Inhibitory control, impulsivity, and recreational substance use

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I declare that the work presented in this thesis is my own

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ABSTRACT

This thesis explores the involvement of self-control and inhibitory control mechanisms in the early stages of drug use and addiction, and investigates specific psychological processes that are thought to be risk factors for substance use and abuse.

An "Intention, Impulse and Control (IIC) framework" is developed, uniting principles drawn from a variety of contemporary perspectives in identifying factors likely to influence whether an individual encounters and engages in substance use. Interrelationships between different self-report and laboratory-based behavioural measures of the psychological constructs implicated by this framework are examined via a cross-sectional study of 497 undergraduate students. Reflecting other findings in the literature, associations between self-report and behavioural measures are found to be weak or non-existent. Factor analysis of the self-report measures yields indices of three key trait constructs: approach tendencies, avoidance tendencies, and cognitive control.

The ensuing research programme tests some predictions of the IIC framework, assessing cross-sectional and longitudinal relationships in a large sample of students who use alcohol and other substances recreationally. Cross-sectional analyses probe the differential involvement of various factors including attitudes, recent stress, approach tendencies, avoidance tendencies, and cognitive control. Substance use is found to be strongly associated with attitudes, life stress, and cognitive control, but not with approach or avoidance tendencies. For a subset of 88 participants who were re-assessed between one and two years after baseline testing, longitudinal analyses address whether (a) pre-existing impairments of self-control processes predispose some individuals towards substance abuse, and (b) substance use itself leads to diminished self-control. Although methodological limitations mean that caution is needed when interpreting these data, the analyses indicate no causal connections between cognitive control, either at baseline or in terms of change over time, and changes in substance use. The implications of the findings for current theories of addiction, and for future research, are considered.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THESIS OVERVIEW

Drug addiction provides one of the clearest behavioural examples of diminished self-control; consequently, theoretical attempts to explain its aetiology inescapably touch upon highly contentious issues regarding the nature of self-control, free will and autonomy. At present, a diagnosis of substance-related dependence using the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 2000) requires a minimum of three indicators out of seven listed criteria: of these, the first two relate to evidence of physiological dependence (i.e. tolerance and withdrawal). The remaining five criteria relate to psychological aspects of addiction: two describe a lack of success in attempts to reduce or desist from substance use and two describe drug seeking and taking behaviours occupying inappropriate amounts of time and energy. The final criterion refers to the persistence of substance use despite the presence of physiological or psychological problems caused or exacerbated by substance use-related behaviours. All five of these criteria involve a weakened command over the actions or decision-making processes involved in drug seeking and consumption. Evidently, a diagnosis of addiction requires the presence of impaired inhibitory control over substance use-related behaviours.

The identification and investigation of factors implicated in the aetiology of substance abuse and dependency has been the focus of much research over the past decades. During that time, various constructs have been the centre of attention for addiction researchers, especially those focusing upon neurobiological accounts of addictive behaviour. One of the first such constructs was negative reinforcement, whereby it is suggested that the behaviour of the addict is largely accounted for by the effects of physical dependence and a desire to alleviate withdrawal symptoms (e.g. Wickler, 1948; in Baker, Piper, McCarthy, Majeskie, & Fiore, 2004). A second related construct was positive reinforcement, where it is argued that appetitive motivational processes underlie the compulsion to use drugs, and drugs of abuse are said to 'hijack' the natural reward system of the brain (e.g. Robinson & Berridge, 2000). In 1999, Alan Lechner, then head of the US National Institute of Drug Abuse (NIDA), famously described addiction as a "chronic, often relapsing brain disease" (p.45). In doing so, he expressly wished to challenge the portrayal of addicts as morally weak individuals who are unwilling, rather than unable, to control their own actions. More recently, Obot, Poznyak and Moneiro defined addiction as "a complex disorder involving brain mechanisms, rather than a failure of will" (2004, p.1497). These definitions are in keeping with a 'hijacked brain' hypothesis and are consistent with the prevailing disease model of addiction, which focused primarily upon the powerful appetitive forces that drive addicted individuals to engage in substance use, and less upon the failure of inhibitory control mechanisms which normally enable people to resist urges to engage in desired but maladaptive behaviours.

Signifying a significant shift in perspective, Ruben Baler and Nora Volkow, current director of NIDA and strong advocate of the disease model of addiction, recently commented:

> "We posit that the time has come to recognize that the process of addiction erodes the same neural scaffolds that enable self-control and appropriate decision making."
>
> (Baler & Volkow, 2006; p. 559)

This timely statement recognises neural commonalities between the processes underlying impaired self-control and those implicated in addiction. It reflects important recent developments in neurobiological research, which have begun to illuminate potential mechanisms underlying both the appetitive motivation to engage in substance use *and* diminished inhibitory control over maladaptive behaviours. These findings have encouraged researchers to include mechanisms related to impaired control and inappropriate decision-making in biological models of addiction (e.g. the Impaired Response Inhibition and Salience Attribution model; Goldstein & Volkow, 2002). This recent shift has been so pervasive that one neurobiologist commented: "Inhibitory control is the third major paradigm in investigation of the neuronal basis of addiction" (Grant, 2004, p.1505).

An important challenge for this relatively new framework will be to account for findings that each of its predecessors failed to explain. For example, a major feature of addiction is the relapse to drug use after a prolonged period of abstinence. While the rewarding effects of drugs of abuse and the relatively short-lasting presence of withdrawal do not readily explain this occurrence, there is evidence that chronic drug use is associated with long-term adaptations to glutamatergic projections from the orbitofrontal prefrontal cortex to the nucleus accumbens, thereby undermining cognitive control even after years of drug abstinence (Kalivas & Volkow, 2005). Another major feature of addiction is the fact that many drug dependent individuals discontinue drug use without treatment (e.g. Walters, 2000). Similarly, while a high percentage of individuals experiment with substances of abuse, only a small minority become dependent. Together these facts demonstrate that exposure to drugs is a necessary but not sufficient condition for substance dependence and that substance dependence is not inevitably a permanently debilitating condition. In addition, there are marked individual differences in the way addictive behaviours develop and manifest, and any theory of addiction must account for these. Fundamentally, how is it that some individuals but not others move from non-user to controlled user, from controlled user to addict and from addict to non-user?

The overall aim of this thesis is to explore the involvement of self-control and inhibitory control mechanisms in the early stages of drug use and addiction. Baler and Volkow's suggestion that these become eroded during the process of becoming addicted prompts several lines of enquiry: do individuals vary in the extent to which these functions deteriorate, providing a marker of susceptibility to dependency? Might pre-existing deficiencies predispose some individuals towards substance use and abuse, thus perhaps explaining why some people become addicted to the very same substances that others use recreationally? A large body of research has already embarked on discussing these questions and their findings will be discussed later in this chapter; however, it has been noted that this body of research into inhibitory control has lacked a "clearly defined operational definition and experimental implementation" (Grant, 2004; p.1505) and a more specific conceptualization is needed. Thus, the present thesis firstly presents a framework that, drawing from the strengths of existing theory and from a review of past findings, provides a rudimentary account of how inhibitory control processes might interact with other psychological constructs to modify the likelihood of substance use. This framework, presented on page 19, is not intended to challenge current models or theories of addiction; rather, it aims to unite principles drawn from a variety of contemporary perspectives. The thesis then goes on to empirically examine the framework's utility and validity by investigating its predictions in relation to specific aspects of substance use behaviours in young adults.

The research programme will assess both cross-sectional and longitudinal relationships between control mechanisms and substance use in a large sample of recreational substance users. Cross-sectional analyses will probe whether, as predicted within the framework, some aspects of impaired inhibitory control are differentially implicated in specific types or features of substance use. Longitudinal analyses will address whether a) pre-existing impairments of self-control processes predispose some individuals towards substance abuse, and b) exposure to substances of abuse itself leads to diminished self-control. Chapter 1 will introduce the theoretical framework within which these research questions will be addressed.

CHAPTER ONE

Impaired control in substance use: introducing a practical framework

Start at the end: from substance use dependency to initiation

That impaired self-control and decision-making processes are involved in *addiction* is apparent in the seemingly irrational behaviour of addicts. For example, the potential negative effects of sustained drug use are today widely known; yet, addicts appear unable or unwilling to make choices based on these longer-term outcomes, focusing instead on the immediate gratification of drug-use and thus incurring the negative future outcomes so detrimental to both individuals and society at large. By disregarding the long-term negative outcomes of behaviour and instead demonstrating a behavioural preference for the positive immediate gains of taking drugs, an addict's actions are indicative of either or both heightened impulsivity and reduced self-control. In cases in which an individual expresses a clear desire to desist from drug use, addiction can aptly be described as:

> "a discrepancy between the personal will and urge; between higher-order reflective cognitive processes and basic, implicit, motivational driven processes."
>
> (Buhringer, 2007, p.1002)

Thus, whilst the individual's stated aim is to avoid substance use, other motivational drives supersede their resolve, impelling him/her towards drug consumption.

As Baler and Volkow commented, and as will be discussed in further detail in later sections of this chapter, neurobiological research suggests a commonality between mechanisms implicated in addiction and those related to "willpower" or self-control. It may be that Buhriger's "basic, implicit, motivation driven processes" underlie the urge to engage in substance use, whereas his "higher-order reflective processes" are involved in self-control. In order to understand the aetiology of addiction, we must identify the interactions *between* the reflective cognitive processes with which an individual is able to distinguish between beneficial and injurious actions, and the internal motivational drives that impel him/her to engage in drug use. As Buhringer continues:

> "Perhaps the nature of these two systems, their interactions and individual differences are a possible source for a better understanding of individual risk levels for onset, continuation and offset of problematic behaviour."
>
> (2007, p.1002)

Substance dependence involves *both* reflective decision-making processes and reflexive motivational processes; therefore, an appreciation of how each contributes separately *and* how they may interact will enable a more comprehensive understanding of individual differences in the manifestation of addiction.

While many researchers have focused on drug addicts to address this issue, the aim of this thesis is to explore the involvement of Buhringer's systems in the earlier stages of substance use initiation and experimentation. Do pre-existing differences in one system or both, or in their interaction, influence the likelihood and extent to which individuals engage in early experimental stages of substance use and their progression towards substance abuse or addiction?

Figure 1.1 presents a speculative framework informed by contemporary neurobiological and psychobiological theories, and its key elements are explained in the following pages.

Introducing the Intention, Impulse & Control (IIC) framework

The IIC framework describes factors that are likely to be important to whether an individual encounters an opportunity to engage in substance use and what the behavioural consequences of such an encounter might be. The framework comprises five levels; although described separately, they are interrelated and interactions are predicted.

Level 1: Attitudinal factors

This level is concerned with the extent to which an individual's attitudes towards and intentions regarding substance use affect their actual drug use. Some individuals

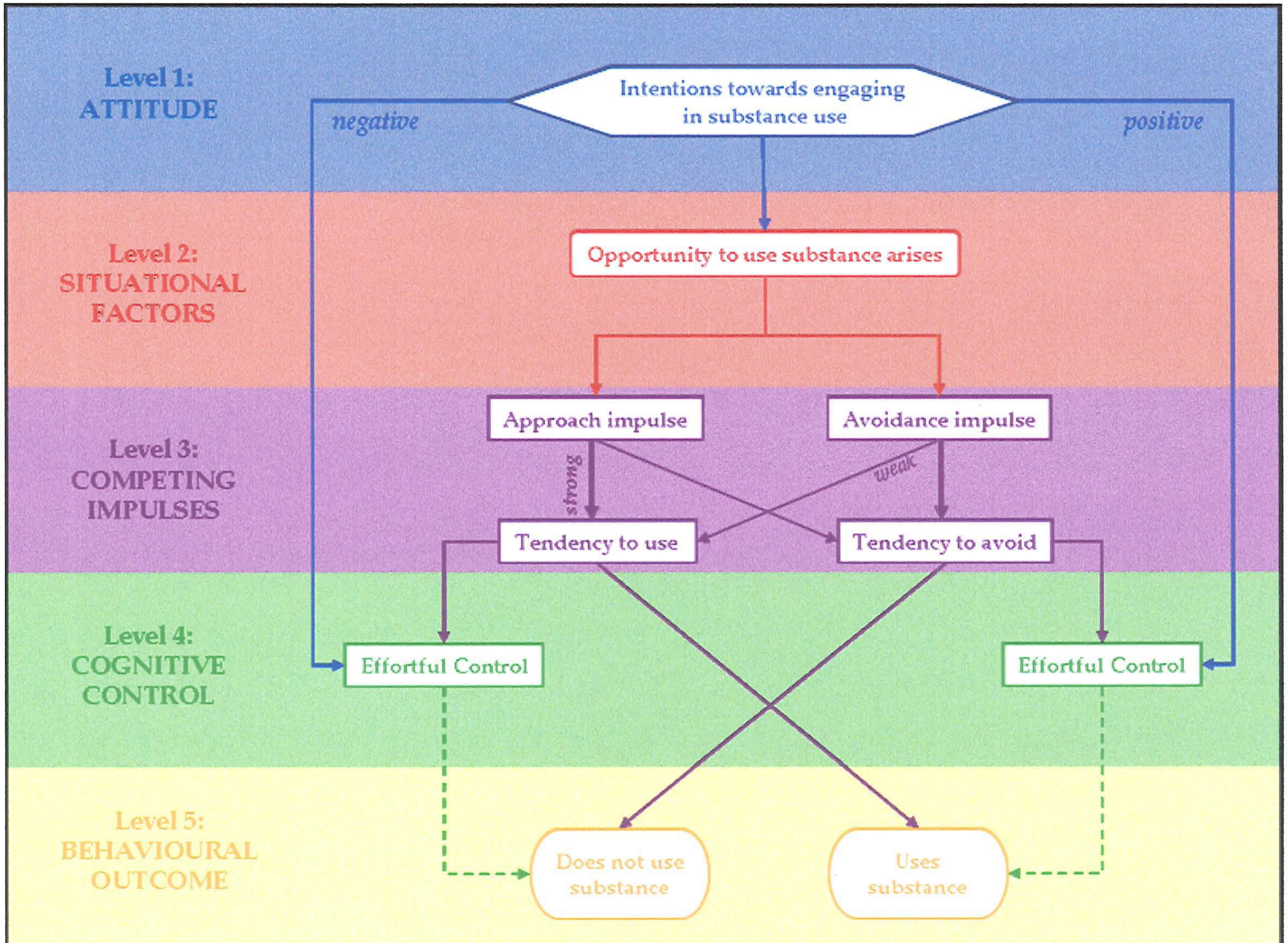

Figure 1.1: The Intention, Impulse & Control (IIC) Framework

actively seek opportunities to experiment with substance use, while others vary in their likelihood of encountering opportunities for other reasons. Thus, an individual's intentional state is relevant to any discussion of self-control and the decision-making processes involved in the stages leading to initial substance use. The IIC framework therefore places attitudes at the very start, representing them as, on balance, either a positive or a negative intentional state that affects subsequent experiences and reactions. Clearly, reducing the highly complex set of beliefs and opinions underlying attitudes towards substance use to a 'positive' vs. 'negative' categorisation is an over-simplification, and the purpose of doing so is primarily to acknowledge and explore in a limited way the extent to which an individual's pre-existing attitudes modulate their subsequent behaviour and cognitions.

Level 2: Situational factors

Clearly, situational factors affecting the accessibility of drugs influence whether an individual will engage in substance use. For example, the attitudes of his/her peers may influence his own, and their behaviours may present him/her with opportunities to engage in substance use. Situational factors are intrinsically linked to other levels of the framework; for example, individuals with strong attitudes towards or against substance use are likely to seek and form friendships with likeminded individuals. Research has shown adverse life experience to be positively associated with levels of substance use by adolescents (Wills et al., 2001), suggesting that life stress is another situational factor likely to have an effect upon whether an individual will encounter and engage in substance use.

Level 3: Competing Impulses

In the third level, the substance has become available to the individual and the focus shifts to a consideration of internally generated motivational impulses. These competing impulses relate directly to the reflexive implicit processes described earlier in this chapter. It is suggested, reflecting contemporary neurobiological research, that subcortical responses to appetitive and aversive substance-use related cues produce competing action tendencies; the first propels the individual towards substance use (approach) and the second is a resisting impulse away from substance use (avoidance).

It is suggested here that the strength of the respective impulses depends on a combination of the individual's biological disposition and his/her beliefs regarding substance use. Approach impulses represent an interaction between his/her general 'reward sensitivity' and his/her expectation that drug use will be rewarding. For example, a relatively low expectation of a pleasurable outcome in someone who has a very high level of responsiveness to appetitive cues, may result in a stronger desire to engage in substance use than that experienced by someone with the same or even higher expectations of reward, but whose reward sensitivity is lower. Responsiveness to appetitive cues is believed to reflect traits such as Sensation Seeking, whilst the expectation of reward will in part reflect attitudinal factors and past experiences. Conversely, it is suggested that avoidance impulses represent an interaction between the individual's general responsiveness to potentially aversive outcomes and their expectation that drug use will lead to negative consequences. Responsiveness to aversive cues is believed to reflect traits such as Neuroticism or Harm Avoidance; the expectation of negative consequences again in part reflects attitudinal factors and learning gained through experience.

An individual is likely to perceive drugs as having both appetitive and aversive effects, thus both approach and avoidance impulses may be triggered simultaneously. As shown in Figure 1.1, depending upon the relative strengths of these impulses, the resultant dominant action tendency will be either to use or to avoid substance use. It is suggested here that when the resulting action tendency is congruent with the person's general attitude (positive or negative), it will lead directly to the corresponding behavioural outcome; i.e. to use drugs or reject the opportunity to do so (Level 5). However, if a conflict arises between the action tendency (Level 3) and attitude (Level 1), it is suggested that "cognitive control" processes come into play to resolve such conflicts. (Level 4).

Levels 4 & 5: Cognitive Control & Behavioural Outcome

Represented as the penultimate level of the IIC framework, reflective decision-making processes act to inhibit action tendencies that oppose the individual's intentional state concerning substance use. Where an individual intends to avoid substance use but the action tendency directs behaviour towards substance use, effortful control mechanisms restrain the inclination to engage in substance use. For example, consider an individual who is high in reward sensitivity and becomes tempted to explore drug use, but also believes that drug use is morally wrong; effortful control mechanisms come into play to ensure that drug use does not take place. Where an individual intends to engage in substance use but action tendencies direct behaviour *away* from substance use, effortful control mechanisms must be applied to over-ride the dominant avoidance impulse. Consider an individual who seeks the approval of drug-using peers but who is fearful of the harmful consequences of drug use; cognitive control processes come into play to ensure that drug use can take place. Effortful control is assumed to depend on executive processes, particularly those implicated in self-regulation and response inhibition. If the effortful control system is insufficiently strong to counteract the prevailing approach or avoidance action tendencies, these tendencies will lead directly to behavioural outcomes.

The following sections will expand upon these descriptions and contextualise the IIC framework with reference to existing theories of impulse control and substance use.

Positioning the IIC framework in existing theory

The five levels of the IIC framework incorporate a broad range of influences, both internal and external to the individual. This section will provide a more in-depth exposition of the framework, considering each level in turn and discussing the ways in which it integrates existing literature and contemporary theories. The IIC framework is so labelled because its key components are 'intentions', implicit motivational 'impulse'-level processes and higher-order reflective cognitive 'control' processes; the majority of this discussion will therefore focus upon these levels.

