when sip-primed by alcohol. Addiction Research and Theory, 8 (3), 221-232.

Julien, R. M. (2005). A Primer of Drug Action (10th Ed.). New York: Worth Publishers.

Junghanns, K., Tietz, U., Dibbelt, L., Keuther, M., Jurth, R., Ehrenthal, D., Blank, S. & Backhaus, J. (2005). Attenuated salivary cortisol secretion under cue exposure is associated with early relapse. Alcohol and Alcoholism, 40 (1), 80-85.

Kaiser, S., Unger, J., Kiefer, M., Markela, J., Mundt, C. & Weisbrod, M. (2003). Executive control deficit in depression: event-related potentials in a go/nogo task. Psychiatry Research, 122 (3), 169-184.

Kamarajan, C., Porjesz, B., Jones, K. A., Choi, K., Chorlian, D. B., Padmanabhapillai, A., Rangaswamy, M., Stimus, A. T. & Begleiter, H. (2004). The role of brain oscillations as functional correlates of cognitive systems: a study of frontal inhibitory control in alcoholism. International Journal of Psychophysiology, 51 (2), 155-180.

Kamarajan, C., Porjesz, B., Jones, K. A., Choi, K., Chorlian, D. B., Padmanabhapillai, A., Rangaswamy, M., Stimus, A. T. & Begleiter, H. (2005a). Alcoholism is a disinhibitory disorder: neurophysiological evidence from a Go/No-Go task. Biological Psychology, 69 (3), 353-373.

Kamarajan, C., Porjesz, B., Jones, K. A., Chorlian, D. B., Padmanabhapillai, A., Rangaswamy, M., Stimus, A. T. & Begleiter, H. (2005b). Spatial-anatomical mapping of No-Go P3 in the offspring of alcoholics: evidence of cognitive and neural disinhibition as a risk for alcoholism. Clinical Neurophysiology, 116 (5), 1049-1061.

Kaplan, R. F., Cooney, N. L., Baker, L. H., Gillespie, R. A., Meyer, R. E. & Pomerleau, O. F. (1985). Reactivity to alcohol-related cues: physiological and subjective responses in alcoholics and non-problem drinkers. Journal of Studies on Alcohol, 46 (4), 267-272.

Kasar, M., Gleichgerrcht, E., Keskinkilic, C., Tabo, A. & Manes, F. F. (2010). Decision-making in people who relapsed to driving under the influence of alcohol. Alcoholism: Clinical and Experimental Research, 34 (12), 2162-2168.

Katayama, J. & Polich, J. (1998). Stimulus context determines P3a and P3b. Psychophysiology, 35 (1), 23-33.

Kavanagh, D. J., Andrade, J. & May, J. (2005). Imaginary relish and exquisite torture: the elaborated intrusion theory of desire. Psychological Review, 112 (2), 446-467.

Kelley, A. E. & Berridge, K. C. (2002). The neuroscience of natural rewards: relevance to addictive drugs. Journal of Neuroscience, 22 (9), 3306-3311.

Ketzenberger, K. E. & Forrest, L. (2000). Impulsiveness and compulsiveness in alcoholics and nonalcoholics. Addictive Behaviours, 25 (5), 791-795.

Kirby, K. N. & Petry, N. M. (2004). Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. Addiction, 99 (4), 461-471.

Kirk, J. M. & de Wit, H. (2000). Individual differences in the priming effect of ethanol in social drinkers. Journal of Studies on Alcohol, 61 (1), 64-71.

Klein, A. A. (2007). Suppression-induced hyperaccessibility of thoughts in abstinent alcoholics: a preliminary investigation. Behaviour Research and Therapy, 45 (1), 169-177.

Klein, D. F. (1974). Endogenomorphic depression. A conceptual and terminological revision. Archives of General Psychiatry, 31 (4), 447-454.

Kollins, S. H. (2003). Delay discounting is associated with substance use in college students. Addictive Behaviour, 28 (6), 1167-1173.

Koob, G. F. & Le Moal, M. (2001). Drug addiction, dysregulation of reward, and allostasis. Neuropsychopharmacology, 24 (2), 97-129.

Koob, G. F. & Volkow, N. D. (2010). Neurocircuitry of addiction. Neuropsychopharmacology, 35 (1), 217-238.

Kozlowski, L. T. & Wilkinson, D. A. (1987). Use and misuse of the concept of craving by alcohol, tobacco and drug researchers. British Journal of Addiction, 82 (1), 31-45.

Kril, J. J., Halliday, G. M., Svoboda, M. D. & Cartwright, H. (1997). The cerebral cortex is damaged in chronic alcoholics. Neuroscience, 79 (4), 983-998.

Kubota, M., Nakazaki, S., Hirai, S., Saeki, N., Yamaura, A. & Kusaka, T. (2001). Alcohol consumption and frontal lobe shrinkage: study of 1432 non-alcoholic subjects. Journal of Neurology, Neurosurgery and Psychiatry, 71 (1), 104-106.

Kutas, M., McCarthy, G. & Donchin, E. (1977). Augmenting mental chronometry: The P300 as a measure of stimulus evaluation time. Science, 197 (4305), 792-795.

Laine, T. P., Ahonen, A., Torniainen, P., Heikkilä, J., Pyhtinen, J., Räsänen, P., Niemalä, O. & Hillbom, M. (1999). Dopamine transporters increase in human brain after alcohol withdrawal. Molecular Psychiatry, 4 (2), 189-191.

Lane, S. D., Moeller, F. G., Steinberg, J. L., Buzby, M. & Kosten, T. R. (2007). Performance of cocaine-dependent individuals and controls on a response inhibition task with varying levels of difficulty. American Journal of Drug and Alcohol Abuse, 33 (5), 717-726.

Lang, P. J., Bradley, M. M. & Cuthbert, B. N. (1997). Motivated attention: affect, activation, and action. In Lang, P. J., Simons, R. F., & Balaban, M. T. (Eds.),

Attention and Orienting: Sensory and Motivational Processes (pp. 97-136). Hillsdale, NJ: Erlbaum.

Laucht, M., Becker, K., Blomeyer, D. & Schmidt, M. H. (2007). Novelty seeking involved in mediating the association between the dopamine D4 receptor gene exon III polymorphism and heavy drinking in male adolescents: results from a high-risk community sample. Biological Psychiatry, 61 (1), 87-92.

Lawrence, A. J., Luty, J., Bogdan, N. A., Sahakian, B. J. & Clark, L. (2009). Impulsivity and response inhibition in alcohol dependence and problem gambling. Psychopharmacology, 207 (1), 163-172.

Lee, G. A. & Forsythe, M. (2011). Is alcohol more dangerous than heroin? The physical, social and financial costs of alcohol. International Emergency Nursing, 19 (3), 141-145.

Li, C. S., Chao, H. H. & Lee, T. W. (2009). Neural correlates of speeded as compared with delayed responses in a stop signal task: an indirect analog of risk taking and association with an anxiety trait. Cerebral Cortex, 19 (4), 839-848.

Li, C. S., Luo, X., Yan, P., Bergquist, K. & Sinha, R. (2009). Altered impulse control in alcohol dependence: neural measures of stop signal performance. Alcoholism: Clinical and Experimental Research, 33 (4), 740-750.

Limosin, F., Loze, J. Y., Dubertret, C., Gouya, L., Adès, J., Rouillon, F. & Gorwood, P. (2003). Impulsiveness as the intermediate link between the dopamine receptor D2 gene and alcohol dependence. Psychiatric Genetics, 13 (2), 127-129.

Loas, G., Dubal, S., Perot, P., Tirel, F., Nowaczkowski, P. & Pierson, A. (1997). [Validation of the French version of the Snaith-Hamilton Pleasure Scale (SHAPS; Snaith *et al*., 1995). Determination of the statistical parameters in 208 normal subjects and 103 hospitalised patients presenting with depression or schizophrenia] [Article in French]. Encephale, 23 (6), 454-458.

Loeber, S. & Duka, T. (2009). Acute alcohol impairs conditioning of a behavioural reward-seeking response and inhibitory control processes—implications for addictive disorders. Addiction, 104 (12), 2013-2022.

Loeber, S., Duka, T., Welzel, H., Nakovics, H., Heinz, A., Flor, H. & Mann, K. (2009a). Impairment of cognitive abilities and decision making after chronic use of alcohol: the impact of multiple detoxifications. Alcohol and Alcoholism, 44 (4), 372-381.

Loeber, S., Duka, T., Welzel Márquez, H., Nakovics, H., Heinz, A., Mann, K. & Flor, H. (2010). Effects of repeated withdrawal from alcohol on recovery of cognitive impairment under abstinence and rate of relapse. Alcohol and Alcoholism, 45 (6), 541-547.

Loeber, S., Kiefer, F., Wagner, F., Mann, K. & Croissant, B. (2009b). [Treatment outcome after inpatient alcohol withdrawal: impact of motivational interventions: a comparative study]. Nervenarzt, 80 (9), 1085-1092.

Logan, G. D. (1994). On the ability to inhibit thought and action: users' guide to the stop signal paradigm. In Dagenbach, D. & Carr, T. H. (Eds.), Inhibitory Processes in Attention, Memory, and Language (pp. 189-239). New York: Academic Press.

London, E. D., Berman, S. M., Mohammadian, P., Ritchie, T., Mandelkern, M. A., Susselman, M. K., Schlagenhauf, F. & Noble, E. P. (2009). Effect of the TaqIA polymorphism on ethanol response in the brain. Psychiatry Research, 174 (3), 163-170.

London, E. D., Ernst, M., Grant, S., Bonson, K. & Weinstein, A. (2000). Orbitofrontal cortex and human drug abuse: functional imaging. Cerebral Cortex, 10 (3), 334-342.

Lovinger, D. M. (1993). Excitotoxicity and alcohol-related brain damage. Alcoholism: Clinical and Experimental Research, 17 (1), 19-27.

Lubman, D. I., Yücel, M. & Pantelis, C. (2004). Addiction, a condition of compulsive behaviour? Neuroimaging and neuropsychological evidence of inhibitory dysregulation. Addiction, 99 (12), 1491-1502.

Ludwig, A. M. & Wikler, A. (1974). "Craving" and relapse to drink. Quarterly Journal of Studies on Alcohol, 35 (1), 108-130.

Lusher, J., Chandler, C. & Ball, D. (2004). Alcohol dependence and the alcohol Stroop paradigm: evidence and issues. Drug and Alcohol Dependence, 75 (3), 225-231.

Lyvers, M., Duff, H., Basch, V. & Edwards, M. S. (2012). Rash impulsiveness and reward sensitivity in relation to risky drinking by university students: potential roles of frontal systems. Addictive Behaviours, 37 (8), 940-946.

MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. A., Sweet, L. H. & Munafò, M. R. (2011). Delayed reward discounting and addictive behaviour: a meta-analysis. Psychopharmacology, 216 (3), 305-321.

MacKillop, J., Miranda, R Jr., Monti, P. M., Ray, L. A., Murphy, J. G., Rohsenow, D. J., McGeary, J. E., Swift, R. M., Tidey, J. W. & Gwaltney, C. J. (2010). Alcohol demand, delayed reward discounting, and craving in relation to drinking and alcohol use disorders. Journal of Abnormal Psychology, 119 (1), 106-114.

MacKillop, J., Mattson, R. E., Anderson MacKillop, E. J., Castelda, B. A. & Donovick, P. J. (2007). Multidimensional assessment of impulsivity in undergraduate hazardous drinkers and controls. Journal of Studies on Alcohol and Drugs, 68 (6), 785-788.