Level 1: Attitudinal factors

The behaviours that are indicative of impaired self-control and decision-making reflect the failure of one or more processes within the complex system that underlies an individual's ability to engage in appropriate behaviour and curb undesirable impulses. The IIC framework importantly also addresses individual differences in whether substance use behaviours *are* deemed appropriate or are actively pursued. Intentional states are rarely explicitly acknowledged in theories of substance use, yet it is self-evident that drug taking sometimes reflects a purposeful and rational intention, and sometimes takes place *despite* an individual's stated intention to abstain. Clearly, in itself, knowing that an individual has engaged in substance use does not provide a full depiction of *how* and *why* s/he did so; thus, an exploration of individual differences in intentions is important to our understanding of substance use initiation and progression.

Cognitive processing theories of intention and behaviour

While there has been limited consideration of behavioral intentions with respect to the initiation of substance use, many theories consider intention to be of central importance to conceptualizing human action. A useful example is Icek Ajzen's influential Theory of Planned Behaviour (TPB), in which intention is assumed to be the "immediate antecedent to behaviour" (Ajzen, 2002; p.665). The theory proposes that beliefs lead to the development of attitudes which, in combination with the perceived pressure of social norms and the perception of behavioural control, lead to the formation of intentions. The TPB has been applied to, and found to improve the predictability of a wide array of behaviours, including physical activity (e.g. Amireault, Godin, Vohl, & Perusse, 2008), eating (e.g. Barberia, Attree, & Todd, 2008), condom use (e.g. Fazekas, Senn, & Ledgerwood, 2001) and also alcohol consumption (e.g. Huchting, Lac, & LaBrie, 2008). Thus, the IIC framework draws on Ajzen's conceptualization of the formation of intention in the prediction of behavioural outcome.

Intentions, religiosity, and substance use/abuse

Comparatively few studies have examined the formation of intentions *prior* to the initiation of substance use. Most contemporary theorists are concerned with the role of attitudes and motivational factors such as self-efficacy, which is typically defined as an individuals' beliefs about his/her ability to succeed in a specific task (Schwartzer & Jerusalem, 1995), in predicting successful abstinence in dependent users. For example, Relapse Prevention (RP; Marlatt & George, 1984; Witkiewitz & Marlatt, 2004) is a cognitive-behavioural intervention which generates techniques by which individuals with drug and alcohol problems can use cognitive and behavioural coping strategies to improve the likelihood that they will achieve abstinence. Consistent with TPB, RP predicts that high self-efficacy and a strong motivation to quit, in combination with effective coping strategies, will increase the probability of success.

A few cross-sectional studies have applied a similar approach to substance use initiation. Wolford and Swisher (1986) looked at the questionnaire responses from 9,400 students about their future intentions to use substance and found behavioral intentions to be consistently related to self-reported past substance use in a large sample of adolescents. More recently, Huver, Engels, Van Breukelen and De Vries (2007) examined whether cognitions (pro-smoking attitude, social norm, self-efficacy, intention) mediated the effects of different parenting styles (supportive, strictly controlling or psychologically controlling) upon the lifetime smoking history of 482 Dutch adolescents. They found that the inverse relationship between measures of strict control and smoking history was partly mediated by positive attitudes towards smoking and reported intentions to smoke in the future. Boys et al. (2007) interviewed 100 young drug and alcohol users and found that their reported intentions to use substances for a second time was predicted by their past substance use and the extent of peer substance use, suggesting that intentions can also be influenced by behaviour. These findings support a link between intentions towards and actual substance use, though the causal direction of the association remains to be ascertained.

Interestingly, one way in which intentions and actual substance use are clearly linked is via the influence of religious affiliation. The Rastafari movement, for whose followers the smoking of cannabis is an important spiritual act, demonstrates one way in which religious beliefs can influence substance use. There is also a well established literature supporting a significant inverse relationship between religiosity and substance use and abuse. For example, Francis (1997) found that religiosity predicted attitudes towards substance use in 13-15 year olds, even after controlling for individual differences in the personality traits Psychoticism, Extraversion and Neuroticism; further, the relationship between alcohol use and religious involvement in college students was shown to be partially mediated by negative beliefs about alcohol (T. J. Johnson, Sheets, & Kristeller, 2008). Consistent with these findings, a large cross-sectional study by Wallace et al. (2007), which included 227 American public high schools and over 16,000 students, found individual differences in religiosity to be negatively related to reported substance use. Thus, the strong negative association between religiosity and substance use illustrates the relevance of attitudes and intentions towards substance use.

Level 2: Situational factors

The contention that substance use initiation and progression are influenced by environmental and psychosocial factors is directly supported by an extensive research literature, much of which has examined the self-reported behaviour of adolescents, an age when experimentation typically takes place (British Medical Association, 2003; cited in Fowler et al, 2007). One multifactorial analysis of over sixteen thousand adolescents across six European countries identified peer and sibling substance use, peer-oriented lifestyle, and antisocial behaviour to be the strongest predictors of legal and illegal substance use; this pattern was common to all countries (Kokkevi et al., 2007). Additionally, findings suggest that peer influence has an age-related effect upon adolescent alcohol use (Li, Barrera, Hops, & Fisher, 2002) and that there is an increased likelihood of substance use in adolescents of lower socioeconomic status (Sussman & Dent, 2000). A review by Nation and Heflinger (2006) found that the highest psychosocial risk factors for drug and alcohol use could be summarised as those related to psychological functioning, family environment, peer relationships and stressful life events.

However, the causal relationship between situational factors and substance use initiation is bi-directional; for example, adolescents who experience higher levels of stress are more likely to become smokers, but those who become smokers are also more likely than their counterparts to subsequently report higher levels of stress and negative affect (Stein, Newcomb, & Bentler, 1996). There is high comorbidity between depression, anxiety, and substance use in adults (e.g. Wadsworth, Moss, Simpson & Smith, 2004) and it is difficult to tease apart the direct effects of situational factors such as life stress or peer influence from their indirect effects via associations with psychological well-being. For example, one study found higher levels of perceived stress in adolescents who smoked, but also less use of positive cognitive coping strategies than by their non-smoking counterparts (Siqueira, Diab, Bodian, &

Rolnitzky, 2000); thus, a full investigation of links between situational factors and substance use would have to explore mediator and/or moderator variables. Within the present thesis, life stress and socioeconomic status have been identified as two potentially important situational influences on substance use; whilst the potential role of mediating psychological variables such as coping is acknowledged, this level of analysis is beyond its scope.

Levels 3 & 4: Partitioning impulse control - competing impulses & cognitive control

It is difficult to separate the theories underlying the third and fourth levels of the IIC framework because, as discussed in the subsequent chapter, uncertainties surround their conceptualisations. Given that the *content* of the IIC framework derives from theory and empirical findings pertaining to reward responsiveness and impulsivity specifically in relation to addictive behaviours, the following sections will present a review of these constructs. Subsequently, discussion will turn to how the hypothetical *structure* of the IIC framework has been developed.

Addiction theory: the brain reward system

In attempting to explain the seemingly irrational behaviour central to substance dependence, early neurobiological and psychological theories of addiction focused upon positive reinforcement and the known ability of drugs of abuse to trigger release of the neurotransmitter dopamine (DA), thought to be crucially involved in the natural reward system of the brain (e.g. Wise, 1987). The brain's reward circuitry consists of dopaminergic neurons which project from within ventral tegmental areas to the ventral striatum (including the nucleus accumbens) and other limbic structures, and also forwards to prefrontal and cingulate cortices (Elliott, Friston, & Dolan, 2000). This circuitry is believed to be evolved to motivate behaviour, through appetitive drive states, towards engaging in vital natural functions such as eating, drinking and sexual reproduction. Normally, the system is involved in mediating experiences of 'natural' reward (e.g. food and sex) and it has been argued that by 'hijacking' this reward system, drugs of abuse become increasingly required by addicts to achieve pleasurable states through dopamine release (Wise, 1987). This is supported by findings such as those from Garavan et al. (2000) where functional magnetic resonance imaging (fMRI) in addicts demonstrated that drug-related cues activated reward pathways more strongly than did natural reinforcers. Addicts also showed a significantly smaller response to the emotionally evocative but non-drug related stimuli than did non-addict controls.

However, newer findings challenge the simple hypothesis that mesocorticolimbic DA mediates positive reinforcement, and that this in turn underlies compulsive drug use. For example, addicts take drugs even when they perceive the drug as no longer pleasurable, and the self-reported reward value of drugs is stronger in drug naïve participants than in addicts (Goldstein & Volkow, 2002; Volkow et al, 1997). Thus, while it is widely accepted that the stimulation of DA release is a necessary property of addictive substances, and that the rewarding effects of drugs play an important role in the initiation and maintenance of substance use, dopamine release alone is not sufficient to explain the development of substance dependence.

More elaborate theories have been proposed regarding the role of DA in reward processing, for example associating its neural substrates with learning and the prediction of hedonic reward (Schultz, 2000), and with broader functions such as attentional switching, effort, or complex sensorimotor integration (see Kelley, 2002 for review). Robinson and Berridge's (2000; 2001) incentive-sensitisation theory proposes that chronic drug use renders brain reward systems hypersensitive to drug and drug-associated stimuli. They suggest that the activation of these pathways mediates 'wanting' or 'craving' and can lead to intensive drug-seeking and taking behaviour. Their theory redefines the role of DA as being to attribute "incentive salience" to drug-associated stimuli, and construes drug 'liking' as reflecting different mechanisms from drug 'wanting'; thus, it is able to account for the persistence of substance use after the subjective experience of pleasure declines. However, as the authors acknowledge, much of the research from which their model is derived was conducted using rodent models, and it is not yet clear how well these findings extrapolate to humans (Bradberry, 2007). Lubman, Yucel and Pantel (2004) point out that addicts rarely cite drug-associated cues or craving as triggers for relapse, and that the model overlooks other compulsive aspects of addictive behaviour that appear unrelated to reward functioning. Thus, for instance, it does not explain why some individuals appear to lose their ability to *suppress* the urge to consume drugs, despite claiming that they want to. This suggests to many researchers (e.g. Jentsch & Taylor, 1999) that there may additionally be a dysfunction of brain regions implicated in self-control and inhibitory control mechanisms. It is to the compulsive, hard-to-control nature of addiction, and the role of inhibitory control mechanisms, that discussion now turns.

Addiction theory: the role of the prefrontal cortex

A recent shift towards examining processes linked with response inhibition and motivation reflects researchers' interest in links between compulsive drug-use and other behaviours involving dysfunction of inhibitory control mechanisms. Jentsch and Taylor (1999) reviewed the association between response inhibition, impulsivity and the control of behaviour in substance abuse. They cite examples of similar deficits in patients with frontal lesions, whose disinhibited behaviour manifests in their inability to prevent inappropriate pre-potent responses. When damage is localised in the orbitofrontal (OFC) or prelimbic cortex, patients demonstrate a preference for immediate, smaller rewards, over larger, delayed rewards (Dias, Robbins, & Roberts, 1997). Lesions to areas of the prefrontal cortex (PFC) in monkeys likewise result in inhibitory deficits and perseveration. Jentsch and Taylor argue that human addicts demonstrate similar deficits, suggesting the potential involvement of these brain regions. The authors note that poor inhibitory control may exacerbate the enhanced incentive salience of drugs to the addict: "First, there may be an enhancement of the potency of the impulse (increased salience of the rewarding or reinforcing qualities of the conditioned stimulus). Second, the ability to actively inhibit that impulse at a cognitive level may diminish."(p. 380).

Impulsive behaviours in general reflect the outcome of a conflict between a potent but inappropriate urge and an attempt to suppress its behavioural expression (e.g. controlling aggressive tendencies or compulsive purchasing). Lubman, Yucel and Pantelis (2004) have focused on mechanisms underlying inhibitory control, reviewing a literature that links features of addiction and obsessive-compulsive disorder (OCD), whereby OCD is characterised by the over-control of behaviour and addiction by under-control. OCD is associated with increased activity in specific frontal regions (including the OFC and anterior cingulate cortex; ACC). While current addicts generally exhibit under-activity in the same areas, those in the early stages of withdrawal show significantly higher levels of OFC metabolism, which correlate with self-reported levels of craving (e.g. Childress et al., 1999). Thus, OFC functioning is abnormal in both disorders, and both groups show performance deficits on experimental cognitive tasks that tap executive functioning (e.g. for OCD, see Rogers et al., 1999; for addicts, see Bechara., et al, 2001).

Antoine Bechara directly addresses issues of willpower and self-control in his 'somatic marker' hypothesis (Bechara, 2005), which proposes that decision-making processes depend on bio-regulatory processes related to homeostasis and emotion. Bechara supposes that willpower emerges from the dynamic interaction of two systems. Firstly, an amygdala, reflexive system triggers affective responses to cues signalling immediate reinforcement; secondly, a prefrontal, reflective system signals future reinforcement through the evocation of recalled or imagined affective events. Top-down control processes of the reflective system include decision-making, the deliberate suppression of prepotent responses, and resistance to the influence of intruding or distracting stimuli. Bottom-up influences from the reflexive system reflect the conditioned rewarding properties of stimuli, and lowering of the threshold for activation of affective responses. Applying his theory to the apparent reduction of free will and self-determination in addicts, Bechara suggests that hyperactivity in the bottom-up reflexive system might make it harder for the reflective system to control behaviour. These reflexive and reflective systems seem to correspond to mechanisms suggested by Jentsch and Taylor, the former mediating the "enhancement of the potency of the impulse" and the latter mediating "the ability to actively inhibit that impulse at a cognitive level" (p. 380).

Goldstein and Volkow's (2002) Impaired Response Inhibition and Salience Attribution model (I-RISA) unites behavioural, cognitive and emotional processes in a single, comprehensive theory of addiction. As seen in Figure 1.2, the I-RISA model contends that the addictive state involves disruptions to the striato-thalamo-orbitofrontal circuit, an area of the prefrontal cortex involved in perseverative behaviours and connected with the limbic system. These disruptions affect cortically regulated emotional and

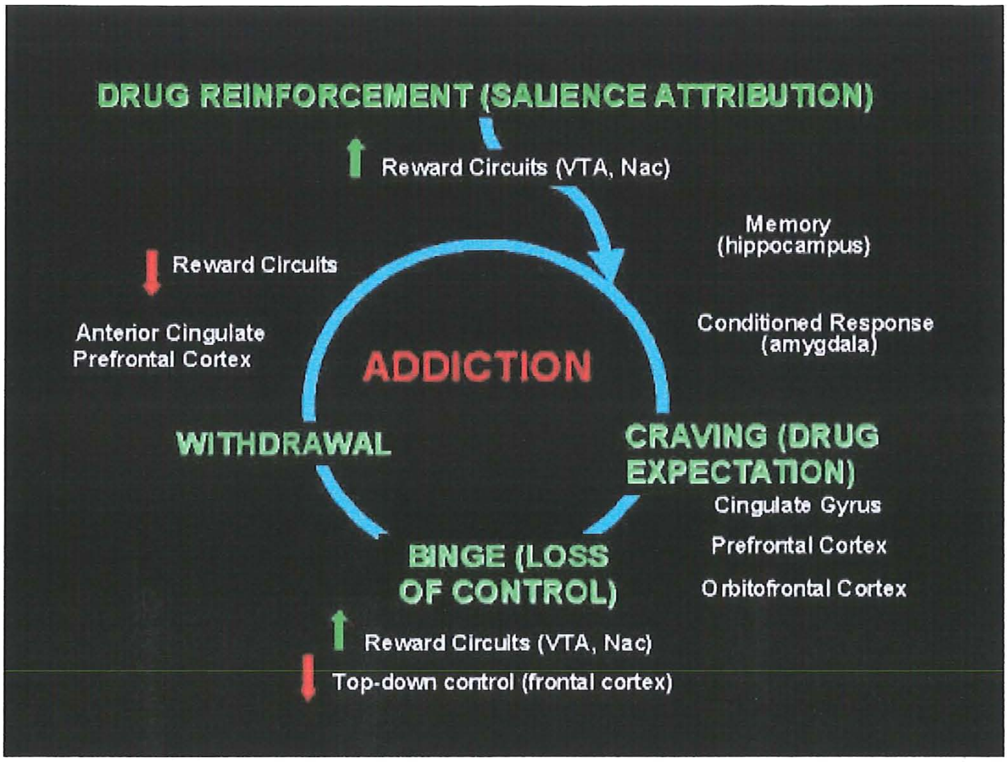

Figure 1.2: I-RISA (Impaired Response Inhibition & Salience Attribution; from Volkow et al. 2004)

motivational processes, and result in an inability to inhibit inappropriate responses elicited by drugs, related stimuli, or internal drive states; this manifests in increased disinhibition and ultimately may explain compulsive drug self-administration. Goldstein et al. (2007) found an association in cocaine addicts between compromised sensitivity to reward, as measured by self-report questionnaire, and activation of regions of both the OFC and amygdala in response to monetary reward. They also found that cocaine addicts showed abnormal neuronal responses to monetary reward and that money-induced activation of the PFC was associated with self-reported trait measures of motivation and self-control (Goldstein, Alia-Klein et al., 2007). Further evidence from neuroimaging studies has demonstrated reduced DA activity in the OFC of drug addicts (Volkow, Fowler, & Wang, 2004), whilst cognitive deficits indicative of OFC dysfunction have been shown to correlate with the duration of substance use in amphetamine users, (Rogers et al., 1999) possibly suggesting that prolonged drug use leads to the brain abnormalities observed.

The IIC framework incorporates all three of the approaches described in the preceding sections. Thus, it notes that factors implicated in strengthening the urge to use drugs influence approach impulses (Level 3), as do factors that increase the salience of substance and substance-related cues. It is suggested that subcortically mediated processes underlie the reflexive level of response, including both approach and avoidance impulses (Level 3), whilst cortically mediated processes underpin the reflective, cognitive level of response, involving the drive and inhibition systems of effortful control (Level 4).

Addiction theory: the chicken and egg conundrum and other complexities

Bechara's somatic marker hypothesis emerged from observed similarities between the behaviour of patients with damage to the ventromedial prefrontal cortex (VM patients) and that of drug addicts, both of whom are arguably hypersensitive to reward, frequently deny that they actually have a problem, and appear insensitive to the future outcomes of their actions. The Iowa Gambling Task (IGT) is a card selection task in which the participant must choose smaller, less risky rewards over larger and more immediate rewards to succeed and VM patients have previously demonstrated significant impairments in this ability (e.g. Bechara, Damasio, Damasio & Anderson, 1994). In one study, Bechara et al. (2001) assessed 41 drug addicts, five VM patients and 40 normal controls using the IGT and observed that 63% of the addicts performed in the range of VM patients, versus only 23% of normal controls. Interestingly, those addicts who did not demonstrate decision-making deficits were better able to hold and maintain employment than those addicts who did show impairments; also, a subgroup of 'normal' controls demonstrated similar deficits to the VMPC patients. Bechara et al. question whether the decision-making deficits in some addicts developed *because* of their drug use, or were predisposing factors *leading to* substance abuse. Since the deficits were not exclusive to VM patients or addicts, are 'normal' individuals who show the same decision-making deficits 'predisposed' towards substance abuse? Bechara concludes that longitudinal research is needed to resolve these important questions.

There is clearly no simple cause-and-effect relationship between drug exposure and drug addiction, nor is there a straightforward causal relationship between impulsive tendencies or impaired decision-making and substance use or dependency. There are likely to be individual differences in the nature and strength of these associations.

While much of the discussion so far has focused on substance dependence, self-control is also implicated in *earlier* stages of exploratory and recreational substance use. At what stage in the development of addiction can an individual be said to have 'lost' control? Bechara's findings suggest that pre-existing differences between individuals in their capacity for self-control may be relevant to the likelihood that they will engage in initial exploratory substance use. Furthermore, given that only a small fraction of experimental and recreational drug users become dependent, it is important to explore what factors differentiate between individuals who do and do not progress to substance abuse following initial exposure.