Madden, G. J., Petry, N. M., Badger, G. J. & Bickel, W. K. (1997). Impulsive and self-control choices in opioid-dependent patients and non-drug-using control participants: drug and monetary rewards. Experimental and Clinical Psychopharmacology, 5 (3), 256-262.

Makris, N., Oscar-Berman, M., Jaffin, S. K., Hodge, S. M., Kennedy, D. N., Caviness, V. S., Marinkovic, K., Breiter, H. C., Gasic, G. P. & Harris, G. J. (2008). Decreased

volume of the brain reward system in alcoholism. Biological Psychiatry, 64 (3), 192-202.

Malmberg, M., Overbeek, G., Monshouwer, K., Lammers, J., Vollebergh, W. A. & Engels, R. C. (2010). Substance use risk profiles and associations with early substance use in adolescence. Journal of Behavioural Medicine, 33 (6), 474-485.

Mann, R. E., Sobell, L. C., Sobell, M. B. & Pavan, D. (1985). Reliability of a family tree questionnaire for assessing family history of alcohol problems. Drug and Alcohol Dependence, 15 (1-2), 61-67.

Marczinski, C. A., Abroms, B. D., Van Selst, M. & Fillmore, M. T. (2005). Alcohol-induced impairment of behavioural control: differential effects of engaging vs. disengaging responses. Psychopharmacology, 182 (3), 452-459.

Marczinski, C. A., Combs, S. W. & Fillmore, M. T. (2007). Increased sensitivity to the disinhibiting effects of alcohol in binge drinkers. Psychology of Addictive Behaviours, 21 (3), 346-354.

Marlatt, G. A., Demming, B. & Reid, J. B. (1973). Loss of control drinking in alcoholics: an experimental analogue. Journal of Abnormal Psychology, 81 (3), 233-241.

Marra, D., Warot, D., Payan, C., Hispard, E., Dally, S. & Puech, A. J. (1998). Anhedonia and relapse in alcoholism. Psychiatry Research, 80 (2), 187-196.

Marsh, D. M., Dougherty, D. M., Moeller, F. G., Swann, A. C. & Spiga, R. (2002). Laboratory-measured aggressive behaviour of women: acute tryptophan depletion and augmentation. Neuropsychopharmacology, 26 (5), 660-671.

Martin, M., Williams, R. M. & Clark, D. M. (1991). Does anxiety lead to selective processing of threat-related information? Behaviour Research and Therapy, 29 (2), 147-160.

Martinez, D., Broft, A., Foltin, R. W., Slifstein, M., Hwang, D. R., Huang, Y., Perez, A., Frankle, W. G., Cooper, T., Kleber, H. D., Fischman, M. W. & Laruelle, M.

(2004). Cocaine dependence and D_2 receptor availability in the functional subdivisions of the striatum: relationship with cocaine-seeking behaviour. Neuropsychopharmacology, 29 (6), 1190-1202.

Martinez, D., Gil, R., Slifstein, M., Hwang, D. R., Huang, Y., Perez, A., Kegeles, L., Talbot, P., Evans, S., Krystal, J., Laruelle, M. & Abi-Dargham, A. (2005). Alcohol dependence is associated with blunted dopamine transmission in the ventral striatum. Biological Psychiatry, 58 (10), 779-786.

Martinez, D., Narendran, R., Foltin, R. W., Slifstein, M., Hwang, D. R., Broft, A., Huang, Y., Cooper, T. B., Fischman, M. W., Kleber, H. D. & Laruelle, M. (2007). Amphetamine-induced dopamine release: markedly blunted in cocaine dependence and predictive of the choice to self-administer cocaine. American Journal of Psychiatry, 164 (4), 622-629.

Mason, O., Startup, M., Halpin, S., Schall, U., Conrad, A. & Carr, V. (2004). Risk factors for transition to first episode psychosis among individuals with 'at-risk mental states'. Schizophrenia Research, 71 (2-3), 227-237.

Mathias, C. W., Dougherty, D. M., Marsh, D. M., Moeller, F. G., Hicks, L. R., Dasher, K. & Bar-Eli, L. (2002). Laboratory measures of impulsivity: a comparison of women with or without childhood aggression. The Psychological Record, 52 (3), 289-303.

Mazas, C. A., Finn, P. R. & Steinmetz, J. E. (2000). Decision-making biases, antisocial personality, and early-onset alcoholism. Alcoholism: Clinical and Experimental Research, 24 (7), 1036-1040.

McAdams, K. K. & Donnellan, M. B. (2009). Facets of personality and drinking in first-year college students. Personality and Individual Differences, 46 (2), 207-212.

McCabe, S. E. & Teter, C. J. (2007). Drug use related problems among non-medical users of prescription stimulants: a web-based survey of college students from a mid-western university. Drug and Alcohol Dependence, 91 (1), 69-76.

McCusker, C. G. & Brown, K. (1990). Alcohol-predictive cues enhance tolerance to and precipitate “craving” for alcohol in social drinkers. Journal of Studies on Alcohol, 51 (6), 494-499.

McCusker, C. G. & Brown, K. (1995). Cue-exposure to alcohol-associated stimuli reduces autonomic reactivity, but not craving and anxiety, in dependent drinkers. Alcohol and Alcoholism, 30 (3), 319-327.

McDonough, B. E. & Warren, C. A. (2001). Effects of 12-hour tobacco deprivation on event-related potentials elicited by visual smoking cues. Psychopharmacology, 154 (3), 282-291.

McKay, D. & Schare, M. L. (1999). The effects of alcohol and alcohol expectancies on subjective reports and physiological reactivity: a meta-analysis. Addictive Behaviours, 24 (5), 633-647.

McManus, S., Meltzer, H., Brugha, T., *et al.* (2009). Adult Psychiatric Morbidity in England, 2007: Results of a Household Survey. Leeds: NHS Information Centre for Health and Social Care.

Mehrabian, A. & Russell, J. A. (1978). A questionnaire measure of habitual alcohol use. Psychological Reports, 43 (3 Part 1), 803-806.

Merry, J. (1966). The “loss of control” myth. Lancet, 1 (7449), 1257-1258.

Miller, M. A. & Fillmore, M. T. (2011). Persistence of attentional bias toward alcohol-related stimuli in intoxicated social drinkers. Drug and Alcohol Dependence, 117 (2-3), 184-189.

Miller, N. S., Summers, G. L. & Gold, M. S. (1993). Cocaine dependence: alcohol and other drug dependence and withdrawal characteristics. Journal of Addictive Diseases, 12 (1), 25-35.

Mintzer, M. Z., Copersino, M. L. & Stitzer, M. L. (2005). Opioid abuse and cognitive performance. Drug and Alcohol Dependence, 78 (2), 225-230.

Mitchell, J. M., Fields, H. L., D'Esposito, M. & Boettiger, C. A. (2005). Impulsive responding in alcoholics. Alcoholism: Clinical and Experimental Research, 29 (12), 2158-2169.

Mitchell, J. M., Tavares, V. C., Fields, H. L., D'Esposito, M. & Boettiger, C. A. (2007). Endogenous opioid blockade and impulsive responding in alcoholics and healthy controls. Neuropsychopharmacology, 32 (2), 439-449.

Modell, J. G., Glaser, F. B., Cyr, L. & Mountz, J. M. (1992). Obsessive and compulsive characteristics of craving for alcohol in alcohol abuse and dependence. Alcoholism: Clinical and Experimental Research, 16 (2), 272-274.

Moeller, F. G., Barratt, E. S., Dougherty, D. M., Schmitz, J. M. & Swann, A. C. (2001). Psychiatric aspects of impulsivity. American Journal of Psychiatry, 158 (11), 1783-1789.

Mogg, K. & Bradley, B. P. (2002). Selective processing of smoking-related cues in smokers: manipulation of deprivation level and comparison of three measures of processing bias. Journal of Psychopharmacology, 16 (4), 385-392.

Moore, S. C. & Cusens, B. (2010). Delay discounting predicts increase in blood level in social drinkers. Psychiatry Research, 179 (3), 324-327.

Moreno, M., Estevez, A. F., Zaldivar, F., Montes, J. M., Gutiérrez-Ferre, V. E., Esteban, L., Sánchez-Santed, F. & Flores, P. (2012). Impulsivity differences in recreational cannabis users and binge drinkers in a university population. Drug and Alcohol Dependence, 124 (3), 355-362.

Mossberg, D., Liljeberg, P. & Borg, S. (1985). Clinical conditions in alcoholics during long-term abstinence: a descriptive, longitudinal treatment study. Alcohol, 2 (3), 551-553.

Munafó, M., Mogg, K., Roberts, S., Bradley, B. P. & Murphy, M. (2003). Selective processing of smoking-related cues in current smokers, ex-smokers and

never smokers on the modified Stroop task. Journal of Psychopharmacology, 17 (3), 310-316.

Murphy, P. & Garavan, H. (2011). Cognitive predictors of problem drinking and AUDIT scores among college students. Drug and Alcohol Dependence, 115 (1-2), 94-100.

Nakonezny, P. A., Carmody, T. J., Morris, D. W., Kurian, B. T. & Trivedi, M. H. (2010). Psychometric evaluation of the Snaith-Hamilton pleasure scale in adult outpatients with major depressive disorder. International Clinical Psychopharmacology, 25 (6), 328-333.

Namkoong, K., Lee, E., Lee, C. H., Lee, B. O. & An, S. K. (2004). Increased P3 amplitudes induced by alcohol-related pictures in patients with alcohol dependence. Alcoholism: Clinical and Experimental Research, 28 (9), 1317-1323.

National Collaborating Centre for Mental Health (2011). Alcohol-Use Disorders: The NICE Guideline on Diagnosis, Assessment and Management of Harmful Drinking and Alcohol Dependence: Commissioned by The National Institute for Health and Clinical Excellence. Great Britain: The British Psychological Society and The Royal College of Psychiatrists.

Navarro, H. J., Doran, C. M. & Shakeshaft, A. P. (2011). Measuring costs of alcohol harm to others: a review of the literature. Drug and Alcohol Dependence, 114 (2-3), 87-99.

Newman, J. P. & Kosson, D. S. (1986). Passive avoidance learning in psychopathic and non-psychopathic offenders. Journal of Abnormal Psychology, 95 (3), 252-256.

The NHS Information Centre (2008). Statistics on Alcohol: England, 2008. London: The NHS Information Centre.

Niaura, R. S., Rohsenow, D. J., Binkoff, J. A., Monti, P. M., Pedraza, M. & Abrams, D. B. (1988). Relevance of cue reactivity to understanding alcohol and smoking relapse. Journal of Abnormal Psychology, 97(2), 133-152.

Noble, E. P. (2000). Addiction and its reward process through polymorphisms of the D_2 dopamine receptor gene: a review. European Psychiatry, 15 (2), 79-89.

Noël, X., Colmant, M., Van Der Linden, M., Bechara, A., Bullens, Q., Hanak, C. & Verbanck, P. (2006). Time course of attention for alcohol cues in abstinent alcoholic patients: the role of initial orienting. Alcoholism: Clinical and Experimental Research, 30 (11), 1871-1877.

Noël, X., Paternot, J., Van der Linden, M., Sferrazza, R., Verhas, M., Hanak, C., Kornreich, C., Martin, P., De Mol, J., Pelc, I. & Verbanck, P. (2001). Correlation between inhibition, working memory and delimited frontal area blood flow measure by 99mTc-Bicisate SPECT in alcohol-dependent patients. Alcohol and Alcoholism, 36 (6), 556-563.