An assumption of the I-RISA model, and other neurobiological theories of addiction, is that the disruptions to brain function seen in addicts are likely to result directly from prolonged exposure to substances of abuse. Thus, Baler and Volkow comment that "the process of addiction erodes the same neural scaffolds that enable self-control and appropriate decision making" (2006; p. 559). Researchers exploring the relationship between addiction and psychological interpretations of these same constructs (i.e. impulsivity, reward sensitivity, and response inhibition) openly question the causal direction of this association (e.g. Moeller, 2002). One of the primary research aims of this thesis is to explore this line of enquiry further, as discussed in Chapter 5.

Thus far, this review has described the rationale behind the *content* of the IIC framework and some of the interesting issues that the present thesis aims to address; discussion will now turn to current psychological conceptualisations of inhibitory control mechanisms, impulsivity, and self-control and to an explanation of the *structure* of the IIC framework.

Psychological perspectives: Defining impulse control

The ability to act appropriately, curb improper impulses, and pursue goal-directed outcomes is vital to our being successful and accepted members of society. 'Will-power', 'self-discipline', 'self-control', and 'restraint' are words variously used to describe our facility to suppress distracting impulses and maintain focus. Antonyms might include 'lack of discipline', 'self-indulgence', and 'impulsiveness'. In general, self-control and restraint are qualities associated with maturity, success, and dependability. On the other hand, self-indulgence and a lack of discipline suggest irresponsibility and evoke an expectation of underachievement. While such assumptions may or may not be justifiable, for the purpose of scientific investigation a more rigorous terminology is needed to describe the various manifestations of impulse control.

Perhaps in part because existing vocabulary is so heavily laden with demotic meaning, the psychological community has so far failed to provide a comprehensive, agreed-upon taxonomy of labels for different aspects of behavioural control. Mitchell (2004) points out that while experimental psychologists have adopted the terms "impulsivity" and "self-control" to describe behavioural preferences for smaller immediate rewards over larger delayed rewards, social psychologists use "self-regulation" and sometimes "self-control" to refer to the internal cognitive activity involved in similar decision-making processes. Many cognitive tasks have been created to quantify impulsive responding; yet these often intercorrelate poorly, suggesting that they may tap varying sets of processes (e.g. Reynolds, Ortengren, Richards, & de Wit, 2006). To complicate the issue further, critical questions regarding the nature of self-control remained unanswered: For example, even if they do not constitute a uni-dimensional construct, are control processes stable trait-like qualities, or tendencies that fluctuate within an individual, or between situations or contexts?

Given these theoretical and terminological issues, it may appear somewhat surprising that Endicott, Ogloff and Bradshaw recently reported that "there is agreement on the general characteristics of impulsive behavior" (2006; p.285). However, there does appear to be some consensus as to which *behaviours* demonstrate impulsivity, or are indicative of reduced self-control; such behaviours are observed in clinical and non-clinical populations and examples are listed in self-report 'impulsivity' questionnaires. However, as Endicott et al, go on to state, the "underlying cognitive cause" (p.285) of such behaviour is not fully understood, and there are certainly many existing perspectives regarding what causes individual differences in self-control and impulsiveness.

Psychological perspectives: Personality and cognitive theory

While the IIC framework is geared towards addressing behavioural outcomes related to substance use, the notion of competing action tendencies has been extensively applied to human behaviour in general. For example, Gray's Reinforcement Sensitivity Theory (RST) provides a neuropsychological model of emotion, motivation and learning in which three systems interact to account for behavioural outcomes. In the most recent version (Gray & McNaughton, 2003), the Behavioural Activation or Approach System is activated by incentive cues, thus mediating responses to appetitive stimuli. The Fight, Flight, and Freezing System (FFFS) is an unlearned system that mediates responses to aversive stimuli; in the presence of punishment or threat cues, the FFFS will act to produce escape and defence behaviours. The Behavioural Inhibition System (BIS) plays a central role in conflict detection and resolution. It is only engaged in situations in which both the BAS and FFFS systems are activated (i.e. mixed incentive environments; note the "AND" in Figure 1.3), and BIS acts by selectively increasing the effect of FFFS output or inhibiting BAS output to produce the most cautious outcome. According to this theory, and paralleling Jentsch and Taylor's arguments with respect to addiction, behavioural outputs from the RST reflect a combination of the potency of reward cues via the BAS and the inhibitory

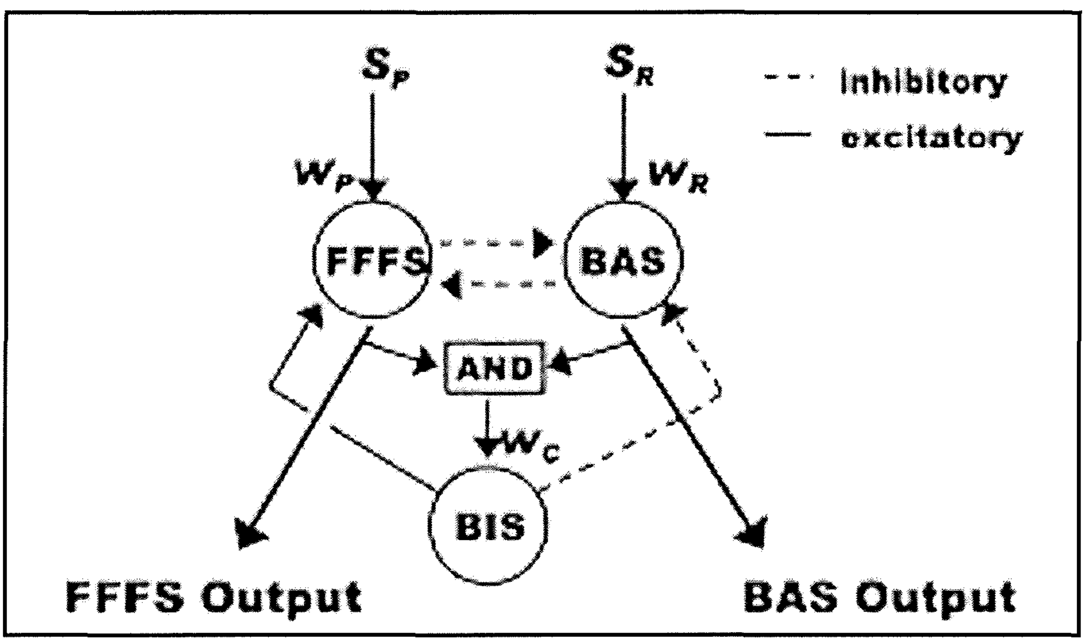

Figure 1.3: Dynamically interacting model of the new reinforcement sensitivity theory involving the FFFS (Flight-Flight and Freezing System), BIS (Behavioural Inhibition System) & BAS (Behavioural Activation System) SP and SR system inputs; WR, WP, and WC are system reactivities. From Smillie et al.

strength of the BIS and the FFFS. While the activation of BAS and FFFS are believed to be independent, situations will arise in which the response to rewarding properties of a stimuli or cue is restrained by influences from FFFS or BIS. The systems are interdependent and reactions to rewarding environmental cues (e.g. expected reward from drug intake) may be counteracted by responses to aversive stimuli (e.g. fear of overdose), depending upon the competing strength of each trigger and the ability of the BIS to override either set of impulses (Smillie, Pickering, & Jackson, 2006).

The IIC framework similarly makes the distinction between inhibition and activation systems (i.e. the generation of avoidance and approach impulses: Level 3) and effortful control mechanisms (Level 4) may correspond to the BIS system, acting to suppress or promote behavioural responses. While in RST, the BIS is activated in mixed-incentive environments, effortful control as represented in the IIC framework is activated when a conflict arises between an individuals' intentional state and the outcome of conflict between avoidance and approach impulses.

According to the RST, excessive impulsiveness may reflect a hyperactive BAS, hypoactive FFFS outputs, or a weak BIS. Behaviours indicative of low self-control or heightened impulsivity (e.g. addiction) are the result of a sub-optimal balance between these three systems. BIS functions to resolve conflict between the BAS and FFFS systems by favouring the FFFS and increasing the negative valence of inputs to it. In relation to the use of psychoactive substances, it suggests that a largely automatic preconscious evaluation a drugs' appetitive and aversive characteristics determines whether an individual will use it. This model does not incorporate 'effortful' self-control (or willpower). By contrast, the IIC framework highlights the role of deliberate restraint and drive, drawing from developmental models of impulse and restraint such as those devised by Mary Rothbart (e.g. Rothbart, Ellis, & Posner, 2004) and later Nancy Eisenberg (e.g. Eisenberg et al., 2004; in Carver, 2005). A schematic representation of Eisenberg's model is presented in Figure 1.4. Impulses arise when subcortical systems respond selectively to cues of reward or threat and are inhibited or restrained by their counterpart systems (horizontal arrows). A cortical system, 'effortful control', is superordinate to approach and avoidance impulses and engages cognitive resources to either foster or suppress actions generated by the subcortical threat-sensitive and incentive-sensitive systems.

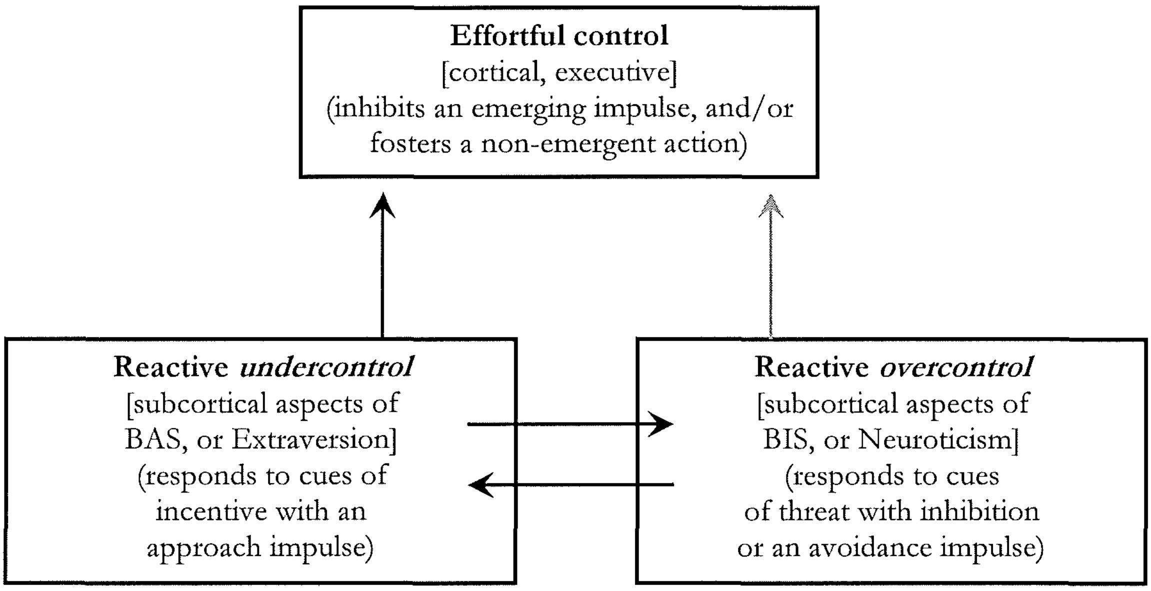

Figure 1.4: Schematic diagram of Eisenberg et al's model of impulse and constraint; from Carver (2005)

In support of this theoretical stance, and based on a review of research into the personality traits extraversion, neuroticism, incentive sensitivity and impulsivity, Carver (2005) concludes that there is persuasive evidence for a higher-order trait measuring "constraint", whose qualities are distinct from simple tendencies towards approach or avoidance. According to his interpretation:

> "First, an impulse can be inhibited subcortically, due to competition from a threat. Second, the impulse can be countermanded by an executive process, if there are competing goals that are more salient or more important."
>
> (Carver, 2005; p.321)

This position is reflected in levels 3 and 4 of the IIC framework where effortful control mechanisms act to either drive or inhibit action tendencies, they manifest in cognitive, particularly executive processes, and behaviourally as self-regulatory control and disinhibition.

The IIC Framework in relation to comprehensive theories of addiction

The IIC framework is thus based on ideas drawn from both addiction theory and theories of human motivation and action, and represents, albeit in an imperfect and oversimplified manner, how factors at various levels of analysis may come together to influence the early stages of substance use. This is by no means a unique endeavour, and two further theories need to be included in this discussion, both of which offer comprehensive accounts of addiction, from initiation to dependency and beyond.

Jim Orford's "Excessive Appetites" model was first published in 1985, and its defining features remain unchanged (Orford, 1985, 2001). At the core of this theory lies the notion that humans are vulnerable to developing excessive appetites for, or attachments to, a range of activities and objects that include substances (e.g. alcohol, tobacco) and behaviours (e.g. sexual offending, exercise). A feature shared by all such activities and objects is that the shape of a curve depicting the distribution of their use within the population will be markedly skewed by the presence of a minority of individuals who differ from the majority only in the extent of their use, and for whom appetitive behaviour is excessive. According to Orford, if allowed unrestrained access to these activities humans would certainly engage in them far more frequently than currently is the case. It is the presence of restraints (e.g. religious convictions, legal and social boundaries) that limits such use, and conversely the absence or ineffectiveness of these restraints in individual cases that can lead to excess use and, potentially, addiction.

Orford (2001) comments that neurobiological theories of addiction fail to fully account for appetitive behaviours because they do not include the social context within which they take place. The pleasures and escapes enjoyed by users of these activities or objects vary depending upon the individual, the nature of the activity/dose, and a variety of person-specific and wider socio-cultural and environmental contexts. Orford turns to learning and conditioning mechanisms to explain the amplification of the motivation to engage in appetitive behaviours. Thus, for instance, the "Opponent Process" theory of addiction (Solomon, 1980), suggests the involvement of homeostatic functions which respond to hedonic experiences by producing counteracting ('opponent') processes; these strengthen over repeated exposures, eventually leading to increases in reward thresholds such that higher doses of the substance are required to overcome the opponent process and achieve the original hedonic effect. This may explain physiological tolerance and withdrawal. Orford also notes incentive theories such as that of Robinson and Berridge (2001), by which drug-related cues acquire conditioned positive incentive value and thereby themselves become capable of eliciting approach responses. Secondary amplification processes, or 'acquired emotional regulation cycles', encourage greater excess; these include the 'chasing of losses' by gamblers, and the 'abstinence violation effect' (Marlatt & George, 1984), i.e.

the resolution of cognitive dissonance, following a lapse, by giving up the effort to abstain. The conflicts arising from an individual's excessive appetite are shown in Figure1.5; as with the abstinence violation effect, each outcome further strengthens the individual's appetite.

Robert West (2006) developed the synthetic PRIME theory of motivation, which he argues provides a comprehensive account of addiction. Its name is an acronym for five elements of motivation: Plans, Responses, Impulses/inhibitions, Motives (wants and needs), and Evaluations (beliefs regarding what is good or bad, etc). There is a

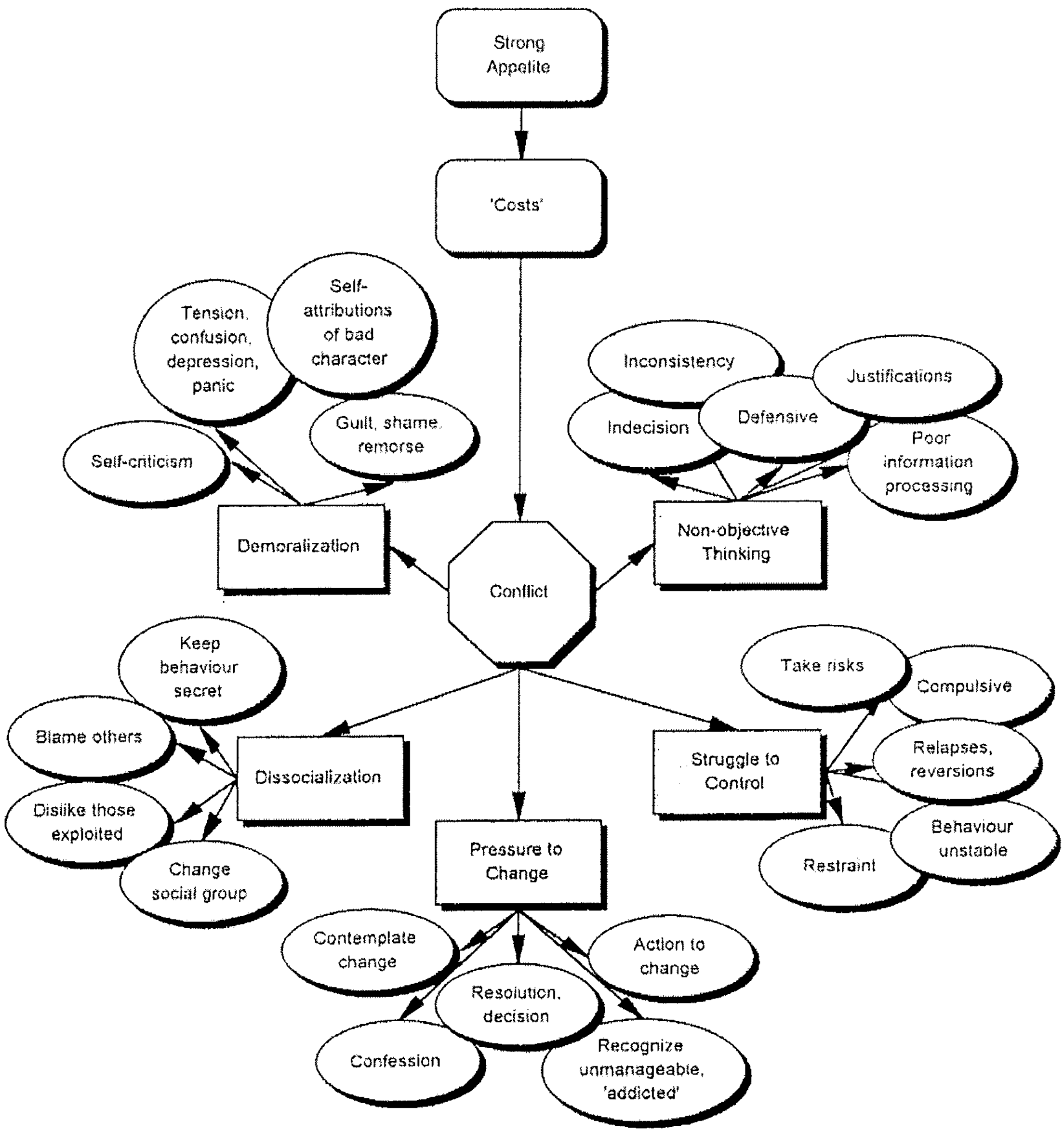

Figure 1.5: The consequences of conflict, from Orford (2001)

flow of influence through the system, which is shown in Figure 1.6. "Plans" are intentions regarding impending actions, and are generated by motives, evaluations and previously conceived plans. "Evaluations" are right/wrong judgements, which take the form of conscious mental representations, and which are arrived at through logical reasoning based on past evaluations, inferences, motives, and plans. "Motives" comprise feelings of attraction and repulsion towards mental representations of an object/action, and are influenced by plans, inferences, and evaluations of previous experiences. "Impulses" and "Inhibitions" are motivational forces generated in response to internal or external stimuli or to motives, and compete or combine to produce forces which typically translate directly into action; where this does not occur, they are experienced consciously as urges. Inhibitory forces can range from stimulus-driven responses (e.g. conditioned avoidance) to the exertion of conscious will power; in PRIME theory, these mechanisms share a single common pathway. Impulses and inhibitions therefore determine responses that, in a dynamic, ever-shifting system in which impulses and inhibitory forces continuously compete, are subject to both momentum and inertia.

West describes three key elements in his theory: identity, dispositions, and the role of the 'unstable mind'. "Identity" reflects mental representations of the self that are attached to evaluations (e.g. not wanting to be a smoker) and motives (e.g. wanting to quit smoking). Self-control is an effortful process that influences the wants and needs

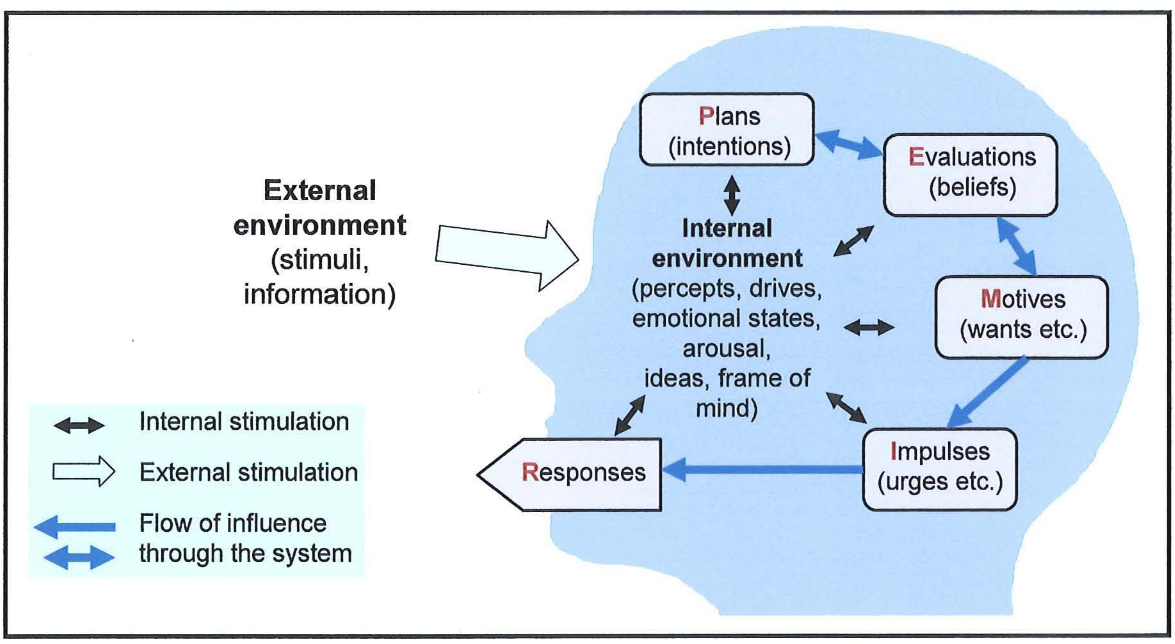

Figure 1.6: The human motivational system, from www.primetheory.com

that arise from the person's identity and either directs behaviour towards desirable outcomes or inhibits impulses to engage in harmful or unwanted behaviours. "Dispositions" are the combined product of genetic endowments and learning gained through experience (e.g. habituation, associative learning, etc) and manifest in more or less stable personality traits or tendencies to react in a certain way. West proposes that shifts within the "dispositional landscape" (i.e. set of dispositions) can and do occur, and manifest in altered behavioural patterns. The 'unstable mind' concept suggests the brain, like all biological systems is inherently reactive with its state at any one moment reflecting the combined influences of numerous inputs. In general, balancing inputs and reactions maintain equilibrium within the system but its overall trajectory can be changed progressively (e.g. by a series of small events) or suddenly (by a major event); change occurs through a combination of a trigger event and the absence of a balancing input. West borrows concepts from chaos theory and embryology to explain how behavioural momentum and inertia can occur.

Orford's theory provides a broad consideration of different levels of analysis, from the population to the individual and from biological explanations, through cognitive schema, to social norms and wider environmental influences. His account of addiction is derived, as Orford puts it, from "a set of very ordinary basic human processes" (2001; p.28) and at the heart of the theory is the idea of conflict about the excessive appetite, which is reflected in the behavioural restraints at individual, social or cultural levels. A key tenet is that the processes underlying addiction are normal and that those individuals with excessive appetites cannot be easily separated from those who do not have them, since everyone lies along a continuum of appetitive attachment. By implication, individuals will differ at every stage of addiction because unique combinations of personal, social, and cultural experiences shape the conflicts that define their experience and reaction to an appetitive drive.

The PRIME theory addresses not only addiction, but also human motivation as a whole. Like Orford's theory, it encompasses theories and findings at many levels of analysis. West explicitly notes that his framework does not attempt to reflect all that is known about specific elements involved in addiction (e.g. social factors, physiological effects of drugs) but that it provides a structure into which knowledge can be assimilated, and a description of how the system as a whole may function, and potentially malfunction (West, 2006; p.146). According to the PRIME theory, addiction can be driven by abnormalities in the motivational system that stem either directly from engaging in the addictive behaviour, or from sources unrelated to the addictive behaviour (e.g. pre-existing depression), and also by abnormalities in the environment of the individual. It implies that individuals who already have an unstable or unbalanced motivational system may be susceptible to addiction, and conversely, that engaging in the potentially addictive behaviour can cause the system to become unbalanced.

The PRIME and Excessive Appetites theories highlight the wide individual variability in the phenomenology of addictive behaviour. This is also reflected in the IIC framework, which identifies in particular a subset of likely influences on stages of addiction. The framework reflects key aspects of the PRIME theory, in that it focuses on how the motivational system responds in a moment-by-moment manner and includes many of the same constructs (e.g. impulses, intentions, self-control). The IIC framework likewise emphasises the role of conflict in a way similar to Orford's theory. However, for pragmatic reasons, it concentrates primarily on intra-individual conflicts and on situational factors that directly influence the individual's attitudes towards, and opportunities to engage in substance use.

It is clear from this summary of the literature to date that there remain many important and unresolved questions concerning the involvement of impulsivity and impaired control in the initiation of substance use and in the progression into substance abuse and dependency. Discussion will now turn to the formulation of specific research questions and hypotheses derived from the IIC framework that will be addressed in the subsequent chapters.

Research questions addressed in this thesis

Chapter 2: Dismantling impulse control

Methodological difficulties in capturing and measuring individual differences in impulse control, or impulsivity, have plagued researchers in this field for decades.

Given that the primary aim of this thesis is to explore various aspects of impulse control and their involvement in the aetiology of substance use, a necessary first step is to determine which measures are the most theoretically relevant and empirically distinct. Chapter 2 describes a large cross-sectional study of undergraduate students in which exploratory factor analyses are used to investigate the dimensional structure underlying a range of self-report and laboratory measures, and to derive measures to serve as indices of impulse control in subsequent chapters.

Chapter 3: Impulse control, alcohol use, and illicit substance use

Having identified indices of control processes, the thesis will then test predictions of the IIC framework empirically, using data from the same large cross-sectional study. Past research has implicated attitudinal, situational, and impulse control-related risk factors for substance use. Chapter 3 will explore associations between impulse control, attitudinal and situational risk factors, and alcohol and illicit substance use and abuse.

Chapter 4: Impulse control and cigarette use

Chapter 4 will explore the association between cigarette use and attitudinal, situational, and impulse control-related risk factors. "Occasional smokers", who do not smoke daily, represent a uniquely interesting group because they appear to be able to control their substance use, suggesting that for some smokers, intermittent smoking is not part of an inexorable progression to dependency. Comparisons between occasional and regular smokers will test whether impulse control or attitudinal and situational factors are differentially implicated in different patterns of cigarette use/abuse.

Chapter 5: Impulse control and substance use: a longitudinal study

Chapter 5 describes a prospective study designed to explore two questions: 1) what is the predictive relationship between impulse control and substance use/abuse over a two-year period; and 2) what combination of factors (from impulse control, attitudinal and situational) best predict change in substance use over the two-year period.

Chapter 6: General Discussion

Chapter 6 will summarise and discuss the findings of Chapters 2 to 5, making reference to the questions raised and theories discussed throughout Chapter 1.

CHAPTER TWO

Dismantling Impulse Control

Chapter Summary

Research into behavioural control often uses the term 'impulsivity', which Mitchell (1999) describes as "the opposite pattern of choice" to self-control (p.455). Impulsivity is complex and multifaceted, and its structure varies between researchers and psychological disciplines; Depue and Collins (1999) list 'sensation seeking', 'risk-taking', 'novelty seeking', 'boldness', 'adventuresomeness', 'boredom susceptibility', 'unreliability', and 'unorderliness' as some of its lower-order traits. Impulsivity has been variously operationalised as 'reduced disinhibition' or 'inhibitory dyscontrol' (Enticott, Ogloff, & Bradshaw, 2006), a preference for immediate over delayed gratification (Bickel & Marsch, 2001), and a tendency to engage in risky situations or undergo novel experiences (Wadsworth, Moss, Simpson, & Smith, 2004). Moeller (2001) conceptualised impulsivity as both a dispositional trait and a pattern of behaviour that is characterised by rapid responding, a lack of regard for both immediate and long-term negative effects of behaviour, and a propensity towards unplanned reactions to stimuli.

Block (1995) describes "jingle" and "jangle" fallacies, terms which aptly summarise some complications to conceptualising impulsivity. "Jingle" fallacies occur when a single label is used to describe very different constructs; for example, the label 'impulsive' is applied both to sensation seeking behaviours and fast reaction times. "Jangle" fallacies occur when distinct labels are applied to constructs that are similar; for example, there are clear overlaps between 'disinhibition', 'inhibitory control' and 'behavioural control', which have been separately identified and measured by disparate research groups (Whiteside & Lynam, 2001). Block comments: "Together, these errors work to prevent the recognition of correspondences that could help build cumulative knowledge." (1995, p.210). While "jingle" and "jangle" fallacies are prevalent, clarity has been sought through the development of self-report questionnaires and laboratory tasks, and through the examination of relationships between the measures of impulsivity that they yield.

This chapter will review past attempts to define and measure impulsivity. A large cross-sectional study will then be used to empirically test assumptions of the Intention, Impulse, and Control (IIC) framework.

Self-report Measures of Impulsivity

Impulsivity within trait models of personality theory

Self-report questionnaires assess the extent to which an individual agrees with a given statement and how he/she believes they would behave under certain circumstances. Self-report measures of personality traits associated with impulsivity and inhibitory control are among the most consistently and strongly associated with substance use and abuse (e.g. Sher, Bartholow and Wood, 2000). This is despite the fact that the various personality theories have yielded a wide array of such instruments to measure impulsive behaviour in humans, each describing a subtly different conceptualisation of impulsivity.

The Five Factor Model of personality (McCrae & Costa, 1990) includes 'Openness', 'Conscientiousness', 'Extraversion', 'Agreeableness', and 'Neuroticism' and there are differing opinions as to which of these reflects which aspects of impulsivity. Costa and McCrae (1992; in Whiteside & Lyman, 2001) proposed that the inability to resist inappropriate behaviour is measured by aspects of Neuroticism, that Conscientiousness measures self-discipline and planning, and that Extraversion assesses the sensation-seeking aspects of impulsivity. According to Carver (2005), Conscientiousness alludes to the ability to delay gratification and use restraint, whereas Agreeableness includes aspects of behavioural inhibition. Individuals high in these two traits have demonstrated higher restraint in a variety of behaviours (e.g. substance abuse, aggressiveness [Lynam, Leukefeld, & Clayton, 2003]; anti-social behaviour [Miller, Lyman & Leukefeld, 2003]), supporting Carver's explanation. However, Whiteside and Lyman (2001) conducted a factor analysis of seventeen self-report impulsivity measures and measures of the Five Factor Model, and their results suggested a solution with four factors: Urgency, Premeditation, (lack of) Perseverance, and Sensation Seeking. Reminiscent of Block's 'jingle' fallacy critique, Whiteside and

Lyman argue that the four factors represent disparate facets of personality that have been erroneously labelled 'impulsivity' in the literature.

Eysenck's theory of personality describes three dimensions, 'Introversion-Extraversion' (EPQ-E), 'Neuroticism' (EPQ-N), and 'Psychoticism' (EQP-P), which are each measured using Eysenck's Personality Questionnaire (EPQ; H. Eysenck & Eysenck, 1991). The Psychoticism dimension is thought by some to be most strongly related to impulsivity, since it is in part concerned with lack of self-control and impulse restraint (e.g. Acton, 2003; Carver, 2005). Cloninger's (1987) neuropsychological Temperament Model hypothesises the existence of specific brain systems for the inhibition, activation and maintenance of behaviour, and that these underlie the respective personality dimensions of 'Harm Avoidance' (HA), 'Novelty Seeking' (NS) and 'Reward Dependence' (RD). The Tridimensional Personality Questionnaire (TPQ; Cloninger, 1987) is used to measure these traits, the three corresponding scales (TPQ-HA, TPQ-NS, & TPQ-RD) each comprising four subscales. Interactions between the dimensions are thought to underlie individual differences in responses to novelty, reward and punishment and certain clinical disorders; for example, Cloninger (1996) suggests that impulsive personality disorder could result from high NS and low HA. In a large-scale seven-year prospective study, Sher, Bartholow and Wood (2000) assessed over 3000 students using both the EPQ and TPQ, and found that EPQ-P best predicted later alcohol dependence, while TPQ-NS was the strongest predictor of later drug abuse and tobacco dependence. Sher et al. suggest that the two measures tap different forms of behavioural undercontrol; TPQ-NS was considered reflective of impulsivity and sensation seeking, while EPQ-P included agreeableness and conscientiousness components. The authors propose that these differences may explain why the two scales were found to be differentially sensitive to different substance use diagnoses. A large number of other studies have also found substance use to be predicted by both EPQ-P (e.g. Patton, Barnes, & Murray, 1993; Heath et al., 1997) and TPQ-NS (e.g. Howard, Kivlahan, & Walker, 1997; Galen, Henderson, & Whiteman, 1997).

In response to growing interest in impulsivity, Eysenck and Eysenck (1978) constructed the Impulsiveness, Venturesomeness and Empathy scales. The Impulsiveness scale (IVE-Imp) correlates with EPQ-P and slightly with EPQ-E, while Venturesomeness correlates with EPQ-E and slightly with EPQ-P. According to the authors, Impulsiveness reflects a pathological aspect of risky behaviour whereby individuals fail to perceive adverse consequences, and Venturesomeness taps 'true' risk-taking, whereby the individual recognises, but then ignores, negative consequences (S.B. Eysenck, 1993). Associations have been found between IVE-Imp and the use of illicit drugs (e.g. Parrott, Sisk, & Turner, 2000; Morgan, 1998) and alcohol use disorders (e.g. Soloff, Lynch, & Moss, 2000).

Impulsivity and the Reinforcement Sensitivity Theory (RST)

Two questionnaires that attempt to directly measure the sensitivity of the 'behavioural approach system' and 'behavioural inhibition system' (BIS) of Gray's (1970) RST are the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia, Avila, Molto and Caseras, 2001), and Carver and White's (1994) BIS-BAS scales. The SPSRQ comprises the Sensitivity to Punishment (SPSRQ-SP) and Sensitivity to Reward (SPSRQ-SR) scales, which are independent measures of avoidant and appetitive behaviour respectively. SPSRQ-SP correlates positively with EPQ-N, negatively with EPQ-E and is unrelated to EPQ-P; SPSRQ-SR correlates positively with all three EPQ scales, and with IVE-Imp (Torrubia et al., 2001). In a study of high school and middle school children, Genovese and Wallace (2007) found that students with the highest levels of drug use were high in SPSRQ-SR and low in SPSRQ-SP. Simons and Arens (2007) similarly found that student cannabis-users reported higher SPSRQ-SR and lower SPSRQ-SP than nonusers. Pardo, Aguilar, Molinuevo, and Torrubia (2007) found that SPSRQ-SR was negatively correlated with age of onset of alcohol use, and that individuals high in SPSRQ- SR and low in SPSRQ-SP reported heavier and more frequent alcohol consumption.

Carver and White's questionnaire comprises one BIS and three BAS scales: 'Reward Responsiveness' (BAS-RR), 'Drive' (BAS-D), and 'Fun Seeking' (BAS-FS). Smillie, Jackson and Dagleish (2006) used confirmatory factor analysis to re-examine the instrument's factor structure in relation to other measures of BAS sensitivity (including SPSRQ-SR & EPQ-E), and impulsivity (including EPQ-P). They found that BAS-RR and BAS-D specifically reflected BAS sensitivity, while BAS-FS correlated with both BAS sensitivity and broader impulsivity measures. Franken and Muris (2006a) explored relationships between BIS-BAS scores and self-reported binge drinking and substance use in a student sample. They found that BAS-D and BAS-FS correlated with the number of illegal drugs used; BAS-FS additionally correlated with the quantity of alcohol use, and frequency of binge drinking; but BAS-RR was not associated with substance use. There were weak negative correlations between BIS and the quantity of alcohol use and frequency of binge drinking reported, which the authors suggest may be due to an avoidance of the harmful consequences of excessive use in high BIS individuals. In a later study of a clinical sample, Franken, Muris and Georgieva (2006) found heightened BAS-FS and BAS-D in drug addicts, but did not replicate this association in alcoholics. Franken at al. conclude that different BIS and BAS profiles are implicated in different types of substance use.

As discussed in Chapter one, a modified version of RST was introduced by Gray and McNaughton in 2003, after the development of the SPSRQ and BIS-BAS scales. In the revised model, BAS still mediates appetitive responding, but the 'Fight, Flight, Freezing System' (FFFS) replaces the BIS in mediating responses to aversive stimuli. The role of the BIS is now to resolve conflict in mixed-incentive situations that engage both the BAS and FFFS. Smillie, Pickering and Jackson (2006) note that "a revision of existing BIS and FFFS measurement inventories is in order" (p.324), but that very few researchers have updated their instruments, or developed new ones, to incorporate these conceptual changes. According to Smillie et al., behavioural outputs from the BAS and FFFS cannot correspond in a simple manner to the separate systems' activation, since they interact with each other; thus, the resulting behaviour reflects the combined functional activation of all three systems. Thus, they suggest that trait impulsivity should be considered a function not simply of the BAS, but rather of all three systems.

Other caveats surround the use of self-report questionnaires, such as the presence of demand characteristics and response bias towards social desirability, which are not easily detected or eliminated; the accuracy of an individual's introspection is also uncertain. To complement the subjective approach, the study to be described here also includes laboratory tasks, which arguably provide more objective indices of behavioural dispositions.

Laboratory measures of Impulsivity

Cognitive and behavioural conceptualisations of impulsivity have led to the development of a range of laboratory measures. Verdejo-Garcia, Lawrence, and Clark (2008) identified three main types of tests used to measure impulsivity: those that tap 'response inhibition' via the individual's ability to suppress automatic responses; those tapping temporal or 'delay discounting', by assessing preference for immediate over delayed reward; and those that tap 'cognitive impulsivity' in the form of risky vs. conservative decision-making.

Measuring Response Inhibition (RI)

Arguably the simplest tests of RI, Go-No Go tasks vary in design but typically involve the suppression of a previously learnt or automatic response. 'Commission errors' (i.e. failure to suppress the prepotent response) and reaction times provide estimates of inhibitory control. Keilp, Sackeim and Mann (2005) asked healthy participants to complete a range of laboratory tests of reaction time, attention, memory, fluency, executive function, and response inhibition (using a Go-No Go task), alongside personality measures. Performance on the Go-No Go task was the strongest correlate of self-reported impulsivity. Elsewhere it has been associated with substance use; for example, Colder and Connor (2002) found an association between increased commission errors and frequent alcohol use. Performance deficits have also been linked to early onset alcohol use (Dom, D'haene, Hulstijn, & Sabbe, 2006), and to heavy smoking (Spinella, 2005).