Nordquist, N., Göktürk, C., Comasco, E., Nilsson, K. W., Oreland, L. & Hallman, J. (2009). Transcription factor AP2 beta involved in severe female alcoholism. Brain Research, 1305 (Supplement), S20-S26.

Oddy, B. W. & Barry, R. J. (2009). The relationship of N2 and P3 to inhibitory processing of social drinkers in a Go/No-Go task. International Journal of Psychophysiology, 72 (3), 323-330.

Oei, T. I., Verhoeven, W. M., Westenberg, H. G., Zwart, F. M. & van Ree, J. M. (1990). Anhedonia, suicide ideation, and dexamethasone nonsuppression in depressed patients. Journal of Psychiatric Research, 24 (1), 25-35.

Office for National Statistics (2001). Living in Britain: Results from the 2000/01 General Household Survey. London: The Stationary Office.

Olmstead, M. C. (2006). Animal models of drug addiction: where do we go from here? Quarterly Journal of Experimental Psychology, 59 (4), 625-653.

Ortner, C. N., MacDonald, T. K. & Olmstead, M. C. (2003). Alcohol intoxication reduces impulsivity in the delay-discounting paradigm. Alcohol and Alcoholism, 38 (2), 151-156.

Palomba, D., Angrilli, A. & Mini, A. (1997). Visual evoked potentials, heart rate responses, and memory to emotional pictorial stimuli. International Journal of Psychophysiology, 27 (1), 55-67.

Papachristou, H., Nederkoorn, C., Havermans, R., van der Horst, M. & Jansen, A. (2012). Can't stop the craving: the effect of impulsivity on cue-elicited craving for alcohol in heavy and light social drinkers. Psychopharmacology, 219 (2), 511-518.

Patel, R. M. (1988). Ethanol's effect on human vigilance during a simple task in the presence of an auditory stressor. Psychological Reports, 63 (2), 363-366.

Patton, J. H., Stanford, M. S. & Barratt, E. S. (1995). Factor structure of the Barratt Impulsiveness Scale. Journal of Clinical Psychology, 51 (6), 768-774.

Pauli, P., Dengler, W., Wiedemann, G., Montoya, P., Flor, H., Birbaumer, N. & Buchkremer, G. (1997). Behavioural and neurophysiological evidence for altered processing of anxiety-related words in panic disorder. Journal of Abnormal Psychology, 106 (2), 213-220.

Payne, T. J., Rychtarik, R. G., Rappaport, N. B., Smith, P. O., Etscheidt, M., Brown, T. A. & Johnson, C. A. (1992). Reactivity to alcohol-relevant beverage and imaginal cues in alcoholics. Addictive Behaviours, 17 (3), 209-217.

Petit, G., Kornreich, C., Noël, X., Verbanck, P. & Campanella, S. (2012). Alcohol-related context modulates performance of social drinkers in a visual Go/No-Go task: a preliminary assessment of event-related potentials. PLoS one, 7 (5), e37466.

Petry, N. M. (2001). Delay discounting of money and alcohol in actively using alcoholics, currently abstinent alcoholics, and controls. Psychopharmacology, 154 (3), 243-250.

Pfefferbaum, A., Ford, J. M., Weller, B. J. & Kopell, B. S. (1985). ERPs to response production and inhibition. Electroencephalography and Clinical Neurophysiology, 60 (5), 423-434.

Polich, J. (2007). Updating P300: an integrative theory of P3a and P3b. Clinical Neurophysiology, 118 (10), 2128-2148.

Pomerleau, O. F., Fertig, J., Baker, L. & Cooney, N. (1983). Reactivity to alcohol cues in alcoholics and non-alcoholics: implications for a stimulus control analysis of drinking. Addictive Behaviour, 8 (1), 1-10.

Pontifex, M. B., Hillman, C. H. & Polich, J. (2009). Age, physical fitness, and attention: P3a and P3b. Psychophysiology, 46 (2), 379-387.

Powell, J., Dawkins, L. & Davis, R. E. (2002). Smoking, reward responsiveness, and response inhibition: tests of an incentive motivational model. Biological Psychiatry, 51 (2), 151-163.

Powell, J., Tait, S. & Lessiter, J. (2002). Cigarette smoking and attention to signals of reward and threat in the Stroop paradigm. Addiction, 97 (9), 1163-1170.

Prime Minister's Strategy Unit (2004). Alcohol Harm Reduction Strategy. London: Cabinet Office.

Rachlin, H. & Green, L. (1972). Commitment, choice, and self-control. Journal of the Experimental Analysis of Behaviour, 17 (1), 15-22.

Rachlin, H., Raineri, A. & Cross, D. (1991). Subjective probability and delay. Journal of the Experimental Analysis of Behaviour, 55 (2), 233-244.

Rao, V., Spiro, J. R., Schretlen, D. J. & Cascella, N. G. (2007). Apathy syndrome after traumatic brain injury compared with deficits in schizophrenia. Psychosomatics, 48 (3), 217-222.

Realmuto, G., Begleiter, H., Odencrantz, J. & Porjesz, B. (1993). Event-related potential evidence of dysfunction in automatic processing in abstinent alcoholics. Biological Psychiatry, 33 (8-9), 594-601.

Rehm, J., Room, R., Graham, K., Monteiro, M., Gmel, G. & Sempos, C. T. (2003). The relationship of average volume of alcohol consumption and patterns of drinking to burden of disease: an overview. Addiction, 98 (9), 1209-1228.

Reid, M. S., Flammino, F., Starosta, A., Palamar, J. & Franck, J. (2006). Physiological and subjective responding to alcohol cue exposure in alcoholics and control subjects: evidence for appetitive responding. Journal of Neural Transmission, 113 (10), 1519-1535.

Reimers, S., Maylor, E. A., Stewart, N. & Chater, N. (2009). Associations between a one-shot delay discounting measure and age, income, education and real-world impulsive behaviour. Personality and Individual Differences, 47 (8), 973-978.

Reynolds, B., Ortengren, A., Richards, J. B. & de Wit, H. (2006a). Dimensions of impulsive behaviour: personality and behavioural measures. Personality and Individual Differences, 40 (2), 305-315.

Reynolds, B., Richards, J. B. & de Wit, H. (2006b). Acute-alcohol effects on the Experiential Discounting Task (EDT) and a question-based measure of delay discounting. Pharmacology, Biochemistry, and Behaviour, 83 (2), 194-202.

Ricaurte, G. A., Guillery, R. W., Seiden, L. S. & Schuster, C. R. (1984). Nerve terminal degeneration after a single injection of D-amphetamine in iprindole-treated rats: relation to selective long-lasting dopamine depletion. Brain Research, 291 (2), 378-382.

Richards, J. B., Zhang, L., Mitchell, S. H. & de Wit, H. (1999). Delay or probability discounting in a model of impulsive behaviour: effect of alcohol. Journal of the Experimental Analysis of Behaviour, 71 (2), 121-143.

Ridley, R. M., Baker, H. F., Owen, F., Cross, A. J. & Crow, T. J. (1982). Behavioural and biochemical effects of chronic amphetamine treatment in the vervet monkey. Psychopharmacology, 78 (3), 245-251.

Robbins, T. W. (1990). The case of frontostriatal dysfunction in schizophrenia. Schizophrenia Bulletin, 16 (3), 391-402.

Robbins, T. W. (1996). Dissociating executive functions of the prefrontal cortex. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 351 (1346), 1463-1470.

Robinson, S. & Bulger, C. (2010). General Lifestyle Survey 2008: Smoking and Drinking Among Adults, 2008. Newport: Office for National Statistics.

Robinson, T. E. & Berridge, K. C. (1993). The neural basis of drug craving: an incentive-sensitisation theory of addiction. Brain Research Reviews, 18 (3), 247-291.

Robinson, T. E. & Berridge, K. C. (2000). The psychology and neurobiology of addiction: an incentive-sensitisation view. Addiction, 95 (Supplement 2), S91-S117.

Robinson, T. E., Gorny, G., Mitton, E. & Kolb, B. (2001). Cocaine self-administration alters the morphology of dendrites and dendritic spines in the nucleus accumbens and neocortex. Synapse, 39 (3), 257-266.

Rodríguez Holguín, S., Corral, M. & Cadaveira, F. (1998). Event-related potentials elicited by infrequent non-target stimuli in young children of alcoholics: family history and gender differences. Alcohol and Alcoholism, 33 (3), 281-290.

Rodríguez Holguín, S., Porjesz, B., Chorlian, D. B. & Polich, J. (1999a). Visual P3a in male alcoholics and controls. Alcoholism: Clinical and Experimental Research, 23 (4), 582-591.

Rodríguez Holguín, S., Porjesz, B., Chorlian, D. B., Polich, J. & Begleiter, H. (1999b). Visual P3a in male subjects at high risk for alcoholism. Biological Psychiatry, 46 (2), 281-291.

Rogers, R. D. & Robbins, T. W. (2001). Investigating the neurocognitive deficits associated with chronic drug misuse. Current Opinion in Neurobiology, 11 (2), 250-257.

Rohsenow, D. J. & Marlatt, G. A. (1981). The balanced placebo design: methodological considerations. Addictive Behaviours, 6 (2), 107-122.

Rose, A. K. & Duka, T. (2006). Effects of dose and time on the ability of alcohol to prime social drinkers. Behavioural Pharmacology, 17 (1), 61-70.

Rose, A. K. & Duka, T. (2008). Effects of alcohol on inhibitory processes. Behavioural Pharmacology, 19 (4), 284-291.

Rossetti, Z. L., Hmaidan, Y. & Gessa, G. L. (1992). Marked inhibition of mesolimbic dopamine release: a common feature of ethanol, morphine, cocaine, and amphetamine abstinence in rats. European Journal of Pharmacology, 221 (2-3), 227-234.

Rossetti, Z. L., Isola, D., De Vry, J. & Fadda, F. (1999). Effects of nimodipine on extracellular dopamine levels in the rat nucleus accumbens in ethanol withdrawal. Neuropharmacology, 38 (9), 1361-1369.

Rossow, I. (2008). Alcohol consumption and discounting. Addiction Research and Theory, 16 (6), 572-584.

Rothblat, D. S., Rubin, E. & Schneider, J. S. (2001). Effects of chronic alcohol ingestion on the mesostriatal dopamine system in the rat. Neuroscience Letters, 300 (2), 63-66.

Royal College of Psychiatrists (1986). Alcohol: Our Favourite Drug. London: Royal College of Psychiatrists.

Rozenkrants, B. & Polich, J. (2008). Affective ERP processing in a visual oddball task: Arousal, valence, and gender. Clinical Neurophysiology, 119 (10), 2260-2265.

Rubio, G., Jiménez, M., Rodríguez-Jiménez, R., Martínez, I., Avila, C., Ferre, F., Jiménez-Arriero, M. A., Ponce, G. & Palomo, T. (2008). The role of

behavioural impulsivity in the development of alcohol dependence: a 4-year follow-up study. Alcoholism: Clinical and Experimental Research, 32 (9), 1681-1687.

Rugg, M. D. (1995). Memory and consciousness: a selective review of issues and data. Neuropsychologia, 33 (9), 1131-1141.

Ruhnau, P., Wetzel, N., Widmann, A. & Schröger, E. (2010). The modulation of auditory novelty processing by working memory load in school age children and adults: a combined behavioural and event-related potential study. BMC Neuroscience, 11, 126.

Rushby, J. A., Barry, R. J. & Doherty, R. J. (2005). Separation of the components of the late positive complex in an ERP dishabituation paradigm. Clinical Neurophysiology, 116 (10), 2363-2380.