The oculomotor antisaccade task (AST) similarly tests RI, involving the suppression of an automatic eye movement towards a visual target. Reaction times and commission errors are used to estimate inhibitory control. Although few studies have tested this paradigm in substance users, Spinella (2002) has reported that smokers were more impaired than non-smokers, whilst Powell, Dawkins and Davis (2002) found that AST impairments in abstinent smokers correlated with the number of cigarettes smoked per day. Furthermore, in a longitudinal study of smokers who were attempting to quit, Powell et al (submitted) found that higher AST error rates in acutely abstinent smokers was associated with an elevated risk of relapse within the first week. Iacono, Carlson and Malone (2000) compared boys classified as at either high risk for substance abuse (father diagnosed with a substance use disorder) or low risk (neither relatives nor child had history of substance abuse) and found a significantly higher AST error rates in the high-risk group. Iacono (1998) has argued that the AST may be sensitive to genetic susceptibility to substance use disorders.

Measuring Delay Discounting

The Delay Discounting task (DDT) is the most frequently used test of 'delay discounting'. It measures an individual's preference for immediate over delayed gratification, and the extent to which reward loses its perceived value as the delay to its delivery increases; this is described as the rate of discounting. Higher discounting rates are considered indicative of higher impulsivity. Studies have demonstrated higher discounting rates in users of various substances (e.g. opiate addicts [Kirby & Petry, 2004]; alcoholics [Mitchell, Fields, D'Esposito, & Boettiger, 2005] smokers, [Mitchell, 1999]). Kollins (2003) was the first to demonstrate an association between elevated rates of discounting and subclinical levels of substance use, with college students who report more illicit drug use or having started to use at a lower age showing greater DDT rates.

Measuring Cognitive Impulsivity

The Iowa Gambling Task (Bechara et al., 1994) is a measure of 'cognitive impulsivity' that incorporates elements of uncertainty, reward and punishment. Participants select between decks of cards that offer either small gains and small losses, or larger rewards but far larger losses. The task yields indices of risk tolerance and decision-making impairments that are believed to reflect impulsivity. Several studies have found abnormal IGT performance in drug addicts. For example, Bechara et al. (2001) observed similar levels of impaired performance in drug addicts, and patients with lesions to areas of the prefrontal cortex that are implicated in decision-making. Verdejo-Garcia et al. (2006) found that both cocaine addicts and heroin users showed poorer performance on this task than controls. In a non-clinical student sample, Goudriaan, Grejin, and Sher (2007) showed that frequent binge drinkers made less advantageous selections than less frequent binge drinkers; however, IGT performance was unrelated to the age of onset of alcohol use.

Examining associations between laboratory & self-report measures

As evidenced above, these self-report and laboratory measures of impulsivity all correlate to some extent with substance use. However, theoretical differences between their underlying conceptualisations of impulsivity make it difficult to draw general conclusions regarding which aspects of impulse control are most relevant to this discussion. In fact, it is widely acknowledged that the interrelationships between self-report and cognitive-behavioural indices of impulsivity are, at best, complex, and in some studies tenuous or non-existent.

Intercorrelations between self-report measures

One study of nine impulsivity questionnaires extracted eight factors, labelled 'concentration', 'decision-making', 'thinking', 'money', 'excitement', 'temper', 'future orientation', and 'complexity' (Harmstead & Lester, 2000). Whiteside and Lyman (2001) extracted four factors ('urgency', 'premeditation', 'perseverance', and 'sensation seeking') from a factor analysis of eighteen self-report impulsivity measures. Quilty and Oakman (2004) proposed a two-factor model, in which BAS and Impulsivity are separate but correlated constructs. In their confirmatory factor analyses, a combined EPQ-E/EPQ-N score, SPSRQ-SR and a total BAS score loaded on the BAS factor, and sensation-seeking and impulsivity measures on the Impulsivity factor. Miller, Joseph, and Tudway (2004) applied a Principal Components Analysis (PCA) to four questionnaires (including IVE-Imp and the BIS-BAS scales) and extracted three components: 'Non-planning/dysfunctional Impulsivity', 'Functional Venturesomeness', and 'Reward Responsiveness/Drive'. BAS-Reward did not correlate with any other BAS or impulsivity measures, and failed to load on the Reward Responsiveness/Drive component. Flory et al. (2006) factor analysed data from four self-report impulsivity measures (including the four TPQ-NS subscales, NS1 to NS4) in a large normal sample. Their solution produced three moderately correlated factors: 'thrill seeking' (loaded highly by NS1 - 'Exploratory Excitability vs. Stoic Rigidity'), 'nonplanning impulsivity' (highly loaded negatively by BIS, and positively by NS2 - 'Impulsiveness vs. Reflection' and NS3 - 'Extravagance vs. Reserve'), 'and 'disinhibited behaviour' (loaded highly by measures of sensation seeking and boredom susceptibility).

Dawe, Gullo, and Loxton (2004) have suggested that impulsivity is best defined by a two-factor model that separates 'Rash Impulsiveness', measured by sensation seeking and generic impulsivity scales (e.g. IVE-Imp & TPQ-NS), from 'Reward Sensitivity', measured by RST measures (e.g. SPSRQ-SR, BAS-D & BAS-RR). Reward Sensitivity is believed to reflect a heightened response to rewarding stimuli (e.g. drugs), and Rash Impulsiveness a cognitive aspect of impulsivity, whereby the individual tends to act without regard to risk and future consequences. Dawe et al. propose that individual differences in Reward Sensitivity influence the likelihood of initial experimentation with drugs, and that Rash Impulsiveness mediates the likelihood of escalating substance use and abuse.

This division is echoed in many structural models of impulsivity, where traits indicative of reward responsiveness or sensitivity (e.g. BAS-RR, SPSRQ-SR) are reported to be distinct from those relating to behavioural inhibition or perseverance (e.g. IVE-Imp, TPQ-NS). There are obvious differences in the item content of these measures. Thus, items in measures designed to assess reward sensitivity typically focus directly upon reward drive (e.g. "I go out of my way to get things I want" in BAS-D; "As a child, did you do a lot of things to gain approval?" in SPSRQ-SR). On the other hand, questionnaire items included in the more general measures of impulsivity are more varied, asking about sensation seeking, uninhibited behaviour, and perseverance. Some depict situations in which an individual could succeed by controlling inappropriate impulses and drawing on cognitive control processes (e.g. "Do you generally do and say things without stopping to think?" in IVE-Imp; "I almost never get so excited that I lose control of myself" in TPQ-NS). Others tap attitudes to risky behaviours, therefore also tapping sensitivity to aversive cues (e.g. "Do you think hitchhiking is too dangerous a way to travel?" in IVE-Venturesomeness). It is likely, therefore, that variance within these measures tap multiple processes, rather than a single underlying system; perhaps this has contributed to inconsistent solutions in the factor analyses that include them.

There are inconsistencies in the nature and number of dimensions suggested in the above solutions. The fact that no two studies include the same measures is likely to be another reason for this, since factor analysis and PCA are data-driven techniques that rely on the researcher to include a complete set of relevant and reliable indices. Interestingly, Barratt (1993) proposed that impulsivity is formed of two sets of factors: those that can be assessed via self-report assessments; and those involving cognitive processes that are not easily quantified using self-report indices. Barratt further argued that, because the accuracy of self-report measures cannot be objectively tested, dispositional traits should never be defined purely in terms of self-report measures.

Intercorrelations between laboratory & self-report measures

Studies including single laboratory tasks have in some cases found positive associations with self-report measures. For example, Fuentes, Tavares, Artes and Gorenstein (2006) found that the number of commission errors on versions of the Go-No Go task correlated with scores on the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995). Zinbarg and Mohlman (1998) looked at learning in a Go-No Go task with reward and punishment, and found associations between BAS-RR and the speed of learning rewarded responses, and between BIS and the speed of learning punished responses. A large number of studies report positive associations between higher delay discounting rates on the DDT and a variety of self-reported measures (e.g. IVE-Imp, Alessi & Petry, 2003; IVE-Imp & BIS-11, Kirby, Petry & Bickel, 1999; IVE-Imp & EPQ-E, Richards, Zhang, Mitchell, & de Wit, 1999), although a few studies have failed to replicate such associations (e.g. BIS-11, McLeish & Oxoby, 2007; BIS-11, Reynolds, Ortengren, Richards, & de Wit, 2006). Good performance on the IGT has been found to be negatively associated with BAS-FS (Suhr & Tsanadis, 2007), but positively with SPSRQ-SR (Davis, Patte, Tweed, & Curtis, 2007).

A few studies have explored interrelationships between multiple laboratory and self-report indices of impulsivity. One early study (Helmers, Young, & Pihl, 1995) looked at associations between four laboratory tasks and four factors derived from factor analysis of several self-report measures. An association was found between a sensation-seeking factor and commission errors on a Go-No Go task, but there were no other significant associations between laboratory tasks and any of the self-report factors. Reynolds, Ortengren, Richards, and de Wit (2006) used three impulsivity questionnaires and four laboratory tasks (including the Go-No Go and DDT); they reported high inter-correlations between self-report measures, but no correlations between the self-report and laboratory indices. Enticott, Ogloff, and Bradshaw (2006) examined associations between the BIS-11 and four laboratory measures of impulsivity; the BIS-11 correlated moderately with two of the laboratory tasks. Swann, Bjork, Moeller and Dougherty (2002) measured rapid responding on a Continuous Performance Task and delay discounting (using the DDT) alongside the BIS-11; the two laboratory measures did not correlate, and only commission errors on the rapid response task correlated with self-reported impulsivity. Lane et al. (2003) found consistently high intercorrelations among four self-report impulsiveness measures (including BIS-11, and IVE-Imp), but no significant intercorrelations between five laboratory measures (including two versions of the DDT), and there were uniformly low correlations between self-report measures and the five laboratory tasks (including the DDT). PCA revealed that a single factor could account for the correlations between self-report measures, and a two-factor solution for the laboratory measures; one defined by tasks assessing response inhibition, and the second by tasks assessing responses to delayed reward.

To date, very few studies have adopted a multi-dimensional approach to assessing impulsivity in substance users. Dom, De Wilde, Hulstijn, and Sabbe (2006) explored associations between two self-report scales and three laboratory tasks (the Go-No Go task, DDT and IGT) in a sample of detoxified alcoholics undergoing treatment. However, self-report and laboratory tasks were not intercorrelated. PCA of the behavioural measures identified the same three groups of laboratory tasks described earlier in this chapter: response inhibition, delay discounting and cognitive impulsivity.

The lack of significant associations between laboratory and self-report measures of impulsivity probably reflects the complex nature of impulsivity, and researchers agree that the measures do not assess a single construct (e.g. Dawe et al., 2004; Evenden, 1999; Hollander & Rosen, 2000; F. G. Moeller, Dougherty, D.M., 2002). Dom et al. argue that laboratory tasks tap transient states, whereas questionnaires assess comparatively stable traits. Reynolds et al. suggest that the self-awareness and insight required by self-report measures may contribute to inconsistencies. Enticott et al. draw a distinction between the highly specific nature of some laboratory tasks, and the lack of specificity in questionnaire items that refer to a range of impulsive behaviours and activities. Significantly, the sample sizes of many studies are relatively small (Reynolds et al., n=70; Enticott et al., n=31; Lane et al., n=32; Dom et al., n=92) and they may therefore lack the power to detect subtle associations. In addition, large numbers of indices are generated in some studies - for example, Swann et al. derive five indices from one laboratory task and report a total of 48 correlations, Reynolds et al. perform 40 correlations, Lane et al. conducted 45, and Enticott et al. report 20 - yet not one of these studies makes an appropriate corrections to reduce Type I error. The use of PCA in many of these reports is also questionable, given the small correlations found, and small samples reported.

To summarise the preceding sections, studies examining intercorrelations within and between laboratory and self-report measures of impulsivity suggest that it is a multi-dimensional construct. However, the empirical literature has failed to reach a consensus either on the exact number or nature of these dimensions. Both laboratory and self-report approaches are plagued by 'jingle' and 'jangle' fallacies, and inconsistencies in the literature complicate research in this area.

Purposes of the current study

The objectives of this thesis are to explore interrelationships between self-report and laboratory measures of impulse control, and to examine firstly how specific indices relate to recreational substance use in undergraduate students, and secondly whether baseline measures of impulse control predict changes in substance use over time. The aim of this first study is therefore to test a series of predictions regarding interrelationships between trait and laboratory measures related to impulse control, and to derive indices that will be used in later cross-sectional (chapters 3 & 4), and longitudinal (chapter 5) studies of recreational substance use.

The IIC framework describes factors likely to influence whether an individual encounters and engages in substance use. Smillie et al. earlier noted that behavioural outputs cannot correspond in a simple manner to the activation of the separate systems' of the RST, since they interact such that the resulting behaviour reflects the combined functional activation of all three systems. The IIC framework likewise assumes that impulsive behaviour results from the combination of three functions: two competing systems generate approach and avoidance impulses, resulting in action tendencies to either engage in or avoid the behavioural outcome; and a third, cognitive control, system acts to inhibit action tendencies that oppose the individual's intentional state. Similarly, the individual strengths of these systems cannot be measured directly and, instead, estimates will be empirically derived. For simplicity, these estimated hypothetical latent constructs will henceforth be referred to as '**Approach**', '**Avoidance**', and '**Control**'. This chapter's literature review has identified self-report and laboratory measures that may serve as reliable indicators of these latent constructs.

Trait measures of Approach, Avoidance, and Control

As discussed, research using self-report or trait measures of impulsivity agrees to some extent that self-report measures of impulsivity can be divided into those that tap reward sensitivity (i.e. SPSRQ-SR, BAS-RR, BAD-D), and those that assess cognitive aspects of inhibition and perseverance (i.e. IVE-Imp, TPQ-NS). Overall, items in measures of reward sensitivity tended to ask about the desire for approval or success, whereas items in more general measures of impulsivity described scenarios in which cognitive control processes may be used. It follows logically that measures of reward sensitivity may represent reliable indices of Approach, while broader measures of impulsivity may serve as better indices of Control. However, it was also noted that the item content of self-report measures is often varied, and that it is likely that variability in responses taps multiple processes. For example, Smillie et al. found that BAS-FS correlated with both reward sensitivity and the broader measures of impulsivity; complex relationships such as this will likely lead to a complicated solution.

Indices of Avoidance are notably absent from much of the impulsivity research described. This is partly due to the focus (certainly in addiction research) on the role of appetitive drive states in impulsive behaviour. There is also less debate surrounding its conceptualisation or measurement, since there is agreement that measures of RST's behavioural inhibition system (e.g. SPSRQ-SP and BIS) and harm avoidance (e.g. TPQ-HA) reflect a single factor (Franken & Muris, 2006b), supported by reports of high intercorrelations between these scales (e.g. Carver & White, 1994; Mardaga &

Hansenne, 2007). Franken and Muris have proposed that high BIS individuals may try to avoid the harmful consequences of excessive substance use, which is supported by studies reporting positive associations between low SPSRQ-SP and various substance use measures, and negative associations between BIS and alcohol use. Simons and Arens (2007) reported that cannabis users were both low in SPSRQ-SP and also high in SPSRQ-SR, suggesting an interaction between measures that tap the Avoidance and Approach systems. These results are in line with the IIC framework's assumption that, depending on the strength of competing approach impulses, stronger avoidance impulses can result in action tendencies away from drug use. The self-report measures used in these studies will therefore serve as useful indicators of the Avoidance construct.

Laboratory task indices of Approach, Avoidance, and Control

As previously noted by Verdejo-Garcia et al., laboratory tasks tapping facets of impulse control can be divided into measures of 'response inhibition', 'delay discounting', and 'cognitive decision-making'. It is suggested that tasks measuring response inhibition index Control, since they involve the intentional suppression of prepotent responses. Thus, for instance, performance on the oculomotor antisaccade task (AST; p.63) is hypothesised to tap Control.

However, as noted amongst self-report measures, laboratory tasks can also yield measures that tap multiple processes. The Go-No Go task used in the present study is an approach-avoidance discrimination task, developed by Zinbarg and Mohlman (1998) to examine the rate of acquisition of expectancies to reward and punishment cues. It yields a number of outcome measures that are expected here to reflect the activity of all three impulse control systems. The rate of discounting in the delay-discounting task (DDT) is also hypothesised to index multiple processes: Approach, in the preference for immediate gratification, and Control, in resisting immediate gratification and selecting larger but delayed rewards. Furthermore, while cognitive decision-making tasks have been argued to tap cognitive control processes, some, such as the IGT used in the present study, include elements of reward and punishment in the risky reward-related outcomes offered. To perform well, individuals must inhibit the desire to choose from card decks offering large rewards and large losses, and advantageously select from decks offering smaller rewards and smaller losses. Thus, IGT performance is expected to primarily index Control, but is also expected to correlate, via risk-avoidance and reward sensitivity, with both Approach and Avoidance systems.

Study hypotheses

The following hypotheses will be tested:

I. Self-reported indices of the latent Approach construct (Trait-Approach) will correlate positively with:

   a. Faster reward learning on the Go-No go task
   b. Higher rates of discounting on the DDT
   c. Riskier decision-making on the IGT

II. Self-reported indices of the latent Avoidance construct (Trait-Avoidance) will correlate positively with:

   a. Faster punishment learning on the Go-No go task
   b. Riskier decision-making on the IGT

III. Self-reported indices of the latent Control construct (Trait-Control) will correlate positively with:

   a. Greater accuracy on the AST

   and negatively with

   b. Riskier decision-making on the IGT
   c. Higher rates of discounting on the DDT
   d. More commission errors on the Go-No go task
   e. Greater interference on the AST

These hypotheses are presented diagrammatically in Figure 2.7. See the methods section entitled "Measures" (p. 60) for details of the self-report indices reflecting Approach, Avoidance, and Control, and descriptions of the laboratory task indices.