Rusted, J. M., Caulfield, D., King, L. & Goode, A. (2000). Moving out of the laboratory: does nicotine improve everyday attention? Behavioural Pharmacology, 11 (7-8), 621-629.

Ryan, F. (2002a). Attentional bias and alcohol dependence: a controlled study using the modified stroop paradigm. Addictive Behaviours, 27 (4), 471-482.

Ryan, F. (2002b). Detected, selected, and sometimes neglected: cognitive processing of cues in addiction. Experimental and Clinical Psychopharmacology, 10 (2), 67-76.

Salamone, J. D. (1994). The involvement of nucleus accumbens dopamine in appetitive and aversive motivation. Behavioural Brain Research, 61 (2), 117-133.

Salgado, J. V., Malloy-Diniz, L. F., Campos, V. R., Abrantes, S. S. C., Fuentes, D., Bechara, A. & Correa, H. (2009). Neuropsychological assessment of impulsive behaviour in abstinent alcohol-dependent subjects. Revista Brasiliera de Psiquiatria, 31 (1), 4-9.

Sarramon, C., Verdoux, H., Schmitt, L. & Bourgeois, M. (1999). [Addiction and personality traits: sensation seeking, anhedonia, impulsivity] [Article in French]. Encephale, 25 (6), 569-575.

Saunders, J. B., Aasland, O. G., Babor, T. F., de la Fuente, J. R. & Grant, M. (1993). Development of the Alcohol Use Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption—II. Addiction, 88 (6), 791-804.

Sayette, M. A. & Hufford, M. R. (1994). Effects of cue exposure and deprivation on cognitive resources in smokers. Journal of Abnormal Psychology, 103 (4), 812-818.

Sayette, M. A., Monti, P. M., Rohsenow, D. J., Gulliver, S. B., Colby, S. M., Sirota, A. D., Niaura, R. & Abrams, D. B. (1994). The effects of cue exposure on reaction time in male alcoholics. Journal of Studies on Alcohol, 55 (5), 629-633.

Sayette, M. A., Shiffman, S., Tiffany, S. T., Niaura, R. S., Martin, C. S. & Shadel, W. G. (2000). The measurement of drug craving. Addiction, 95 (Supplement 2), S189-S210.

Schmaal, L., Joos, L., Koeleman, M., Veltman, D. J., van den Brink, W. & Goudriaan, A. E. (2013). Effects of modafinil on neural correlates of response inhibition in alcohol-dependent patients. Biological Psychiatry, 73 (3), 211-218.

Schoenbaum, G. & Shaham, Y. (2008). The role of orbitofrontal cortex in drug addiction: a review of preclinical studies. Biological Psychiatry, 63 (3), 256-262.

Schoenmakers, T., Wiers, R. W. & Field, M. (2008). Effects of a low dose of alcohol on cognitive biases and craving in heavy drinkers. Psychopharmacology, 197 (1), 169-178.

Schoenmakers, T. M. & Wiers, R. W. (2010). Craving and attentional bias respond differently to alcohol priming: a field study in the pub. European Addiction Research, 16 (1), 9-16.

Schultz, W., Dayan, P. & Montague, P. R. (1997). A neural substrate of prediction and reward. Science, 275 (5306), 1593-1599.

Schulze, D. & Jones, B. T. (1999). The effects of alcohol cues and an alcohol priming dose on a multi-factorial measure of subjective cue reactivity in social drinkers. Psychopharmacology, 145 (4), 452-454.

Schulze, D. & Jones, B. T. (2000). Desire for alcohol and outcome expectancies as measures of alcohol cue-reactivity in social drinkers. Addiction, 95 (7), 1015-1020.

Schupp, H. T., Cuthbert, B. N., Bradley, M. M., Cacioppo, J. T., Ito, T. & Lang, P. J. (2000). Affective picture processing: the late positive potential is modulated by motivational relevance. Psychophysiology, 37 (2), 257-261.

Sharma, D., Albery, I. P. & Cook, C. (2001). Selective attentional bias to alcohol related stimuli in problem drinkers and non-problem drinkers. Addiction, 96 (2), 285-295.

Sharma, D. & McKenna, F. P. (2001). The role of time pressure on the emotional Stroop task. British Journal of Psychology, 92 (3), 471-481.

Shen, R. Y. & Chiodo, L. A. (1993). Acute withdrawal after repeated ethanol treatment reduces the number of spontaneously active dopaminergic neurons in the ventral tegmental area. Brain Research, 622 (1-2), 289-293.

Shen, R. Y., Choong, K. C. & Thompson, A. C. (2007). Long-term reduction in ventral tegmental area dopamine neuron population activity following repeated stimulant or ethanol treatment. Biological Psychiatry, 61 (1), 93-100.

Sher, K. J., Bartholow, B. D. & Wood, M. D. (2000). Personality and substance use disorders: a prospective study. Journal of Consulting and Clinical Psychology, 68 (5), 818-829.

Sher, K. J., Wood, M. D., Richardson, A. E. & Jackson, K. M. (2005). Subjective effects of alcohol 1: effects of the drink and drinking context. In: Earleywine, M. (Ed.), Mind Altering Drugs: the Science of Subjective Experience. Oxford University Press, Oxford, p. 86-134.

Sher, L. (2008). Research on the Neurobiology of Alcohol Use Disorders. New York: Nova Science Publishers, Inc.

Shiels, K., Hawk, L. W. Jr, Reynolds, B., Mazzullo, R. J., Rhodes, J. D., Pelham, W. E. Jr, Waxmonsky, J. G. & Gangloff, B. P. (2009). Effects of methylphenidate on discounting of delayed rewards in attention deficit/hyperactivity disorder. Experimental and Clinical Psychopharmacology, 17 (5), 291-301.

Shippenberg, T. S., Zapata, A. & Chefer, V. I. (2007). Dynorphin and the pathophysiology of drug addiction. Pharmacology and Therapeutics, 116 (2), 306-321.

Siegel, S. (1990). Classical conditioning and opiate tolerance and withdrawal. In Balfour, D. J. K. (Ed.), Psychotropic Drugs of Abuse: International Encyclopaedia of Pharmacology and Therapeutics (pp. 59-86). New York: Pergamon.

Siegel, S. & Ramos, B. M. (2002). Applying laboratory research: drug anticipation and the treatment of drug addiction. Experimental and Clinical Psychopharmacology, 10 (3), 162-183.

Silverstone, P. H. (1991). Is anhedonia a good measure of depression? Acta Psychiatrica Scandinavica, 83 (4), 249-250.

Singleton, E. G., Tiffany, S. T. & Henningfield, J. E. (1994). Development and Validation of a New Questionnaire to Assess Craving for Alcohol, paper presented at 56th Annual Meeting of College on Problems of Drug Dependence, Palm Beach, July 1994.

Skinner, H. A. (1982). The drug abuse screening test. Addictive Behaviour, 7 (4), 363-371.

Smith, J. L. & Mattick, R. P. (2013). Evidence of deficits in behavioural inhibition and performance monitoring in young female heavy drinkers. Drug and Alcohol Dependence, Epub. ahead of print.

Smith, L., Watson, M., Gates, S., Ball, S. & Foxcroft, D. (2008). Meta-analysis of the association of the Taq1A polymorphism with the risk of alcohol dependency: a HuGE gene-disease association review. American Journal of Epidemiology, 167 (2), 125-138.

Snaith, P. (1992). Anhedonia: exclusion from the pleasure dome. BMJ, 305 (6846), 134.

Snaith, R. P., Hamilton, M., Morley, S., Humayan, A., Hargreaves, D. & Trigwell, P. (1995). A scale for the assessment of hedonic tone: the Snaith-Hamilton pleasure scale. British Journal of Psychiatry, 167 (1), 99-103.

Sobell, L. C., Sobell, M. B., Toneatto, T. & Leo, G. I. (1993). Severely dependent alcohol abusers may be vulnerable to alcohol cues in television programs. Journal of Studies on Alcohol, 54 (1), 85-91.

Squires, N. K., Squires, K. C. & Hillyard, S. A. (1975). Two varieties of long-latency positive waves evoked by unpredictable auditory stimuli in man. Electroencephalography and Clinical Neurophysiology, 38 (4), 387-401.

Stacey, D., Clarke, T. K. & Schumann, G. (2009). The genetics of alcoholism. Current Psychiatry Reports, 11 (5), 364-369.

Staiger, P. K. & White, J. M. (1991). Cue-reactivity in alcohol abusers: stimulus specificity and extinction of the responses. Addictive Behaviour, 16 (5), 211-221.

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E. & Patterson, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: an update and review. Personality and Individual Differences, 47 (5), 385-395.

Stanford, M. S., Vasterling, J. J., Mathias, C. W., Constans, J. I. & Houston, R. J. (2001). Impact of threat-relevance on P3 event-related potentials in combat-

related post-traumatic stress disorder. Psychiatry Research, 102 (2), 125-137.

Steele, C. M. & Josephs, R. A. (1988). Drinking your troubles away. II: An attention-allocation model of alcohol's effects on psychological stress. Journal of Abnormal Psychology, 97 (2), 196-205.

Steele, C. M. & Josephs, R. A. (1990). Alcohol myopia. Its prized and dangerous effects. The American Psychologist, 45 (8), 921-933.

Steele, C. M. & Southwick, L. (1985). Alcohol and social behaviour I: The psychology of drunken excess. Journal of Personality and Social Psychology, 48 (1), 18-34.

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. Psychological Bulletin, 87 (2), 245-251.

Stetter, F., Ackermann, K., Bizer, A., Straube, E. R. & Mann, K. (1995). Effects of disease-related cues in alcoholic inpatients: results of a controlled "Alcohol Stroop" study. Alcoholism: Clinical and Experimental Research, 19 (3), 593-599.

Stetter, F., Chaluppa, C., Ackermann, K., Straube, E. R. & Mann, K. (1994). Alcoholics' selective processing of alcohol-related words and cognitive performance on a Stroop task. European Psychiatry, 9 (2), 71-76.

Stewart, J., de Wit, H. & Eikelboom, R. (1984). Role of unconditioned and conditioned drug effects in the self-administration of opiates and stimulants. Psychological Review, 91 (2), 251-268.

Stockwell, T. (1991). Experimental analogues of loss of control: a review of human drinking studies. In Heather, N., Miller, W. & Greely, J. (Eds.), Self-Control and the Addictive Behaviours, Sydney: Macmillan.

Stormark, K. M., Field, N. P., Hugdahl, K. & Horowitz, M. (1997). Selective processing of visual alcohol cues in abstinent alcoholics: an approach-avoidance conflict? Addictive Behaviours, 22 (4), 509-519.

Stormark, K. M., Laberg, J. C., Nordby, H. & Hugdahl, K. (2000). Alcoholics' selective attention to alcohol stimuli: automated processing? Journal of Studies on Alcohol, 61 (1), 18-23.

Strakowski, S. M., Fleck, D. E., DelBello, M. P., Adler, C. M., Shear, P. K., Kotwal, R. & Arndt, S. (2010). Impulsivity across the course of bipolar disorder. Bipolar Disorders, 12 (3), 285-297.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 18 (6), 643-662.

Swann, A. C., Anderson, J., Dougherty, D. M. & Moeller, F. G. (2001). Measurement of inter-episode impulsivity in bipolar disorder: a preliminary report. Psychiatry Research, 101 (2), 195-197.

Tabachnik, B. G. & Fidell, L. S. (2007). Using Multivariate Statistics (5th Ed.). United States of America: Pearson Education Inc.

Tannock, R., Ickowicz, A. & Schachar, R. (1995). Differential effects of methylphenidate on working memory in ADHD children with and without comorbid anxiety. Journal of the American Academy of Child and Adolescent Psychiatry, 34 (7), 886-896.

Thompson, L. L., Whitmore, E. A., Raymond, K. M. & Crowley, T. J. (2006). Measuring impulsivity in adolescents with serious substance and conduct problems. Assessment, 13 (1), 3-15.

Tiffany, S. T. (1990). A cognitive model of drug urges and drug-use behaviour: the role of automatic and non-automatic processes. Psychological Review, 97 (2), 147-168.

Tiffany, S. T., Carter, B. L. & Singleton, E. G. (2000). Challenges in the manipulation, assessment and interpretation of craving relevant variables. Addiction, 95 (Supplement 2), S177-S187.

Tiffany, S. T. & Conklin, C. A. (2000). A cognitive processing model of alcohol craving and compulsive alcohol use. Addiction, 95 (Supplement 2), S145-S153.

Tiffany, S. T. & Drobes, D. J. (1991). The development and initial validation of a questionnaire on smoking urges. British Journal of Addiction, 86 (11), 1467-1476.

Tómasson, K. & Vaglum, P. (1995). A nationwide representative sample of treatment-seeking alcoholics: a study of psychiatric comorbidity. Acta Psychiatrica Scandinavica, 92 (5), 378-385.

Tsai, G. & Coyle, J. T. (1998). The role of glutamatergic neurotransmission in the pathophysiology of alcoholism. Annual Review of Medicine, 49 , 173-184.

Tupala, E., Hall, H., Bergström, K., Mantere, T., Räsänen, P., Särkioja, T. & Tiihonen, J. (2003). Dopamine D2 receptors and transporters in type 1 and 2 alcoholics measured with human whole hemisphere autoradiography. Human Brain Mapping, 20 (2), 91-102.

Tupala, E., Hall, H., Bergström, K., Särkioja, T., Räsänen, P., Mantere, T., Callaway, J., Hiltunen, J. & Tiihonen, J. (2001). Dopamine D(2)/(3)-receptor and transporter densities in nucleus accumbens and amygdala of type 1 and 2 alcoholics. Molecular Psychiatry, 6 (3), 261-267.

Turkkan, J. S., McCaul, M. E. & Stitzer, M. L. (1989). Psychophysiological effects of alcohol-related stimuli: I. The role of stimulus intensity. Alcohol: Clinical and Experimental Research, 13 (3), 386-391.

Van de Laar, M. C., Licht, R., Franken, I. H. & Hendriks, V. M. (2004). Event-related potentials indicate motivational relevance of cocaine cues in abstinent cocaine addicts. Psychopharmacology, 177 (1-2), 121-129.

Verdejo-García, A., Lawrence, A. J. & Clark, L. (2008). Impulsivity as a vulnerability marker for substance-use disorders: review of findings from high-risk research, problem gamblers, and genetic association studies. Neuroscience and Biobehavioural Reviews, 32 (4), 777-810.

Verdejo-García, A. J., Perales, J. C. & Pérez-García, M. (2007). Cognitive impulsivity in cocaine and heroin polysubstance abusers. Addictive Behaviours, 32 (5), 950-966.

Verheul, R., van den Brink, W. & Geerlings, P. (1999). A three-pathway psychobiological model of craving for alcohol. Alcohol and Alcoholism, 34 (2), 197-222.

Vicenzi, G., Giorgi, I. & Pessa, E. (2006). [Impulsiveness as a multidimensional construct: an analysis in alcoholic patients] [Article in Italian]. Giornale Italiano di Medicina del Lavoro ed Ergonomia, 28 (3 Supplement 2), 89-98.

Volkow, N. D., Chang, L., Wang, G. J., Fowler, J. S., Ding, Y. S., Sedler, M., Logan, J., Franceschi, D., Gatley, J., Hitzemann, R., Gifford, A., Wong, C. & Pappas, N. (2001). Low level of brain dopamine D_2 receptors in methamphetamine abusers: association with metabolism in the orbitofrontal cortex. American Journal of Psychiatry, 158 (12), 2015-2021.

Volkow, N. D., Fowler, J. S. & Wang, G. J. (2004b). The addicted human brain viewed in the light of imaging studies: brain circuits and treatment strategies. Neuropharmacology, 47 (Supplement 1), 3-13.

Volkow, N. D., Fowler, J. S., Wang, G. J. & Goldstein, R. Z. (2002). Role of dopamine, the frontal cortex and memory circuits in drug addiction: insight from imaging studies. Neurobiology of Learning and Memory, 78 (3), 610-624.

Volkow, N. D., Fowler, J. S., Wang, G. J., Hitzemann, R., Logan, J., Schlyer, D. J., Dewey, S. L. & Wolf, A. P. (1993). Decreased dopamine D_2 receptor availability is associated with reduced frontal metabolism in cocaine abusers. Synapse, 14 (2), 169-177.

Volkow, N. D., Fowler, J. S., Wang, G. J. & Swanson, J. M. (2004a). Dopamine in drug abuse and addiction: results from imaging studies and treatment implications. Molecular Psychiatry, 9 (6), 557-569.

Volkow, N. D., Fowler, J. S., Wang, G. J., Swanson, J. M. & Telang, F. (2007). Dopamine in drug abuse and addiction: results of imaging studies and treatment implications. Archives of Neurology, 64 (11), 1575-1579.

Volkow, N. D. & Li, T. K. (2004). Drug addiction: the neurobiology of behaviour gone awry. Nature Reviews: Neuroscience, 5 (12), 963-970.

Volkow, N. D., Wang, G. J., Begleiter, H., Porjesz, B., Fowler, J. S., Telang, F., Wong, C., Ma, Y., Logan, J., Goldstein, R., Alexoff, D. & Thanos, P. K. (2006). High levels of dopamine D2 receptors in unaffected members of alcoholic families: possible protective factors. Archives of General Psychiatry, 63 (9), 999-1008.

Volkow, N. D., Wang, G. J., Fowler, J. S., Logan, J., Gatley, S. J., Hitzemann, R., Chen, A. D., Dewey, S. L. & Pappas, N. (1997). Decreased striatal dopaminergic responsiveness in detoxified cocaine-dependent subjects. Nature, 386 (6627), 830-833.

Vollrath, M. E. & Torgersen, S. (2008). Personality types and risky health behaviours in Norwegian students. Scandinavian Journal of Psychology, 49 (3), 287-292.

Vollstädt-Klein, S., Loeber, S., Richter, A., Kirsch, M., Bach, P., von der Goltz, C., Hermann, D., Mann, K. & Kiefer, F. (2011). Validating incentive salience with functional magnetic resonance imaging: association between mesolimbic cue reactivity and attentional bias in alcohol-dependent patients. Addiction Biology, 17 (4), 807-816.

Von Diemen, L., Bassani, D. G., Fuchs, S. C., Szobot, C. M. & Pechansky, F. (2008). Impulsivity, age of first alcohol use and substance use disorders among male adolescents: a population based case-control study. Addiction, 103 (7), 1198-2005.

Von Knorring, L., Oreland, L. & von Knorring, A. L. (1987). Personality traits and platelet MAO activity in alcohol and drug abusing teenage boys. Acta Psychiatrica Scandinavica, 75 (3), 307-314.

Vuchinich, R. E. & Simpson, C. A. (1998). Hyperbolic temporal discounting in social drinkers and problem drinkers. Experimental and Clinical Psychopharmacology, 6 (3), 292-305.

Waldeck, T. L. & Miller, L. S. (1997). Gender and impulsivity differences in licit substance use. Journal of Substance Abuse, 9, 269-275.

Walitzer, K. S. & Sher, K. J. (1990). Alcohol cue reactivity and ad lib drinking in young men at risk for alcoholism. Addictive Behaviour, 15 (1), 29-46.

Warren, C. A. & McDonough, B. E. (1999). Event-related potentials as indicators of smoking cue-reactivity. Clinical Neurophysiology, 110 (9), 1570-1584.

Waters, A. J., Shiffman, S., Sayette, M. A., Paty, J. A., Gwaltney, C. J. & Balabanis, M. H. (2003). Attentional bias predicts outcome in smoking cessation. Health Psychology, 22 (4), 378-387.

Weafer, J. & Fillmore, M. T. (2008). Individual differences in acute alcohol impairment of inhibitory control predict ad libitum alcohol consumption. Psychopharmacology, 201 (3), 315-324.

Weiss, F., Parsons, L. H., Schulteis, G., Hyytiä, P., Lorang, M. T., Bloom, F. E. & Koob, G. F. (1996). Ethanol self-administration restores withdrawal-associated deficiencies in accumbal dopamine and 5-hydroxytryptamine release in dependent rats. The Journal of Neuroscience, 16 (10), 3474-3485.

Weiss, F. & Porrino, L. J. (2002). Behavioural neurobiology of alcohol addiction: recent advances and challenges. The Journal of Neuroscience, 22 (9), 3332-3337.

West, R. (2006). Theory of Addiction. Oxford: Blackwell Publishing Limited.

Whiteside, S. P. & Lynam, D. R. (2001). The five factor model and impulsivity: using a structural model of personality to understand impulsivity. Personality and Individual Differences, 30 (4), 669-689.

Wikler, A. (1973). Dynamics of drug dependence: implications of a conditioning theory for research and treatment. Archives of General Psychiatry, 28 (5), 611-616.

Williams, J. M., Mathews, A. & MacLeod, C. (1996). The emotional Stroop task and psychopathology. Psychological Bulletin, 120 (1), 3-24.

World Health Organisation (1992). The International Classification of Diseases: Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines (10th Ed.). Geneva: World Health Organisation.

World Medical Association (2002). Declaration of Helsinki: ethical principles for medical research involving human subjects. Journal of Postgraduate Medicine, 48 (3), 206-208.

Wrase, J., Grüsser, S. M., Klein, S., Diener, C., Hermann, D., Flor, H., Mann, K., Braus, D. F. & Heinz, A. (2002). Development of alcohol-associated cues and cue-induced brain activation in alcoholics. European Psychiatry, 17 (5), 287-291.

Yan, P. & Li, C. S. (2009). Decreased amygdala activation during risk taking in non-dependent habitual alcohol users: A preliminary fMRI study of the stop signal task. American Journal of Drug and Alcohol Abuse, 35 (5), 284-289.

Zack, M., Woodford, T. M., Tremblay, A. M., Steinberg, L., Zawertailo, L. A. & Busto, U. E. (2011). Stress and alcohol cues exert conjoint effects on go and stop signal responding in male problem drinkers. Neuropsychopharmacology, 36 (2), 445-458.

Ziervogel, C. F., Morojele, N. K., Riet, J. V., Parry, C. D. & Robertson, B. A. (1997). A qualitative investigation of alcohol drinking among male high school students from three communities in the cape peninsula, South Africa. International Quarterly of Community Health Education, 17 (3), 271-295.

Zigmond, A. S. & Snaith, R. P. (1983). The hospital anxiety and depression. Acta Psychiatrica Scandinavica, 67 (6), 361-370.

Zuckerman, M., Kolin, E. A., Price, L. & Zoob, I. (1964). Development of a sensation-seeking scale. Journal of Consulting Psychology, 28 (6), 477-482.