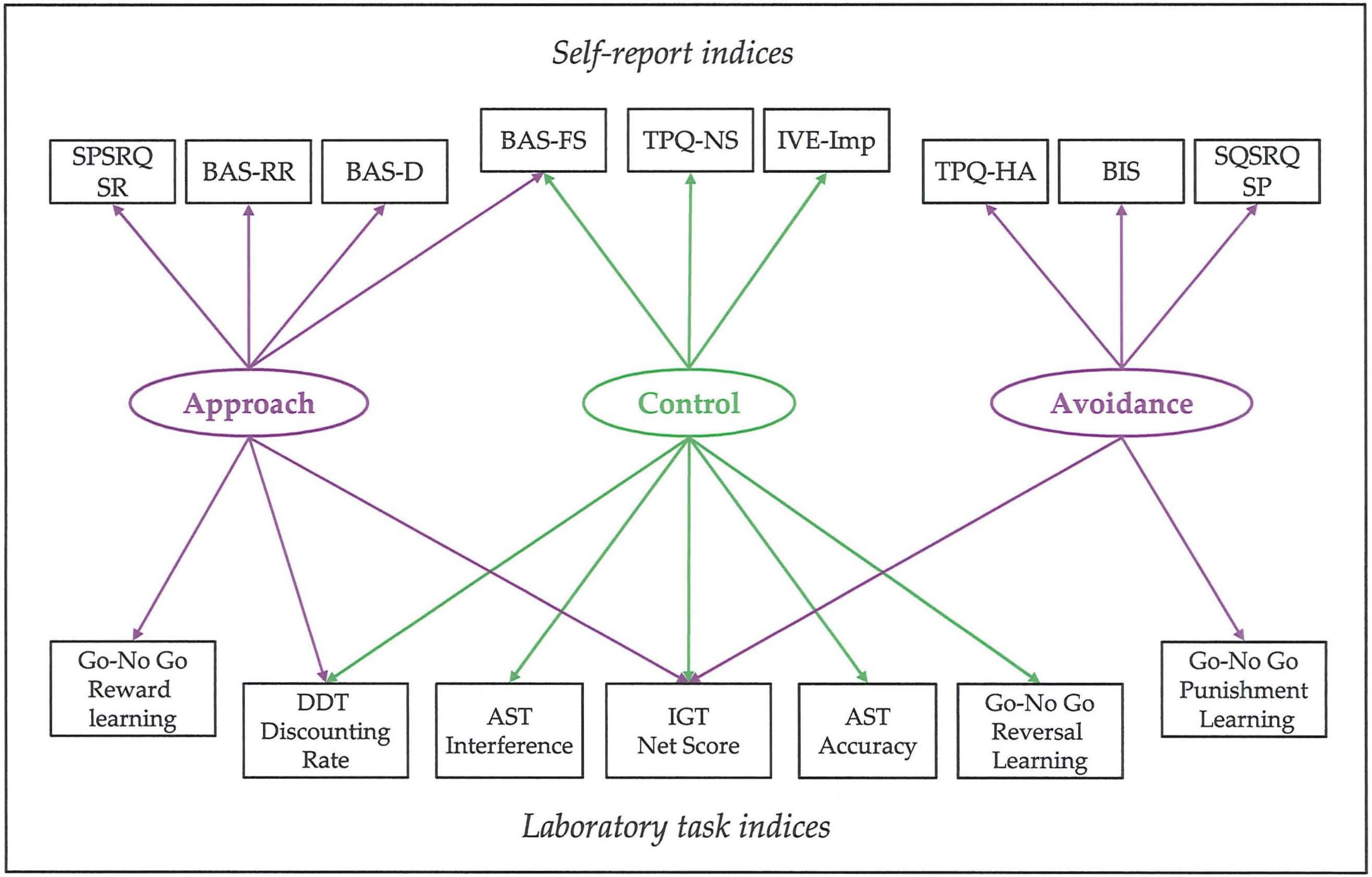

Figure 2.7: Hypothesised interrelationships between self-report and laboratory measures of Approach, Avoidance, and Control

Method

Participants

Of a total of 496 participants, 213 were first-year undergraduate students entering Goldsmiths, University of London in 2005, 2006 and 2007, and 283 were undergraduate students entering Griffith University, Brisbane, in 2006 and 2007. These two subgroups are henceforth referred to as the London and Brisbane samples. Because of limited resources, the Brisbane sample were only tested on a selected sub-set of measures. Thus, the sample size varied between analyses; information regarding sample composition and demographics will be provided within each section.

The complete London sample comprised 51 (23.9%) males and 162 (76.1%) females; all aged between 18 and 22 (mean 19.1 years; s.d. 1.0) at the time of recruitment. Seventy-seven of these were Psychology undergraduates who received course credits for participating; the remaining 133 were recruited via advertisements and were paid £10 for their participation. Of the complete Brisbane sample, 83 (29.3%) were male and 200 (70.7%) were female; recruitment was not age-restricted and the students ranged from 16 to 57 (mean 21.0 years, s.d. 5.6). The combined sample comprised 134 male (27.0%) and 362 female (73.0%), aged between 16 and 57 (mean 20.2, s.d. 4.4). The samples did not differ in male-to-female ratio [$\chi 2$ (1) = 2.21, p=0.135]; however, the Brisbane sample was significantly older than the London sample [Mann Whitney U =26263.5, $p<0.05$]. All participants were informed that the study would investigate cognitive and behavioural factors related to substance use. Informed consent was obtained from each participant; Goldsmiths Psychology Department Ethics Committee, Goldsmiths, University of London and the Psychology Department Ethics Committee, Griffith University, Brisbane approved the study.

Demographics and additional measures:

London participants provided information about their ethnicity, education, parental occupation, English language fluency, and religious beliefs. Participants reported ongoing and past mental illnesses or mood disorders, and were asked for details of any prescribed medication taken on a regular basis. They completed the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983); the Revised Life Changes Questionnaire was used to obtain a measure of recent life stress (M. A. Miller & Rahe, 1997); and Baddeley's three-minute Reasoning Test (Baddeley, 1968) provided a brief measure of verbal intelligence. Participants in the Brisbane sample provided details regarding their age, gender and ethnicity and completed Baddeley's Reasoning Test. The data for these measures are presented in later chapters of this thesis.

Design & Analyses

This was a cross-sectional study, exploring interrelationships between nine self-report measures (TQP-NS, TPQ-HA, BIS, BAS-RR, BAS-D, BAS-FS, IVE-Imp, SPSRQ-SR, & SPSRQ-SP), and selected indices from four laboratory tasks (DDT, IGT, Go-No Go, & AST). Exploratory factor analysis (EFA) was used to explore correlations between self-report measures. There was sufficient data to employ a split-sample approach; cases with odd identification codes were included in an initial EFA to establish factor structure; even numbered cases were included in a second factor analysis to assess model invariance. Pearson's correlations were used to test two-tailed hypotheses regarding intercorrelations between laboratory measures and the factor scores estimated as trait measures of Approach, Avoidance, and Control. All analyses were performed using SPSS 14.

Measures

Self-report Questionnaires

The Tri-Dimensional Personality Questionnaire (TPQ; Cloninger, 1987)

This 100-item yes/no questionnaire yields measures of Novelty Seeking (TPQ-NS), Harm Avoidance (TPQ-HA), and Reward Dependence (TPQ-RD). TPQ-RD was not scored in this study, since it assesses dependency upon social approval (e.g. "I would like to have warm and close friends with me most of the time"), rather than more general hedonistic aspects of reward. TPQ-NS (34 items) comprises four sub-scales, 'Exploratory excitability vs. stoic rigidity' (NS1), 'Impulsiveness vs. reflection' (NS2), 'Extravagance vs. reserve' (NS3), and 'Disorderliness vs. regimentation' (NS4). NS1 items focus on sensation seeking behaviours and boredom susceptibility (e.g. "It is difficult for me to keep the same interests for a long time because my attention often shifts to something else"). NS2 items describe scenarios in which impulsive bottom-up processes fail to be controlled by cognitive top-down processes (e.g. "I often react so strongly to unexpected news that I say or do things that I regret"). Items in both NS3 and NS4 also tap control processes, but focus more upon a lack of behavioural restraint (e.g. NS3: "I often spend money until I run out of cash or get into debt form using too much credit"), and self-discipline (e.g. NS4: "I lose my temper more quickly than most people"). Flory et al. (2006) reported that these reflect different aspects of impulsivity; however, internal consistency checks in this study revealed low Cronbach alphas for individual sub-scales (NS1=0.51; NS2=0.58; NS3=0.65, NS4=0.49), and so only a total TPQ-NS score (Cronbach α=0.74) was used here. Dawe et al. suggest TPQ-NS is a measure of 'Rash Impulsiveness'; in Flory et al.'s study, NS2 and NS3 subscales loaded on a 'nonplanning impulsivity' factor. A common feature of these subscales is that they refer to the lack of cognitive control over bottom-up, reward-driven impulses to seek novel stimuli. For this reason, and in line with previous findings, it was expected that TPQ-NS would emerge as an indicator of Control.

TPQ-HA (34 items) also comprises four subscales. 'Anticipatory worry and pessimism' (HA1) reflects a lack of optimism about future success (e.g. "I often have to stop what I am doing because I start worrying about what might go wrong). 'Fear of uncertainty' (HA2) comprises items that describe a general tendency to fear novel situations (e.g. "I usually feel tense and worried when I have to do something new and unfamiliar"), and 'Shyness with strangers' (HA3) describes a general tendency to fear novel people (e.g. I usually stay away from social situations where I would have to meet strangers, even if I am assured they are friendly"). 'Fatigability and asthenia' (HA4) reflects a susceptibility to fatigue and immobility in the face of strife (e.g. "I need much extra rest, support, or reassurance to recover from minor illnesses or stress"). Internal consistency checks in this study revealed low Cronbach alphas for some individual sub-scales (HA1=0.73; HA2=0.58; HA3=0.70, HA4=0.54), and so only a total TPQ-HA score (Cronbach α=0.84) was used here. All four subscales describe scenarios in which avoidance tactics are used in the presence of aversive stimuli, making this likely to index Avoidance.

Eysenck's IVE-Imp (S. B. Eysenck & Eysenck, 1978)

This 19-item yes/no scale is widely used as a broad measure of impulsivity. Along with TPQ-NS, it was selected by Dawe et al. to reflect 'Rash Impulsiveness' and included in Miller et al.'s 'Non-planning and dysfunctional impulsive behaviour' component. Items are varied in content: one simply asks the participant "Are you an impulsive person?", others focus on reduced self-control (e.g. "When people shout at you, do you shout back?"), and some on premeditation (e.g. "Do you usually think carefully before doing anything?"). Like TPQ-NS, items in IVE-Imp consistently refer to cognitive control processes, rather than bottom-up impulses, making this a candidate measure for Control. IVE-Imp has been shown to have good internal consistency in past research (e.g. Cronbach α=0.85 in Eysenck and Eysenck, 1978), and checks revealed good internal consistency in this study (Cronbach α=0.79).

The BIS/BAS scale (Carver & White, 1994)

Responses to statements in this instrument are given on a four-point scale, from "Strongly agree" to "Strongly disagree". It comprises a single BIS scale (7 items), and three BAS subscales (13 items) that reflect different facets of reward sensitivity: Reward Responsiveness (BAS-RR), Drive (BAS-D) and Fun Seeking (BAS-FS). Some research using the BIS/BAS subscales report low Cronbach alphas (e.g. Smillie et al., 2006), leading some authors to retain only overall BIS and BAS scores. However, there is also empirical support for the scale's four-factor structure (e.g. Cooper, Gomez, & Aucote, 2007), and internal consistency checks in the present study revealed satisfactory alpha coefficients (Cronbach α: BIS=0.78, BAS-RR=0.71, BAS-D=0.75, BAS-FS=0.71).

The seven items of the BIS scale reflect a simplified version of TPQ-HA, in that they describe similar fear, worry and avoidance responses, but are less specific in describing the aversive stimuli themselves (e.g. "If I think something unpleasant is going to happen I usually get pretty 'worked up'", and "I worry about making mistakes"). BIS provides a candidate measure of Avoidance.

Numerous studies report that, while BAS-RR and BAS-D reflect reward sensitivity, BAS-FS correlates with both BAS and broader impulsivity measures (e.g. Franken & Muris, 2006b; E. Miller et al., 2004; Smillie, Jackson et al., 2006). Likewise, Dawe et al.

suggest that BAS-FS reflects 'Rash Impulsiveness', rather than 'Reward Drive'. Three of the BAS-FS items describe sensation seeking ("I crave excitement and new sensations", "I often do things for no other reason than that they might be fun", & "I'm always willing to try something new if I think it will be fun"), while the remaining item describes the lack of forethought ("I often act on the spur of the moment"). Despite its brevity and mixed content, BAS-FS demonstrates good internal consistency as noted above (Cronbach α=0.71), and, in line with past findings, is expected here to index both Approach and Control. BAS-RR items describe emotional responses (e.g. "It would excite me to win a contest"), while BAS-D items focus on behavioural responses (e.g. "When I want something, I go all out to get it"). Both describe approach impulses in response to appetitive stimuli, and were therefore expected to index Approach.

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001)

The original SPSRQ contained 48 yes/no items; however, confirmatory factor analyses have since suggested that a reduced pool of items may provide an improved solution (Cogswell, Alloy, van Dulmen, & Fresco, 2006; O'Connor, Colder, & Hawk, 2004). A shortened version (O'Connor et al. 2004), including 18 'Sensitivity to Punishment' (SP) and 17 'Sensitivity to Reward' (SR) items, was used here. SPSRQ-SR items describe responses to a variety of rewarding stimuli, such as social approval (e.g. "Do you often do things to be praised?"), money ("Does the good prospect of obtaining money motivate you strongly to do some things?"), and success ("Do you like to compete and do everything you can to win"?); a small number of items refer to conflict between appetitive and aversive stimuli (e.g. "Do you like displaying your physical abilities, even though this may involve danger?"). Overall, it is a strong candidate measure of Approach. SPSRQ-SP items describe responses to uncertainty or novelty (e.g. "Are you often afraid of new or unexpected situations?"), and fear of failure or social disapproval (e.g. "Do you often refrain from doing something you like in order not to be rejected or disapproved by other?"), and this scale was therefore expected to prove a third indicator of Avoidance. O'Connor et al. (2004) reported good alpha reliability coefficients for both shortened scales (Cronbach α: SPSRQ-SR=0.74; SPSRQ-SP=0.83), and internal consistency checks in the present study show good internal consistency (Cronbach α: SPSRQ-SR=0.76; SPSRQ-SP=0.81).

Laboratory Tasks

Go-No Go Task

The computerised Go-No Go paradigm used in this study was developed in-house to replicate a task designed by Zinbarg and Mohlman (1998). In the first half of the task participants learned to respond to one set of stimuli, and to not respond to another set; the response contingencies then switched, and they had to unlearn previous associations in order to respond correctly. The stimuli were 12 two-digit numbers presented sequentially on a computer monitor for three seconds each, or until the participant responded. Six of the numbers were designated reward ('go') cues, and the other six punishment ('no go') cues. The two sets of stimuli were carefully selected to ensure that their properties (i.e. magnitude, position of odd and even digits) were well matched. Designation of the two sets as 'go' or 'no-go' cues was counterbalanced, and participants were randomly assigned to either version at the start of the task based on a simple coin-toss. Participants were required to respond to each 'go' stimulus by pressing the space bar key, and not to respond to 'no go' stimuli; responses made after the three second stimulus presentation were not recorded. The inter-stimulus interval was one second, during which feedback was presented - a probabilistic reinforcement schedule was used to increase the difficulty of the task. Key-presses to 'go' cues were rewarded on a proportion (80%) of trials, with 'virtual' monetary gains and positive feedback (£100 of play money and the word "correct" on the screen in green font); key-presses to 'no-go' cues (commission errors) were punished in 80% of trials, with the loss of £100 of play money and negative feedback (the word "wrong" on the screen in red font). On the remaining 20%, no feedback was given when participants correctly refrained from responding to 'no-go' cues, or incorrectly withheld responses to 'go' stimuli.

The task consisted of two phases, 'acquisition' and 'reversal', each involving ten blocks of 12 trials (120 stimuli trials per phase). Within each of the first eight blocks of the acquisition phase, and throughout the reversal phase, equal numbers of 'go' and 'no-go' cues were presented in a randomised order. However, in the last two blocks of the acquisition phase, the stimulus presentation sequence was modified to facilitate a dominant approach response set: instead of presenting 6 'go' and 6 'no-go' cues in each block, 18 'go' and 6 'no-go' cues were presented in a pseudo-random order across the combined blocks. This was intended to optimise learning of the discriminative task prior to the reversal phase, which was identical to the acquisition phase, except that the numbers categorised as 'go' and 'no-go' cues were switched. There was no break between phases and the participant was not informed of the change in the task. At the end of each block, the participant was presented with an on-screen questionnaire to provide a self-reported measure of expectancy. For each cue, they indicated on a nine-point scale how confident they were that responding would lead to reward or punishment (1=absolute certainty that key-pressing leads to losing money; 9=absolute certainty that key-pressing will lead to winning money).

Zinbarg and Mohlman (1998) averaged both behavioural key-press responses and self-report expectancy scores across 'go' and 'no-go' cues for each block, and estimated the slope of the linear trend for across the blocks of the task; these estimated slopes serve as indices of the speed of reward and punishment learning. They hypothesised that the speed of acquisition of reward learning would positively correlate with activation of Gray's BAS, and that speed of acquisition of punishment learning would correspond to activation of the BIS. In line with previous research that has reported a lack of association between laboratory and self-report measures of impulsivity (e.g. Dom et al. 2006), Carver and White's BIS/BAS measures correlated with self-reported expectancy data, but not with behavioural key-press responses.

In the present study, both self-reported expectancy data and behavioural key-press responses will be examined. Nonlinear regression will be used to derive the slope of the linear trend of self-reported expectancy ratings to reward cues (henceforth referred to as 'GNG Reward expectancy') and punishment cues ('GNG Punishment expectancy), and key-press responses to reward ('GNG Reward responses') and punishment cues ('GNG Punishment responses'). Blocks 9 and 10 were excluded from these estimates because, as described, the stimulus presentation sequence was modified in these trials to differentially influence expectancy ratings to reward and punishment cues. The speed of learning - both self-reported and behavioural - of reward cues and punishment cues across the first eight blocks in the acquisition phase are expected to index Approach and Avoidance respectively.

In the 'reversal' phase of the task, participants must inhibit previous learning and learn new associations, and it is expected that the speed of learning will, in part, reflect inhibitory control processes. Therefore, the slope of the linear trend of both self-reported expectancy (henceforth referred to as 'GNG Reversal expectancy') and behavioural errors ('GNG Reversal responses') to punishment cues in the reversal phase are derived to tap Control.

Oculomotor Antisaccade Task (AST)

Participants were fitted with eye-tracking headgear and seated in front of a 35cm computer monitor in a quiet, darkened, room, with a chin rest positioned 25cm from the screen to minimise head movements. Horizontal eye-movements were recorded from the left eye only using an infrared reflection technique (IRIS IR 6500 by Skalar Medical), with a sampling rate of 500 Hz. Incoming recordings were digitised using a custom-built 12-bit analogue-to-digital interface, created in-house. To determine the point at which a saccade (eye movement) began, a rectangular window corresponding to 20-millisecond duration was slid along a data line representing the temporal pattern of eye movements, and the sum of changes between consecutive data points along this window was taken as a measure of eye activity. When the magnitude of this activity first exceeded 4.8 degrees, the location of the corresponding window was used to calculate the reaction time of the response. The stimuli in both calibration and experimental trials were simple white dots, which appeared at one of four vertically central positions on a black screen (-12°, -6°, 0°, +6°, and +12° horizontally). The equipment was calibrated at the start of each task: the participant tracked a dot at each of the central fixation and peripheral locations; the experimenter then manually checked the calibration, adjusting the apparatus to improve the accuracy of recordings.

The experimental paradigm used is a classic response-inhibition task involving prosaccades and antisaccade trials, and has been used successfully elsewhere to index inhibitory control (e.g. Dawkins et al., 2007; Powell et al., 2004; Crawford et al., 2005). A central fixation point appeared for a period varying randomly between two and four seconds; 200msecs after the stimulus was extinguished, one of the four peripheral targets was presented for 500msecs. In prosaccade trials, participants were instructed to look *at* the dot, whenever it appeared on the screen, as quickly and accurately as possible. There were 60 prosaccade trials, 15 at each of the four peripheral target positions. After a five minute break and a brief re-calibration, the participants then performed 60 antisaccade trials. Again, participants were instructed to fixate on the central fixation target until it disappeared, but this time to respond to each peripheral stimulus by looking *away* from it, at a point approximately equidistant from the centre in the opposite direction. For both prosaccade and antisaccade trials, responses were classified as incorrect if the initial saccade was in the wrong direction, even if a subsequent correction was made. Trials with a saccade latency of less than 200ms after stimulus presentation (anticipatory errors), and trials where saccade latencies exceeded one second (i.e. after the stimulus had gone), were excluded from analysis. Furthermore, cases were excluded if less than 20 (33.3%) of prosaccade *or* antisaccade trials could be retained for analysis.