Appendices

Appendix 1: Barratt Impulsiveness Scale (BIS-11; Patton, Stanford & Barratt, 1995)

	Rarely / Never	Occasionally	Often	Almost Always / Always
*1. I plan tasks carefully.**				
2. I do things without thinking.				
3. I make-up my mind quickly.				
4. I am happy-go-lucky.				
5. I don't 'pay attention'.				
6. I have 'racing' thoughts.				
*7. I plan trips well ahead of time.**				
*8. I am self-controlled.**				
*9. I concentrate easily.**				
*10. I save regularly.**				
11. I 'squirm' at plays or lectures.				
*12. I am a careful thinker.**				
*13. I plan for job security.**				
14. I say things without thinking.				
*15. I like to think about complex problems.**				
16. I change jobs.				
17. I act 'on impulse'.				
18. I get easily bored when solving thought problems.				
19. I act on the spur of the moment.				
*20. I am a steady thinker.**				
21. I change residences.				
22. I buy things on impulse.				
23. I can only think about one problem at a time.				
24. I change hobbies.				
25. I spend more than I earn.				
26. I often have extraneous thoughts when thinking.				

BIS-11 continues over the page

BIS-11 continued

	Rarely / Never	Occasionally	Often	Almost Always / Always
27. I am more interested in the present than in the future.				
28. I am restless at the theatre / cinema / lectures.				
*29. I like puzzles.**				
*30. I am future oriented.**				

Items are scored 1, 2, 3, 4; *Indicates item is reverse-scored;
Attentional Impulsiveness subscale = items 5, 6, 9, 11, 20, 24, 26 and 28;
Motor Impulsiveness subscale = items 2, 3, 4, 16, 17, 19, 21, 22, 23 and 30;
Non-Planning Impulsiveness subscale = items 1, 7, 8, 10, 12, 13, 14, 15, 18, 27 and 29.

Appendix 2: EASI-III Temperament Survey: Impulsivity Subscales (Buss & Plomin, 1984)

Instructions: For each question, try to rate yourself on a scale from 1 to 5, with 1 being uncharacteristic or not at all like you and 5 being characteristic or very much like you.

Inhibitory control

1. **I have trouble controlling my impulses:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

2. **Usually I can't stand waiting:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

3. **I can tolerate frustration better than most (reverse):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

4. **I have trouble resisting my cravings (for food, cigarettes, etc.):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

Continued

5. **I like to spend my money right away rather than save it for long-range goals:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

Decision time

1. **I often say the first thing that comes into my head:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

2. **I often have trouble making up my mind (reverse):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

3. **I like to plan things way ahead of time (reverse):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

4. **I often act on the spur of the moment:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

Continued

5. **I like to make detailed plans before I do something (reverse):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

Sensation seeking

1. **I generally seek new and exciting experiences and sensations:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

2. **I'll try anything once:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

3. **I sometimes do "crazy" things just to be different:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

4. **I'm happiest in familiar surroundings (reverse):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

Continued

5. **I get bored easily:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

<u>Persistence</u>

1. **I generally like to see things through to the end (reverse):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

2. **I tend to hop from interest to interest quickly:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

3. **I tend to give up easily:**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

4. **Unfinished tasks really bother me (reverse):**
    1 Uncharacteristic (NOT at all like you)
    2 Somewhat Uncharacteristic (NOT very much like you)
    3 Neither Uncharacteristic nor Characteristic
    4 Somewhat Characteristic (sort of like you)
    5 Characteristic (very much like you)

Continued

5. Once I get going on something I hate to stop (reverse):

1 Uncharacteristic (NOT at all like you)
2 Somewhat Uncharacteristic (NOT very much like you)
3 Neither Uncharacteristic nor Characteristic
4 Somewhat Characteristic (sort of like you)
5 Characteristic (very much like you)

Appendix 3: Functional and Dysfunctional Impulsivity Scales (Dickman, 1990)

	TRUE	FALSE
Functional Impulsivity		
1. I don't like to make decisions quickly, even simple decisions, such as choosing what to wear, or what to have for dinner.		
2. I am good at taking advantage of unexpected opportunities, where you have to do something immediately or lose your chance.		
3. Most of the time, I can put my thoughts into words very rapidly.		
4. I am uncomfortable when I have to make up my mind rapidly.		
5. I like to take part in really fast-paced conversations, where you don't have much time to think before you speak.		
6. I don't like to do things quickly, even when I am doing something that is not very difficult.		
7. I would enjoy working at a job that required me to make a lot of split-second decisions.		
8. I like sports and games in which you have to choose your next move very quickly.		
9. I have often missed out on opportunities because I couldn't make up my mind fast enough.		
10. People have admired me because I can think quickly.		
11. I try to avoid activities where you have to act without much time to think first.		
Dysfunctional Impulsivity		
1. I will often say whatever comes into my head without thinking first.		
2. I enjoy working out problems slowly and carefully.		
3. I frequently make appointments without thinking about whether I will be able to keep them.		
4. I frequently buy things without thinking about whether or not I can really afford them.		
5. I often make up my mind without taking the time to consider the situation from all angles.		
6. Often, I don't spend enough time thinking over a situation before I act.		
7. I often get into trouble because I don't think before I act.		

Functional and Dysfunctional Impulsivity Scales continue over the page

8. Many times the plans I make don't work out because I haven't gone over them carefully enough in advance.		
9. I rarely get involved in projects without first considering the potential problems.		
10. Before making any important decision, I carefully weigh the pros and cons.		
11. I am good at careful reasoning.		
12. I often say and do things without considering the consequences.		

Appendix 4: I-7 (Eysenck *et al.*, 1985a)

Instructions: Please answer each question by putting a circle around the 'YES' or 'NO' following the questions. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the question.

PLEASE REMEMBER TO ANSWER EACH QUESTION

	YES	NO
1. Do you often buy things on impulse?		
2. Do you generally do and say things without stopping to think?		
3. Do you often get into a jam because you do things without thinking?		
4. Are you an impulsive person?		
5. Do you usually think carefully before doing anything?		
6. Do you often do things on the spur of the moment?		
7. Do you mostly speak before thinking things out?		
8. Do you often get involved in things you later wish you could get out of?		
9. Do you get so 'carried away' by new and exciting ideas that you never think of possible snags?		
10. Do you need to use a lot of self-control to keep out of trouble?		
11. Would you agree that almost everything enjoyable is illegal or immoral?		
12. Are you often surprised at people's reactions to what you do or say?		
13. Do you think an evening out is more successful if it is unplanned or arranged at the last moment?		
14. Do you usually work quickly, without bothering to check?		
15. Do you often change your interests?		
16. Before making up your mind, do you consider all the advantages and disadvantages?		
17. Do you prefer to 'sleep on it' before making decisions?		
18. When people shout at you, do you shout back?		
19. Do you usually make up your mind quickly?		

'Yes' responses receive a score of 1; 'No' responses receive a score of 0.

PLEASE CHECK TO SEE THAT YOU HAVE ANSWERED ALL THE QUESTIONS

Appendix 5: UPPS Impulsive Behaviour Scale (Whiteside & Lynam, 2001)

	Rarely / Never	Occasio -nally	Often	Almost Always / Always
Premeditation				
1. I have a reserved and cautious attitude toward life.				
2. My thinking is usually careful and purposeful.				
3. I am not one of those people who blurt out things without thinking.				
4. I like to stop and think things over before I do them.				
5. I don't like to start a project before I know exactly how to proceed.				
6. I tend to value and follow a rational, "sensible" approach to things.				
7. I usually make up my mind through careful reasoning.				
8. I am a cautious person.				
9. Before I get into a new situation I like to find out what to expect from it.				
10. I usually think carefully before doing anything.				
11. Before making up my mind, I consider all the advantages and disadvantages.				
Urgency				
1. I have trouble controlling my impulses.				
2. I have trouble resisting my cravings (for food, cigarettes, etc.).				
3. I often get involved with things I later wish I could get out of.				

UPPS continues over the page

UPPS continued

	Rarely / Never	Occasio -nally	Often	Almost Always / Always
4. When I feel bad, I will often do things I later regret in order to make myself feel better now.				
5. Sometimes when I feel bad, I can't seem to stop what I am doing even though it is making me feel worse.				
6. When I am upset I often act without thinking.				
7. When I feel rejected, I will often say things that I later regret.				
8. It is hard for me to resist acting on my feelings.				
9. I often make matters worse because I will act without thinking when I am upset.				
10. In the heat of an argument, I will often say things that I later regret.				
11. I am always able to keep my feelings under control. (R)				
12. Sometimes I do things on impulse that I later regret.				
Sensation Seeking				
1. I generally seek new and exciting experiences and sensations.				
2. I'll try anything once.				
3. I like sports and games in which you have to choose your next move very quickly.				
4. I would enjoy water skiing.				
5. I quite enjoy taking risks.				
6. I would enjoy parachute jumping.				
7. I welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional.				
8. I would like to learn to fly an aeroplane.				

UPPS continues over the page

UPPS continued

	Rarely / Never	Occasio -nally	Often	Almost Always / Always
9. I sometimes like doing things that are a bit frightening.				
10. I would enjoy the sensation of skiing very fast down a high mountain slope.				
11. I would like to go scuba diving.				
12. I would enjoy fast driving.				
Perseverance				
1. I generally like to see things through to the end.				
2. I tend to give up easily. (R)				
3. Unfinished tasks really bother me.				
4. Once I get going on something I hate to stop.				
5. I concentrate easily.				
6. I finish what I start.				
7. I'm pretty good about pacing myself so as to get things done on time.				
8. I am a productive person who always gets the job done.				
9. Once I start a project, I almost always finish it.				
10. There are so many little jobs that need to be done that I sometimes just ignore them all. (R)				

Items scored 1, 2, 3, 4; (R) – indicates that the item is reverse-scored.

Appendix 6: Pilot Version of the Recent Impulsivity Scale (RIS)

Instructions: The following questionnaire asks about your behaviour over **THE LAST 2 WEEKS**. Please read through each statement, and put a tick in one of the four response categories to indicate how often you have behaved as described.

IN THE LAST TWO WEEKS:

Item	Never	Rarely	Quite Often	Very Often
1. *I have thought carefully before doing and saying things.**				
2. *I have been surprised at people's reactions to things that I have done or said.*				
3. *I have become so frustrated when waiting, for example in a shop queue, that I have left.*				
4. *I have found it easy to concentrate.**				
5. *I have tended to act 'on impulse'.*				
6. *I have tended to work quickly, without bothering to check.*				
7. *I have planned work tasks and activities in my free time carefully.**				
8. *I have found it difficult thinking ahead.*				
9. *I have found it easy to exercise self-control.**				
10. *I have been focused, seeing things through to the end.**				
11. *I have encountered problems because I did things without stopping to think.*				
12. *I have spent more money than I should have.*				
13. *I have been restless when watching things, for example at the cinema / theatre, on television, at lectures.*				
14. *I have become involved with something that I later wished I could have got out of.*				

Pilot RIS continues over the page

Pilot RIS continued

Item	Never	Rarely	Quite Often	Very Often
15. *I have planned events and activities well ahead of time.**				
16. *I have tended to jump from one interest to another.*				
17. *I have become easily bored when working.*				

Items scored 0, 1, 2 and 3; * Indicates item is reverse-scored.

Appendix 7: Pilot Version of the Trait Impulsivity Scale (TIS)

Instructions: The following questionnaire asks about your behaviour **IN GENERAL**. Please read through each statement, and put a tick in one of the four response categories to indicate how often you behave as described.

IN GENERAL:

Item	Never	Rarely	Quite Often	Very Often
1. *I think carefully before doing and saying*				
2. *I am surprised at people's reactions to things that I do or say.*				
3. *I become so frustrated when waiting, for example in a shop queue, that I leave.*				
4. *I find it easy to concentrate.**				
5. *I tend to act 'on impulse'.*				
6. *I tend to work quickly, without bothering to check.*				
7. *I plan work tasks and activities in my free time carefully.**				
8. *I find it difficult thinking ahead.*				
9. *I find it easy to exercise self-control.**				
10. *I am focused, seeing things through to the end.**				
11. *I encounter problems because I do things without thinking.*				
12. *I spend more money than I should.*				
13. *I am restless when watching things, for example at the cinema / theatre, on television, at lectures.*				
14. *I become involved with something that I later wish I could get out of.*				
15. *I plan events and activities well ahead of*				
16. *I tend to jump from one interest to*				
17. *I become easily bored when working.*				

Items scored 0, 1, 2 and 3; * Indicates item is reverse-scored.

Appendix 8: Initial Correlation Matrix for the pilot TIS at Time 1

Table A1 shows the initial correlation matrix for the 17 items of the pilot TIS at Time 1.

Table A1: Initial correlation matrix for pilot TIS items at Time 1

	Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**	**Item 7**	**Item 8**	**Item 9**	**Item 10**	**Item 11**	**Item 12**	**Item 13**	**Item 14**	**Item 15**	**Item 16**	**Item 17**
Item 1	1.00	0.05	-0.02	0.32	0.30	-0.05	0.16	0.36	0.25	0.37	0.43	0.35	0.21	0.10	0.18	0.39	0.08
Item 2	0.05	1.00	0.30	0.15	0.15	0.00	0.16	0.01	0.09	0.22	0.09	0.27	0.14	0.17	0.25	0.00	0.21
Item 3	-0.02	0.30	1.00	0.18	0.12	0.03	0.17	-0.05	-0.01	0.11	0.04	0.19	0.10	0.08	0.28	-0.05	0.23
Item 4	0.32	0.15	0.18	1.00	0.06	-0.30	0.32	0.23	0.18	0.33	0.34	0.19	0.14	0.09	0.13	0.17	0.14
Item 5	0.30	0.15	0.12	0.06	1.00	0.22	0.25	0.12	0.12	0.16	0.15	0.41	0.32	0.14	0.28	0.14	0.25
Item 6	-0.05	0.00	0.03	-0.30	0.22	1.00	-0.03	-0.14	0.17	-0.15	-0.24	0.07	0.09	-0.07	0.05	-0.13	0.07
Item 7	0.16	0.16	0.17	0.32	0.25	-0.03	1.00	0.24	0.20	0.16	0.29	0.23	0.23	0.22	0.31	0.13	0.33
Item 8	0.36	0.01	-0.05	0.23	0.12	-0.14	0.24	1.00	0.23	0.29	0.44	0.15	0.20	0.06	0.22	0.53	0.05
Item 9	0.25	0.09	-0.01	0.18	0.12	-0.17	0.20	0.23	1.00	0.20	0.29	0.21	0.17	0.19	0.16	0.28	0.14
Item 10	0.37	0.22	0.11	0.33	0.16	-0.15	0.16	0.29	0.20	1.00	0.47	0.23	0.21	0.07	0.14	0.20	0.17
Item 11	0.43	0.09	0.04	0.34	0.15	-0.24	0.29	0.44	0.29	0.47	1.00	0.22	0.17	0.17	0.22	0.36	0.15
Item 12	0.35	0.27	0.19	0.19	0.41	0.07	0.23	0.15	0.21	0.23	0.22	1.00	0.36	0.32	0.41	0.19	0.31
Item 13	0.21	0.14	0.10	0.14	0.32	0.09	0.23	0.20	0.17	0.21	0.17	0.36	1.00	0.11	0.20	0.18	0.19
Item 14	0.10	0.17	0.08	0.09	0.14	-0.07	0.22	0.06	0.19	0.07	0.17	0.32	0.11	1.00	0.32	0.08	0.23
Item 15	0.18	0.25	0.28	0.13	0.28	0.05	0.31	0.22	0.16	0.14	0.22	0.41	0.20	0.32	1.00	0.12	0.36
Item 16	0.39	0.00	-0.05	0.17	0.14	-0.13	0.13	0.53	0.28	0.20	0.36	0.19	0.18	0.08	0.12	1.00	0.01
Item 17	0.08	0.21	0.23	0.14	0.25	0.07	0.33	0.05	0.14	0.17	0.15	0.31	0.19	0.23	0.36	0.01	1.00

Appendix 9: Modified Alcohol Use Questionnaire (AUQ: Mehrabian & Russell, 1978)

Instructions: The following questions ask you about your habitual use of various types of alcoholic beverages. Please consider your drinking for the **last 12 months** in answering the questions and take your time to give an accurate answer to each question.

Item	**Respond in this column**
0. If you never drink, type a '1' in the response column for this item and ignore all the remaining questions. If you do drink, ignore this item and answer all the remaining questions.	
1. How many days per week do you drink some wine (at least one small, 125 ml glass)?	
2. On those days you do drink wine, about how many glasses (125 ml each) do you typically have?	
3. How many glasses (125 ml) of wine do you have in a week, in total?	
4. How many days a week do you drink some beer, lager, or cider (at least 1 pint of approx. 5%)?	
5. On the days you do drink beer, lager, or cider, about how many pints do you have?	
6. How many pints of beer do you have in a week, in total?	
7. How many days a week do you drink spirits (whisky, scotch, brandy, bourbon, vodka, gin, rum, etc.)?	
8. On the days you do drink spirits, about how many drinks do you typically have (a drink being 25 ml of spirits, that is, a single shot, alone or mixed)?	
9. How many drinks of spirits do you have in a week, in total?	

Appendix 10: Drug Abuse Screening Test (DAST-10; Skinner, 1982)

Instructions: The following questionnaire asks about your typical drug use over the past 12 months. Please read through each question and circle the response that best describes your behaviour. For the purposes of this questionnaire, term 'drug' includes recreational use of both prescription drugs and other illicit drugs such as marijuana, cocaine, LSD, ecstasy, etc. but does *not* include alcohol.

Item	***Circle your response***	
1. Have you used drugs other than those required for medical reasons?	Yes	No
2. Do you abuse more than one drug at a time?	Yes	No
3. Are you always able to stop using drugs when you want to?	Yes	No
4. Have you had "blackouts" or "flashbacks" as a result of drug use?	Yes	No
5. Do you ever feel bad or guilty about your drug use?	Yes	No
6. Does your spouse (or parents) ever complain about your involvement with drugs?	Yes	No
7. Have you neglected your family because of your use of drugs?	Yes	No
8. Have you engaged in illegal activities in order to obtain drugs?	Yes	No
9. Have you ever experienced withdrawal symptoms (felt sick) when you stopped taking drugs?	Yes	No
10. Have you had medical problems as a result of your drug use (e.g. memory loss, hepatitis, convulsions, bleeding, etc.)?	Yes	No

'Yes' responses receive a score of 1; 'No' responses receive a score of 0.

Appendix 11: Eysenck Personality Questionnaire – Revised: Extraversion Scale (EPQ-R; Eysenck *et al.*, 1985b)

Instructions: Please answer each question by putting a circle around the 'YES' or 'NO' following the question. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the questions.

PLEASE REMEMBER TO ANSWER EACH QUESTION

1. Do you have many different hobbies?	YES / NO
2. Are you a talkative person?	YES / NO
3. Are you rather lively?	YES / NO
4. Can you usually let yourself go and enjoy yourself at a lively party?	YES / NO
5. Do you enjoy meeting new people?	YES / NO
6. Do you tend to keep in the background on social occasions?	YES / NO
7. Do you like going out a lot?	YES / NO
8. Do you prefer reading to meeting people?	YES / NO
9. Do you have many friends?	YES / NO
10. Would you call yourself happy-go-lucky?	YES / NO
11. Do you usually take the initiative in making new friends?	YES / NO
12. Are you mostly quiet when you are with other people?	YES / NO
13. Can you easily get some life into a rather dull party?	YES / NO
14. Do you like telling jokes and funny stories to your friends?	YES / NO
15. Do you like mixing with people?	YES / NO
16. Have people said that you sometimes act too rashly?	YES / NO
17. Do you nearly always have a 'ready answer' when people talk to you?	YES / NO
18. Do you like doing things in which you have to act quickly?	YES / NO

EPQ-R continues over the page

Continued

19. Do you often make decisions at the spur of the moment?	YES / NO
20. Do you often take on more activities than you have time for?	YES / NO
21. Can you get a party going?	YES / NO
22. Do you like plenty of bustle and excitement around you?	YES / NO
23. Do other people think of you as being very lively?	YES / NO

PLEASE CHECK THAT YOU HAVE ANSWERED ALL THE QUESTIONS

'Yes' responses receive a score of 1; 'No' responses receive a score of 0.

Appendix 12: Recent Impulsivity Scale (RIS) – Final Version

Instructions: The following questionnaire asks about your behaviour over **THE LAST 2 WEEKS**. Please read through each statement, and put a tick in one of the four response categories to indicate how often you have behaved as described.

IN THE LAST TWO WEEKS:

Item	Never	Rarely	Quite Often	Very Often
1. *I have thought carefully before doing and saying things.**				
2. *I have tended to act 'on impulse'.*				
3. *I have planned work tasks and activities in my free time carefully.**				
4. *I have been focused, seeing things through to the end.**				
5. *I have encountered problems because I did things without stopping to think.*				
6. *I have become involved with something that I later wished I could*				
7. *I have planned events and activities well ahead of time.**				
8. *I have tended to jump from one interest to another.*				

Items scored 0, 1, 2, and 3;

* Indicates item is reverse-scored.

Items 1, 3, 4, and 7 constitute the Cognitive Impulsivity Subscale;

Items 2, 5, 6, and 8 constitute the Motor Impulsivity Subscale.

Appendix 13: Trait Impulsivity Scale (TIS) – Final Version

Instructions: The following questionnaire asks about your behaviour **IN GENERAL**. Please read through each statement, and put a tick in one of the four response categories to indicate how often you have behaved as described.

IN GENERAL:

Item	Never	Rarely	Quite Often	Very Often
1. *I think carefully before doing and*				
2. *I tend to act 'on impulse'.*				
3. *I plan work tasks and activities in my free time carefully.**				
4. *I am focused, seeing things through to*				
5. *I encounter problems because I do things without stopping to think.*				
6. *I become involved with something that I later wish I could get out of.*				
7. *I plan events and activities well ahead*				
8. *I tend to jump from one interest to*				

Items scored 0, 1, 2, and 3;

* Indicates item is reverse-scored.

Items 1, 3, 4 and 7 constitute the Cognitive Impulsivity Subscale;

Items 2, 5, 6 and 8 constitute the Motor Impulsivity Subscale.

Appendix 14: Details of go/no-go stimuli

The animal-related ('go') words were: tiger; horse; elephant; seal; shark; cat; dog; giraffe; zebra; goat; lion; snake; kangaroo; and whale. The non-animal-related ('no-go') words were all stationary-related and were as follows: pencil; ruler; stapler; pen; eraser; pin; holepunch; paper; glue; sharpener; laptop; paperclip; folder; and tray. The subsets of 14 animal-related and stationery-related words were matched for word length, number of syllables and frequency in the English language as indexed in the CELEX database (Baayen, Piepenbrock & Gulikers, 1995; see Table A2).

Table A2: Means (standard deviations) of the final go and no-go word stimuli

Characteristic	**Go words (*n* = 14)**	**No-go words (*n* = 14)**	***t* value**	***p* value**
Word length *(no of letters)*	5.07 (1.59)	5.86 (2.07)	-1.13 (*df* = 26)	ns
Number of syllables	1.57 (0.76)	1.93 (0.73)	-1.27 (*df* = 26)	ns
Word frequency *(appearances per million words)*	35.79 (43.34)	28.58 (63.37)	0.34 (*df* = 24)	ns

Note = word frequency data for 'laptop' and 'holepunch' was not available in the CELEX database; therefore, the independent-measures *t*-test for word frequency was conducted without these items (hence *df* = 24).