As used elsewhere, inhibitory control was measured by the difference between the proportion of correct saccades in the pro and antisaccade tasks (e.g. Powell et al., 2004), and saccadic reaction times for correct eye movements (e.g. Koval, Ford, & Everling, 2004; Kramer, de Sather, & Cassavaugh, 2005). The proportion of correct saccades (hereafter referred to as 'AST-Accuracy') was computed by subtracting the percentage of correct saccades in the antisaccade trials from the percentage of correct saccades in the prosaccade trials – scores were reversed so that higher scores indicated better performance on antisaccade, relative to prosaccade trials. The difference in reaction times (hereafter referred to as 'AST-Interference') was calculated by subtracting the mean reaction time for correct responses in the prosaccade trials from the mean reaction time for correct responses in the antisaccade trials– scores were reversed so that higher scores indicate that performance was less slowed in antisaccade, relative to prosaccade trials.

Delay Discounting Task

In this task, the participant was presented with a choice between a hypothetical, variable amount of money available immediately, and a fixed amount (£1000) available after a delay. The magnitude of the sum available immediately was adjusted until the participant considered the two options equal in value. The monetary values and hypothetical delays were printed on separate cards. There were seven delay periods (1 week, 2 weeks, 1 month, 6 months, 1 year, 5 years, and 25 years) and 27 monetary rewards (£1000, £990, £960, £920, £850, £800, £750, £700, £650, £600, £550, £500, £450, £400, £350, £300, £250, £200, £150, £100, £80, £60, £40, £20, £10, £5 and £1). This protocol has been used in many delay discounting studies (e.g. Bickel, Odum, & Madden, 1999).

At the start of the task, the participant was first asked to choose between £1000 available immediately, and £1000 to be received after a period of one week. If the participant selected the immediate reward, its value was progressively decreased, one step at a time, until s/he indicated a switch in preference from the immediate to the delayed amount. The period of delay was then increased, and the participant was again presented with the different amounts in order of decreasing size, until they switched their preference. The magnitude of the immediate rewards was presented in both ascending and descending order. The last immediate reward selected in preference to the delayed reward in the descending sequence, and first immediate reward selected in preference to the delayed reward in the ascending sequence was recorded; the average of these values was taken as the 'indifference point', i.e. that at which the immediate and delayed rewards were of equal subjective value. The discounting rate ('*k*') was calculated with the following formula, developed by Mazur (1987; in Bickel et al. 1999):

$$V = A/(1+kD)$$

where 'V' is the present discounted value of a delayed reward or indifference point, 'A' is the objective amount of the delayed reward, and 'D' is the period of delay. Past research has demonstrated that empirically derived indifference curves are best approximated using this hyperbolic function (e.g. Bickel et al., 1999). Nonlinear regression was used to estimate the discounting parameter ('*k*'), which represents the rate of discounting (henceforth referred to as 'DDT Discounting Rate'); higher values indicate steeper rates and thus a stronger preference for immediate rather than delayed rewards.

Iowa Gambling Task (IGT)

The IGT is a computerised task created by and used with the kind permission of Bechara et al. (1994). The participant was presented with four decks of cards and must select one card per trial (see Figure 2.8). The participant won hypothetical money after every card selection; however, on selecting some cards, the participants lost money. Choosing a card from two of the decks (A′ and B′) was followed by high monetary gains, but on some unpredictable occasions, also by a high loss of money. For the other two decks (C′ and D′), the monetary gains were smaller, but the occasional associated losses were also smaller; over the course of the task it was more advantageous to select from these latter two decks than from A′ or B′.

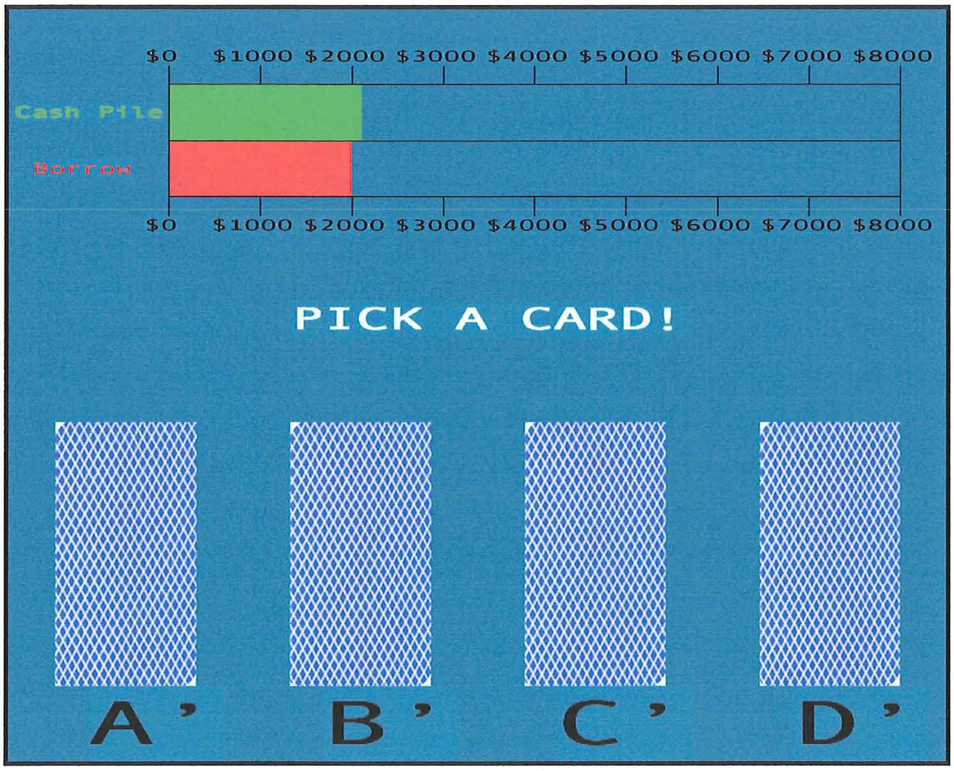

Figure 2.8: Iowa Gambling Task

The task involved 100 card selections (five blocks of 20 trials). The reward/punishment schedule was structured such that the discrepancy between gains and losses in the disadvantageous decks increased across the task, (i.e. resulting in progressively larger losses), while the discrepancy between gains and losses decreased in the advantageous decks (i.e. resulting in progressively larger gains). The total number of selections made from advantageous decks, minus those made from disadvantageous decks, indexes task performance (henceforth referred to as 'IGT Net Score'). Lower scores indicate a preference for selecting from the 'risky' decks and higher scores reflect a bias towards advantageous, less risky selections. Poorer performance may be related to reward sensitivity, insensitivity to punishment, or difficulty in discriminating between the reward and punishment associations.

Procedure

The full testing procedure is described here, though measures not used within this study will be described in fuller detail in later chapters.

The study involved a single session, lasting approximately 90-100 minutes, in which participants completed a battery of questionnaires and the four laboratory tasks described above, in a quiet testing laboratory. Undergraduate Psychology students in receipt of course credits for their participation completed the battery of self-report scales in a separate group session, conducted in a quiet lecture theatre; otherwise, all participants underwent an identical testing protocol. The order of presentation was as follows: the IGT; the Go-No Go task; Baddeley's Reasoning Task; battery of self-report questionnaires (unless already completed); short break; the DDT; the AST; interview about substance use; battery of questionnaires related to opinions of, and future intentions regarding, substance use. To eliminate the possibility that they might influence responses to other questionnaires and tasks, questions about substance use were asked at the very end. Participants in the Brisbane sample completed a battery of self-report questionnaires, followed by Baddeley's Task, the IGT, the Go-No Go task, and lastly the AUDIT and ASSIST.

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Results

Prior to analysis, all variables were screened for missing data and to determine whether they met assumptions of univariate and multivariate normality. The following section will describe data screening and exclusions for self-report measures and laboratory tasks. Subsequent, descriptive statistics will be summarised across all variables for the London and Brisbane samples, separately and combined.

Data screening for experimental variables

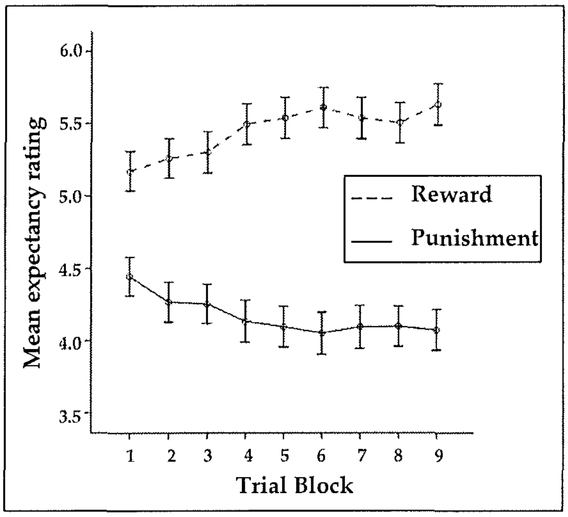
Self-report Questionnaires

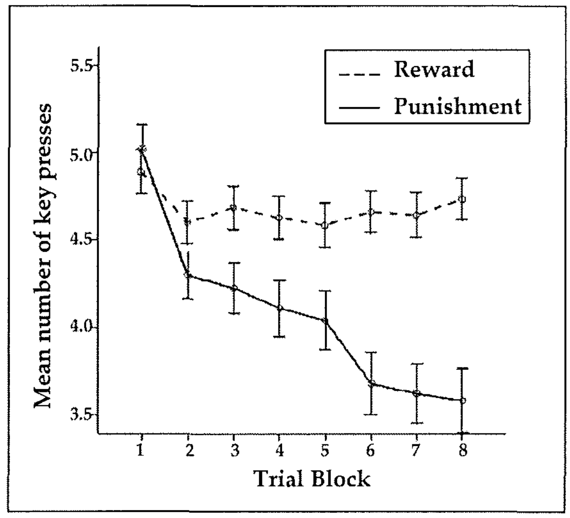
Patterns of missing data for self-report subscales were assessed using SPSS MVA (Missing Values Analysis); Little's MCAR test was not significant, suggesting that data was Missing Completely At Random (MCAR). Within each questionnaire, where a participant failed to respond to 5% or less of the items, Expectation Maximisation (EM) was used to estimate missing data; this was the case for 38 TPQ, 6 BIS/BAS, 16 IVE-Imp, and 16 SPSRQ indices. If a participant failed to respond to more than 5% of the items in any one questionnaire, s/he was excluded from the analyses described in this chapter. Thus, 57 participants were excluded; of these, 25 cases (6.3%) were missing 5% or more data on the TPQ, 20 (5.0%) on the BIS/BAS scales, 24 (6.0%) on IVE-Imp, and 21 (5.3%) on the SPSRQ. Assessment of univariate normality revealed the presence of four outliers on BIS, six outliers on BAS-RR and one outlier on BAS-FS. These cases were retained, but their scores altered; each was assigned a score one unit higher, or lower, than the next most extreme score, to reduce their impact. Two multivariate outliers were identified and removed, leaving 438 cases (London: n = 166, Brisbane: n = 272). Laboratory task data is only described for these participants below.

Laboratory Tasks

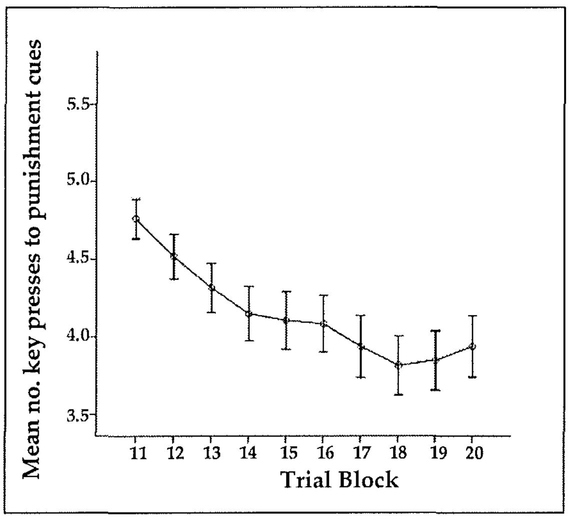
Go-No Go Task

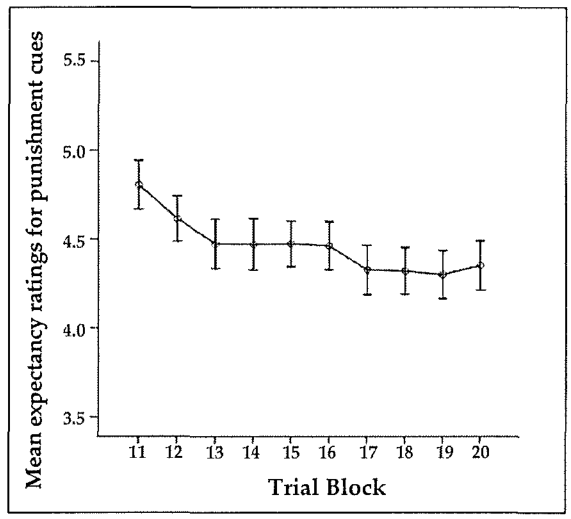
Due to technical problems, data from one London participant was lost; 104 of the Brisbane sample did not complete this task. This left 333 cases with complete data. As explained on page 64, 'GNG Reward expectancy' and 'GNG Punishment expectancy' were estimated as the slope of the linear trend of self-reported expectancy ratings of reward and punishment cues respectively, across the first eight blocks of the task. Figure 2.9 shows mean expectancy ratings for these data. 'GNG Reward responses' and 'GNG Punishment responses' were estimated as the slope of the linear trend of behavioural responses to reward and punishment cues respectively, across the first eight blocks of the task - see Figure 2.10. 'GNG Reversal expectancy' and 'GNG Reversal responses' are estimates of the slope of the linear trend of expectancy ratings of, and behavioural responses respectively, to punishment cues in the 'reversal' phase of the task – see Figures 2.11 and 2.12.





Figures 2.9 & 2.10: Mean expectancy ratings for Blocks 1-9, and no. key presses for Blocks 1-8 to Reward and Punishment cues in the Go-No Go task (error bars represent 95% CI)





Figures 2.11 & 2.12 Mean expectancy ratings and number of key presses (commission errors) for punishment cues in Go-No Go task Blocks 11-20 (error bars represent 95% CI)

Positive reward learning slopes (i.e. scores above zero), and negative punishment learning slopes (i.e. scores below zero) indicate learning, with higher absolute scores indicating steeper slopes, and faster learning. The slope of expectancy ratings and behavioural responses were less steep than that reported by Zinbarg and Mohlman (1998); this is likely due to the use of a probabilistic reinforcement schedule here, but not in their study, to increase task difficulty. In fact, 38.5% of participants did not show learning on 'GNG Reward expectancy', 37.2% on 'GNG Punishment expectancy', 43.2% on 'GNG Reward responses', 39.6% on 'GNG Punishment responses', 39.0% 'GNG Reversal expectancy', and 34.5% on 'GNG Reversal responses'. Since the variance in scores for participants who failed to show learning (i.e. negative reward-learning slopes, and positive punishment-learning slopes) is essentially meaningless, these were replaced with the value of zero, thus enabling comparisons between 'non-learners' and the speed of learning for other participants. Transformations could not correct the positive skew in these data, and nonparametric analyses were used.

Oculomotor Antisaccade Task (AST)

Twelve participants withdrew from the AST because of complaints of eye-strain or fatigue; one further participant could not be tested because she had no left eye, leaving data for 202 participants from the complete London sample. The Brisbane sample was not assessed on this task. Thirty-five cases were excluded because less than 33% (20 trials) of the data for either prosaccade or antisaccade phases could be retained for analysis. The difference in percentage of correct saccades between prosaccade and antisaccade trials (AST-Accuracy) was calculated, and scores reversed so that higher scores indicated better performance on antisaccade, relative to prosaccade trials. The difference in reaction times between correct prosaccade trials and correct antisaccade trials (AST-Interference) were computed; higher positive scores indicate slower performance in antisaccade trials, compared with prosaccade trials.

Delay Discounting Task

Values of '*k*', the 'DDT discounting rate', were estimated for the full London sample (n=166); the Brisbane sample were not assessed on this task. R^2 values are typically used to determine the amount of variance in participant's choices accounted for by the hyperbolic formula (e.g. Bickel et al., 1999). However, Johnson and Bickel (2008) suggest that R^2 is not appropriate for used with nonlinear regression, and instead propose two specific exclusion criteria for identifying non-systematic DDT data: firstly, the reward value should be seen to decrease as delay increases; secondly, reward is expected to be discounted by at least 10% over 25 years. All cases fulfilled the first criteria, but five were excluded based on the second, leaving 161 cases. The DDT Discounting Rate was log-transformed to correct a strong positive skew.

Iowa Gambling Task (IGT)

Technical problems resulted in the loss of IGT data for six cases, leaving data from 160 student in the London sample; 104 participants in the Brisbane sample did not complete the IGT, leaving 127 cases. IGT Net Score was therefore computed for 287 participants. Figure 2.13 shows the mean number of advantageous and disadvantageous card selections (out of 20) for each block.

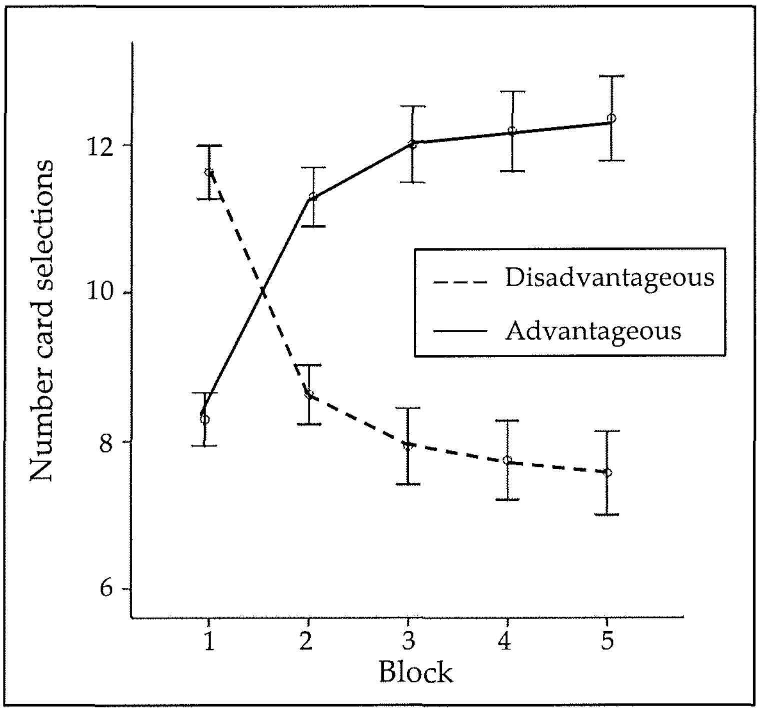


Figure 2.13 Number of advantageous (C' & D') and disadvantageous (A' & B') selections in IGT blocks 1-5 (error bars represent 95% CI)

Descriptive statistics for demographic & experimental variables

Of the 496 participants originally assessed, laboratory tasks data were only analysed for those cases with complete self-report data (*n*=438). Of these, 166 London cases comprised 41 male (24.7%) and 125 female (75.3%) students, aged 18 to 22 (mean 19.1 years; s.d. 1.0); of the 272 Brisbane cases, 79 were male (29.0%) and 193 (71.0%) were female, aged 16 to 57 (mean 21.0 years, s.d. 5.7). The samples did not differ in male-to-female ratio [$\chi 2$ (1) = 0.98, $p > 0.3$]; however, the Brisbane sample was significantly older than the London sample [Mann Whitney U =19978.5, $p < 0.05$]. The combined sample comprised 120 males (27.4%) and 318 females (72.6%), aged 16 to 57 (mean 20.25 years, s.d. 4.6). Table 2.1 presents descriptive statistics for all experimental variables.