Appendix 15: Main Effects of ELECTRODE REGION on no-go P3 and N2 Amplitudes and Latencies

Table A3 shows all main effects of ELECTRODE REGION for the 2 (DRINKING GROUP: HDs vs. LDs) x 5 (ELECTRODE REGION: frontal vs. central vs. parietal vs. temporal vs. occipital) ANOVAs on HDs' and LDs' P3 and N2 amplitudes and latencies for no-go trials in the CPT. In all cases the Greenhouse-Geisser statistic is reported due to violations of the sphericity assumption.

Table A3: Main effects of ELECTRODE REGION on no-go P3 and N2 amplitudes and latencies

	Main effect of ELECTRODE REGION		
	F	***df***	***p***
Nogo P3 amplitude	17.33	1.62, 29.23	< 0.01
Nogo P3 latency	1.36	1.87, 33.59	ns
Nogo N2 amplitude	4.62	1.97, 35.50	0.02
Nogo N2 latency	20.86	2.65, 47.67	< 0.01

Appendix 16: Main and Interaction Effects of 2 x 2 x 2 x 3 ANOVA on P3 Amplitudes

Table A4 shows all main and interaction effects for the 2 (DRINKING GROUP: HDs vs. LDs) x 2 (WORD-TYPE: AR vs. HR) x 2 (HEMISHERE: left vs. right) x 3 (CAUDALITY: anterior vs. central vs. posterior) ANOVA on HDs' and LDs' P3 amplitudes in response to AR and HR words.

Table A4: Main and interaction effects of mean P3 amplitudes

Main effects	***F***	***df***	***p***
DRINKING GROUP	0.24	1, 20	ns
WORD-TYPE	3.63	1, 20	0.07
HEMISPHERE	5.88	1, 20	0.03
CAUDALITY†	9.76	1.24, 24.78	< 0.01
Interaction effects			
DRINKING GROUP x WORD-TYPE	4.89	1, 20	0.04
DRINKING GROUP x HEMISPHERE	0.00	1, 20	ns
DRINKING GROUP x CAUDALITY	0.33	2, 40	ns
WORD-TYPE x HEMISPHERE	1.22	1, 20	ns
WORD-TYPE x CAUDALITY†	0.21	1.29, 25.76	ns
HEMISPHERE x CAUDALITY†	4.16	1.45, 28.93	0.04
DRINKING GROUP x WORD-TYPE x HEMISPHERE	2.13	1, 20	ns
DRINKING GROUP x WORD-TYPE x CAUDALITY	1.33	2, 40	ns
DRINKING GROUP x HEMISPHERE x CAUDALITY	0.43	2, 40	ns
WORD-TYPE x HEMISPHERE x CAUDALITY	1.65	2, 40	ns
DRINKING GROUP x WORD-TYPE x HEMISPHERE x CAUDALITY	0.29	2, 40	ns

†Greenhouse-Geisser statistic used due to a violation of sphericity.

Appendix 17: Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983)

Instructions: This questionnaire is concerned with how you have been feeling within the **last week**. Please answer each question by putting a tick next to the sentence underneath it that best describes how much you have had that feeling over the **last week**.

1. I feel tense or 'wound up':		**2. I still enjoy the things I used to enjoy:**	
Most of the time		Definitely as much	
A lot of the time		Not quite so much	
Time to time, occasionally		Only a little	
Not at all		Not at all	
3. I get a sort of frightened feeling like something awful is about to happen:		**4. I can laugh and see the funny side of things:**	
Very definitely and quite badly		As much as I always could	
Yes, but not too badly		Not quite so much now	
A little, but it doesn't worry me		Definitely not so much now	
Not at all		Not at all	
5. Worrying thoughts go through my mind:		**6. I feel cheerful:**	
A great deal of the time		Not at all	
A lot of the time		Not often	
From time to time but not too		Sometimes	
Only occasionally		Most of the time	
7. I can sit at ease and feel relaxed:		**8. I feel as if I am slowed down:**	
Definitely		Nearly all of the time	
Usually		Very often	
Not often		Sometimes	
Not at all		Not at all	

HADS continues over the page

HADS continued

9. I get a sort of frightened feeling like 'butterflies in the stomach':		**10. I have lost interest in my appearance:**	
Nearly all of the time		Definitely	
Very often		I don't take as much care as I	
Sometimes		I may not take quite as much	
Not at all		I take just as much care as ever	
11. I feel restless as if I have to be on the move:		**12. I look forward with enjoyment to things:**	
Very much indeed		As much as I ever did	
Quite a lot		Rather less than I used to	
Not very much		Definitely less than I used to	
Not at all		Hardly at all	
13. I get sudden feelings of panic:		**14. I can enjoy a good book or radio or TV programme:**	
Very often indeed		Often	
Quite often		Sometimes	
Not very often		Not often	
Not at all		Very seldom	

Items are scored 0, 1, 2, 3;
HADS Anxiety Scale = Items 1, 3, 5, 7, 9, 11 and 13;
HADS Depression Scale = Items 2, 4, 6, 8, 10 and 12.

Appendix 18: The Snaith-Hamilton Pleasure Scale (SHPS; Snaith *et al.*, 1995)

Instructions: This questionnaire is designed to measure your ability to experience pleasure. It is important to read each statement very *carefully*. Tick *one* of the boxes [ ] to indicate how much you agree or disagree with each statement.

1. I would enjoy my favourite television or radio programme:

Strongly disagree [ ]
Disagree [ ]
Agree [ ]
Strongly agree [ ]

2. I would enjoy being with my family or close friends:

Strongly disagree [ ]
Disagree [ ]
Agree [ ]
Strongly agree [ ]

3. I would find pleasure in my hobbies and pastimes:

Strongly disagree [ ]
Disagree [ ]
Agree [ ]
Strongly agree [ ]

4. I would be able to enjoy my favourite meal:

Strongly disagree [ ]
Disagree [ ]
Agree [ ]
Strongly agree [ ]

5. I would enjoy a warm bath or refreshing shower:

Strongly disagree [ ]
Disagree [ ]
Agree [ ]
Strongly agree [ ]

6. **I would find pleasure in the scent of flowers or the smell of a fresh sea breeze or freshly baked bread:**

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

7. **I would enjoy seeing other people's smiling faces:**

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

8. **I would enjoy looking smart when I have made an effort with my appearance:**

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

9. **I would enjoy reading a book, magazine or newsletter:**

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

10. **I would enjoy a cup of tea or coffee or my favourite drink:**

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

11. **I would find pleasure in small things, e.g. bright sunny day, a telephone call from a friend:**

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

12. I would be able to enjoy a beautiful landscape or view:

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

13. I would get pleasure from helping others:

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

14. I would feel pleasure when I receive praise from other people:

Strongly disagree	[ ]
Disagree	[ ]
Agree	[ ]
Strongly agree	[ ]

Responses are scored 4, 3, 2, 1 (Franken *et al.*, 2007).

Appendix 19: Emotional Stroop Task

1. Neutral words condition:

Percent	Bound	Courier	Engineers
Cadet	Associate	Apartment	Level
Level	Hoop	Emulsion	Pavement
Associate	Courier	Engineers	Cadet
Apartment	Cadet	Hoop	Associate
Courier	Apartment	Pavement	Percent
Engineers	Level	Bound	Hoop
Associate	Percent	Percent	Apartment
Pavement	Emulsion	Courier	Associate
Apartment	Cadet	Level	Hoop
Bound	Associate	Engineers	Emulsion
Percent	Engineers	Apartment	Courier
Emulsion	Percent	Hoop	Percent
Cadet	Pavement	Bound	Level
Engineers	Emulsion	Emulsion	Courier
Courier	Bound	Pavement	Pavement
Bound	Hoop	Engineers	Apartment
Pavement	Cadet	Bound	Associate
Percent	Associate	Hoop	Level
Emulsion	Level	Apartment	Hoop
Level	Bound	Cadet	Emulsion
Engineers	Pavement	Courier	Cadet

2. Appetitive words condition:

Ecstatic	Adventure	Caress	Euphoria
Adventure	Euphoria	Affection	Adventure
Cuddle	Love	Love	Cuddle
Love	Pleasure	Euphoria	Passion
Euphoria	Bliss	Passion	Ecstatic
Kiss	Ecstatic	Kiss	Love
Ecstatic	Kiss	Affection	Caress
Caress	Passion	Cuddle	Pleasure
Affection	Caress	Ecstatic	Passion
Pleasure	Euphoria	Love	Adventure
Adventure	Affection	Bliss	Kiss
Love	Bliss	Cuddle	Pleasure
Euphoria	Cuddle	Caress	Affection
Affection	Adventure	Adventure	Love
Caress	Passion	Pleasure	Bliss
Passion	Caress	Bliss	Kiss
Ecstatic	Kiss	Affection	Affection
Pleasure	Euphoria	Kiss	Passion
Cuddle	Bliss	Passion	Pleasure
Bliss	Pleasure	Euphoria	Kiss
Caress	Cuddle	Cuddle	Adventure
Ecstatic	Ecstatic	Bliss	Love

3. Aversive words condition:

Coffin	Emergency	Embarrassed	Paralysed
Pathetic	Ambulance	Lonely	Ashamed
Paralysed	Coffin	Emergency	Lonely
Embarrassed	Paralysed	Ashamed	Coffin
Emergency	Pathetic	Lonely	Ambulance
Coffin	Embarrassed	Blunder	Harm
Corpse	Coffin	Paralysed	Emergency
Blunder	Emergency	Ambulance	Pathetic
Ambulance	Harm	Ashamed	Coffin
Pathetic	Coffin	Pathetic	Paralysed
Harm	Ambulance	Blunder	Lonely
Emergency	Ashamed	Paralysed	Embarrassed
Pathetic	Ashamed	Ambulance	Blunder
Ambulance	Coffin	Lonely	Corpse
Blunder	Emergency	Ashamed	Harm
Corpse	Embarrassed	Harm	Emergency
Ashamed	Corpse	Blunder	Lonely
Embarrassed	Ashamed	Paralysed	Blunder
Lonely	Embarrassed	Corpse	Pathetic
Ambulance	Blunder	Corpse	Harm
Lonely	Harm	Embarrassed	Paralysed
Corpse	Pathetic	Harm	Corpse

4. Alcohol-related words condition:

Pub	Liqueur	Beer	Cider
Liqueur	Cider	Spirits	Liqueur
Wine	Whisky	Whisky	Wine
Whisky	Drunk	Cider	Scotch
Cider	Booze	Scotch	Pub
Alcohol	Pub	Alcohol	Whisky
Pub	Alcohol	Spirits	Beer
Beer	Scotch	Wine	Drunk
Spirits	Beer	Pub	Scotch
Drunk	Cider	Whisky	Liqueur
Liqueur	Spirits	Booze	Alcohol
Whisky	Booze	Wine	Drunk
Cider	Wine	Beer	Spirits
Spirits	Liqueur	Liqueur	Whisky
Beer	Scotch	Drunk	Booze
Scotch	Beer	Booze	Alcohol
Pub	Pub	Spirits	Spirits
Drunk	Cider	Alcohol	Scotch
Wine	Booze	Scotch	Drunk
Booze	Drunk	Cider	Alcohol
Beer	Wine	Wine	Liqueur
Pub	Alcohol	Booze	Whisky