Table 2.1: Means (s.d.), and t-tests for differences between for the London and Brisbane samples.

	London			Brisbane			*t*	Total		
	n	Mean	s.d.	*n*	Mean	s.d.		*n*	Mean	s.d.
TPQ-NS	166	18.89	5.0	272	17.86	5.5	1.97	438	18.25	5.3
TPQ-HA	166	14.51	6.5	272	15.79	7.2	-1.87	438	15.30	7.0
BIS	166	20.69	3.4	272	20.97	3.5	-0.84	438	20.87	3.5
BAS-RR	166	16.75	1.9	272	16.58	1.9	0.91	438	16.64	1.9
BAS-D	166	10.72	2.3	272	10.65	2.1	0.31	438	10.68	2.2
BAS-FS	166	11.80	2.1	272	11.42	2.1	1.81	438	11.57	2.1
IVE-Imp	166	8.30	4.0	272	8.31	4.5	-0.02	438	8.31	4.3
SPSRQ-SR	166	7.46	3.6	272	8.02	3.6	-1.57	438	7.81	3.6
SPSRQ-SP	166	7.70	4.1	272	9.25	4.4	-3.63*	438	8.66	4.4
Go-No Go Task										
Reward expectancy	165	0.13	0.2	168	0.12	0.2	0.29	333	0.13	0.2
Punishment expectancy	165	-0.12	0.2	168	-0.12	0.1	-0.13	333	-0.12	0.2
Reversal expectancy	165	-0.08	0.1	168	-0.08	0.1	0.38	333	-0.08	0.1
Reward responses	165	0.09	0.1	168	0.09	0.1	-0.14	333	0.09	0.1
Punishment responses	165	-0.19	0.2	168	-0.20	0.2	0.65	333	-0.19	0.2
Reversal responses	165	-0.11	0.2	168	-0.14	0.2	1.43	333	-0.12	0.2
IGT Net Score	160	2.9	27.2	127	24.88	26.2	-6.90*	287	12.65	28.8
AST Accuracy	124	47.34	19.7	-	-	-	-	-	-	-
AST Interference	124	0.15	0.1	-	-	-	-	-	-	-
DDT Discounting Rate	161	-1.29	0.7	-	-	-	-	-	-	-

* Difference is significant at p<0.004 (2-tailed; Bonferroni corrected)

The Brisbane sample scored significantly higher on SPSRQ-SP, and performed better on the IGT. As shown in Figure 2.14, participants in the Brisbane sample consistently made fewer disadvantageous selections on the task. Differences in SPSRQ-SP and IGT performance remained significant after removing the effect of age-differences.

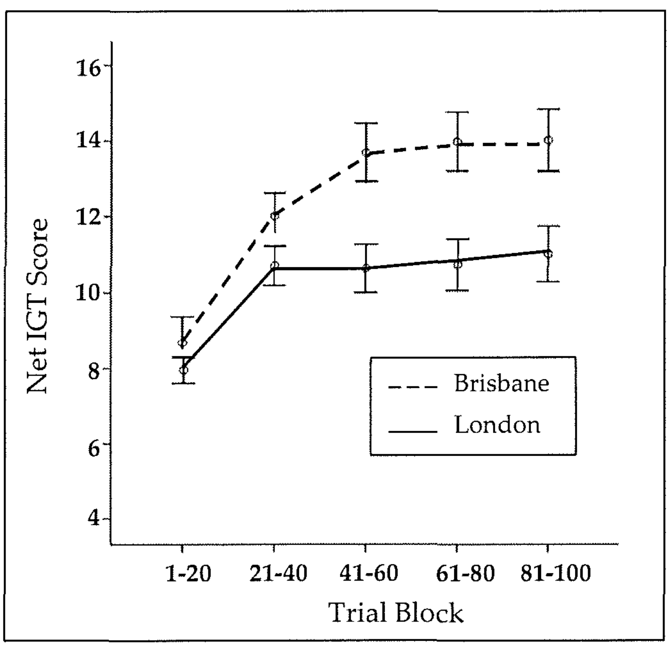


Figure 2.14: IGT Net score (number advantageous minus disadvantageous card selections) across 100 trials (error bars represent 95% CI)

Factor analysis of self-report measures

Table 2.2 presents Pearson correlations between self-report measures; these were sizeable and provided sufficient factorability (Kaiser-Meyer-Olkin MSA= 0.71) to enable factor analysis. The sample was divided into two groups; odd-numbered cases (n=219) were included in an initial EFA to establish factor structure; even-numbered cases (n=219) were included in a second factor analysis to assess structure invariance.

Table 2.2: Bivariate intercorrelations between self-report measures

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. TPQ-NS	-	-0.27*	-0.23*	0.02	0.10	0.51*	0.62*	0.19*	-0.28*
2. TPQ-HA		-	0.65*	0.03	-0.16	-0.38*	-0.05	-0.01	0.70*
3. BIS			-	0.32*	0.06	-0.18*	-0.05	0.11	0.59*
4. BAS-RR				-	0.44*	0.30*	0.04	0.31*	0.06
5. BAS-D					-	0.41*	0.17*	0.40*	-0.07
6. BAS-FS						-	0.44*	0.30*	-022*
7. IVE-Imp							-	0.32*	-0.00
8. SPSRQ-SR								-	0.16
9. SPSRQ-SP									-

* Correlation is significant at p<0.00125 (2-tailed; corrected).

Initial Factor analysis

Principal factors extraction revealed three factors with eigenvalues greater than one. While an oblique rotation was also tested, correlations between factors were low (0.3), supporting an orthogonal extraction; a Varimax rotation was used to improve this solution. Table 2.3 reports factor loadings, explained variance, and eigenvalues for the three factors; this solution explained 58.8% of the variance in self-report data. Communality values were moderate-to-high (0.31 to 0.76), suggesting that the variables were adequately defined by the solution. Simple structure was achieved for most variables: TPQ-HA, BIS, and SPSRQ-SP loaded on a single factor (Avoidance); IVE-Imp and TPQ-NS loaded on a second factor (Control); and BAS-RR, BAS-D, and SPSRQ-SR loaded on a third (Approach). BAS-FS was the only complex variable, loading on both Approach and Control.

Assessing structure invariance

A principal factors extraction with varimax rotation and a three-factor solution was requested for the second subset of cases. The results were almost identical to the initial solution. Only eigenvalues for the three requested factors exceeded one; this solution explained 59.2% of the variance in self-report data, and communalities ranged from

0.33 to 0.86. TPQ-HA, SPSRQ-SP, and BIS again loaded on a single factor (Avoidance); TPQ-NS and IVE-Imp on a second factor (Control); and BAS-RR, BAS-D, and SPSRQ-SR on a third (Approach). Again, BAS-FS loaded on both Approach and Control. Table 2.3 reports factor loadings, explained variance, and eigenvalues for this solution.

Table 2.3: Rotated factor loadings, eigenvalues,& variance explained by initial/replication solutions

	Avoidance	*Control*	*Approach*
Eigenvalues	2.9 / 2.5	1.8 / 1.9	1.0 / 0.9
Proportion of variance explained	23.2% / 24.7%	18.3% / 18.2%	17.3% / 16.3%
TPQ-HA	*0.85 / 0.91*		
SPSRQ-SP	*0.78 / 0.81*		
BIS	*0.73 / 0.76*		
TPQ-NS		*0.74 / 0.80*	
IVE-Imp		*0.87 / 0.77*	
BAS-FS		*0.44 / 0.51*	*0.55 / 0.42*
BAS-RR			*0.64 / 0.73*
BAS-D			*0.72 / 0.68*
SPSRQ-SR			*0.47 / 0.48*

Note: only loadings ≥ 0.4 are reported

To test model invariance across the two sites, the same solution was requested for London and Brisbane samples separately. Table 2.4 shows these factor loadings, which are nearly identical, indicating that the solution is stable across samples and sites.

Table 2.4: Rotated factor loadings, eigenvalues, & variance explained by London/Brisbane solutions

	Avoidance	*Control*	*Approach*
Eigenvalues	2.8 / 2.9	1.9 / 2.2	0.8 / 1.0
Proportion of variance explained	22.4% / 24.5%	18.6% / 18.2%	15.9% / 17.1%
TPQ-HA	*0.85 / 0.90*		
SPSRQ-SP	*0.77 / 0.81*		
BIS	*0.73 / 0.76*		
TPQ-NS		*0.74 / 0.79*	
IVE-Imp		*0.78 / 0.84*	
BAS-FS		*0.53 / 0.49*	*0.42 / 0.52*
BAS-RR			*0.73 / 0.67*
BAS-D			*0.66 / 0.71*
SPSRQ-SR			*0.46 / 0.48*

Note: only loadings ≥ 0.4 are reported

Standardised factor scores for Approach, Avoidance, and Control were estimated using SPSS regressions, from a solution extracted using all 438 cases. Scores for Control were reversed, so that higher scores reflected higher levels of control (i.e. lower TPQ-NS, IVE-Imp, & BAS-FS). These variables were labelled Trait-Approach, Trait-Avoidance, and Trait-Control.

Scores were screened for univariate and multivariate outliers, and normality.

Intercorrelations between self-report and laboratory task measures

Pearson and Spearman correlations were used to examine interrelationships between laboratory task measures, and between laboratory tasks and Trait-Approach, Trait--Avoidance, and Trait-Control. A conservative approach was taken to reducing Type I error. The hypotheses listed on page 57 describe 13 directional relationships, which were tested using Bonferroni corrected significance levels (p<0.0077; one-tailed). A Bonferroni correction was separately applied to the remaining 62 correlations (p<0.0016; two-tailed). Table 2.5 shows all correlations, where emboldened figures identify hypothesised relationships.

Table 2.5: Intercorrelations between self-report and laboratory measures

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Trait-Approach	**0.05**	-0.12	-0.05	**-0.02**	-0.11	0.12	-0.02	-0.11	**-0.14**	**-0.01**
Trait-Avoidance	0.06	**0.04**	-0.05	-0.02	**0.04**	-0.04	0.03	-0.04	0.22	**0.04**
Trait-Control	0.04	0.07	**0.09**	0.03	0.04	**-0.04**	**0.31***	**0.21**	**-0.08**	**0.01**
Go-No Go Task [1] ‡										
1. Reward expectancy	-	0.16	-0.07	0.28†	-0.05	-0.08	-0.04	-0.02	0.10	-0.03
2. Punish. expectancy		-	0.04	0.12	0.25†	0.09	-0.13	-0.04	0.02	-0.03
3. Reversal expectancy			-	0.01	0.07	0.26†	-0.04	0.01	0.04	-0.02
4. Reward responses				-	0.26†	0.11	0.11	0.00	0.03	-0.07
5. Punish. responses					-	0.14	-0.02	0.04	-0.01	-0.06
6. Reversal responses						-	-0.23	-0.11	-0.09	-0.05
7. AST Accuracy [2]							-	0.00	-0.09	0.04
8. AST Interference [2]								-	0.06	0.08
9. DDT Disc. Rate [3]									-	-0.06
10. IGT Net Score [4]										-

Hypothesised relationships are **emboldened** * p<0.0077 (1 tailed; Bonferroni corrected);
† p<0.0016 (2 tailed; Bonferroni corrected); [1] n=333; [2] n=124; [3] n=161; [4] n=287
‡ Spearman's rho correlations; all others Pearson's r correlations

Trait-Approach and Trait-Avoidance factors were not significantly correlated with any laboratory task measures. There was a significant positive correlation between Trait-Control and AST accuracy; participants who scored higher on Trait-Control made fewer errors on anti-saccade trials, compared to pro-saccade trials. On the Go-No Go task, Reward expectancy correlated with Reward responses, Punishment expectancy with Punishment responses, Reversal expectancy with Reversal responses, and Reward responses with Punishment responses. There were no other significant intercorrelations amongst laboratory tasks.

Discussion

While many researchers agree that impulsivity is a multidimensional construct, there is little consensus regarding the number or nature of its dimensions. The IIC framework assumes that impulsive behaviour results from interactions between three systems; two responsible for competing impulses (Approach and Avoidance), and a third "cognitive Control" system that acts to foster appropriate and to inhibit inappropriate behaviours. The aim of this chapter was to consolidate the literature on impulsivity, and derive theoretically relevant indices of these systems. This study examined intercorrelations between nine self-report subscales and four laboratory task measures, to test a series of hypotheses regarding the proposed multi-dimensional nature of impulse control.

Factor analysis of self-report measures

The predicted associations between self-report measures received strong empirical support. Factor analysis of the nine self-report subscales revealed a robust three-factor solution, and the subscales loaded with one or more factors exactly as predicted from past research (e.g. BAS-FS, Smillie et al). The identification of three distinct facets of impulse control supports the observations of other researchers, with distinctions between punishment sensitivity and reward sensitivity (e.g. Franken & Muris, 2006b), and between cognitive impulsivity and reward sensitivity (e.g. Dawe et al., 2004) being upheld. Participants' scores grouped onto three factors, which corresponded with the conceptualisation of the constructs Approach, Avoidance, and Control described within the IIC framework. The expected factor structure was stable across samples, and in both London and Brisbane students.

Intercorrelations between self-report and laboratory task measures

There were some small, significant intercorrelations amongst Go-No Go task measures, specifically between the linear trends of trait and behavioural responses to reward and punishment in the acquisition phase, and to punishment cues in the reversal phase. It difficult to interpret these results; although they demonstrate an association between self-reported and behavioural responses, it is not clear what the small amount of shared variance (around six per cent) between the different response modalities represents. There was also a positive correlation between behavioural responses to reward and punishment cues in the acquisition phase, suggesting that the acquisition of approach responding may be related to the acquisition of avoidance responding.

All other correlations amongst laboratory task measures were uniformly low and non-significant. Likewise, intercorrelations between the laboratory task measures and Trait-Approach, Trait-Avoidance, and Trait-Control were also low. Out of 13 hypothesised correlations, only one was significant – there was a small significant, positive correlation between Trait-Control and accuracy on the antisaccade task (AST), suggesting that participants scoring higher on Trait-Control were also better able to inhibit incorrect eye movements on the AST. Since inhibitory control is a defining feature of the Trait-Control system, this correlation offers some support for proposed links between mechanisms tapped by laboratory task measures, and systems underlying impulse control.

The overall lack of significant associations between laboratory and trait measures is not surprising, and adds to a growing literature that reports similar findings (e.g. Reynolds et al., 2006; Lane et al., 2003). Performance on each of the tasks used in this study has been associated with impulsive behaviour (i.e. substance use and/or abuse) in past research (e.g. Bechara et al., 1994; Keilp et al., 2005; Kollins et a., 2003); likewise, empirical studies show that the self-report measures quantify some aspects of impulsivity (e.g. Pardo et al., 2007; Sher et al., 1999). Yet there was very little shared variance between the two types of measure. Barratt (1993) has suggested that impulsivity comprises facets that can be assessed via self-report assessments, and factors involving cognitive processes that are not easily quantified using questionnaire measures. One explanation for the lack of association found here could be, as Barratt suggests, that the two types of measures simply tap very different processes; however, the correlation between Trait-Control and inhibitory control in the antisaccadic eye-movement task demonstrates that there can be shared variance (around 9%) between the two types of measures.

Reynolds et al. (2006) similarly noted the lack of association between self-report and laboratory measures, and suggested that the two assess behavioural tendencies in different ways; while self-report measures depend upon the accuracy of self awareness, laboratory tasks are less susceptible to self-perception biases. Furthermore, it has been argued that laboratory tasks measure specific aspects of behaviour, whereas self-report measures tap broader behavioural tendencies (Enticott et al., 2006). However, the lack of association reported amongst laboratory task measures, even those thought to tap similar processes (i.e. response inhibition, delay discounting, and cognitive impulsivity), adds to uncertainty about the aspects of impulsive behaviour the tasks actually measure. Previous attempts to explore interrelationships between self-report and laboratory measures of impulse control have suffered from low sample size, and perhaps lacked sufficient power to detect subtle associations. This study represented a comparatively large-scale attempt, but still could not confirm the conceptually predicted associations.

Conclusions

This study reports two main findings. First, intercorrelations between widely used self-report measures of impulse control supported a robust three-factor solution, which directly maps onto the conceptualisation of Approach, Avoidance, and Control proposed within the IIC framework. Estimated measures of the three factors (Trait-Approach, Trait-Avoidance, and Trait-Control) will serve as useful indices of impulse control in subsequent chapters of this thesis. Second, laboratory task measures were largely unrelated to self-report measures, and to each other. A small, significant correlation between Trait-Control, and inhibitory control in the AST, demonstrates that there can be shared variance between the two assessment methods; but much research is still needed, to clarify exactly how behavioural task measures are related to impulse control, and to fully explain the general lack of association. Past research has linked laboratory task measures of impulse control with impulsive behavioural tendencies, and therefore these measures will be included alongside Trait-Approach, Trait-Avoidance, and Trait-Control, to explore interrelationships between impulse control and substance use and abuse.

CHAPTER THREE

Impulse control, alcohol, and illicit substance use

Chapter Summary

According to the 2007/8 report on Crime in England and Wales (Home Office, 2008), illicit drug use among 16 to 24 year olds is decreasing, and is at its lowest since 1995; last year 24.1 percent reportedly engaged in illicit drug use, compared with 21.3 percent this year, and the proportion reporting frequent use of an illicit substance dropped from 8.3 to 7.3 percent. Yet the UK National Health Service (The Information Centre, 2006) reports a rise in the number of drug-related deaths from 1495 in 2004 to 1608 in 2006. Alcohol use statistics are also disturbing, especially among younger drinkers. According to the National Statistics Omnibus Survey (The Information Centre, 2006), 31 percent of 16 to 24 years old males exceed eight units of alcohol, and 22 percent of females exceed six units, on at least one day a week. Additionally, the number of hospital admissions with a primary diagnosis related to alcohol use has risen by 52 percent since 1995/6, and nearly five thousand such admissions in 2006/7 involved patients less than 18 years of age. Similar problems are observed in the United States, where an estimated 31% of college students meet the criteria for alcohol abuse, and alcohol use contributed to an estimated 1717 deaths among college students in 2001 (Borsari, Murphy, & Barnett, 2007). Thus, while patterns of recreational substance use are changing, the use and abuse of drugs and alcohol among young adults remains a source of legitimate concern. To be successful, prevention/ intervention programmes need to accurately target risk factors implicated in substance use initiation and progression.

The Intention, Impulse, and Control (IIC) framework describes a broad range of factors likely to influence whether an individual encounters an opportunity to engage in substance use and how they may then respond. The framework comprises five levels, namely attitudinal factors, situational factors, competing approach and avoidance impulses, cognitive control, and behavioural outcomes (see Figure 1.1, page 19). The aim of this chapter and the next is to explore cross-sectional associations between recreational substance use and factors implicated within the framework. This chapter will review risk factors for alcohol and illicit drug use, using data from a large cross-sectional study to test hypotheses based upon assumptions of the IIC framework. Chapter 4 will consider tobacco use and dependence.

Alcohol and illicit substance use and abuse

There is statistically an overall trend for alcohol use to increase during adolescence, peak during late adolescence and early adulthood, and subsequently decline (Sher, Grekin, & Williams, 2005). However, there is considerable individual variability around this trend; in the US, for example, binge drinkers represent only around one in five students but reportedly consume 68% of all alcohol drunk by college students (Wechsler, Molnar, Davenport, & Baer, 1999). In another study, 43% of 18 to 19 year old students diagnosed with an alcohol use disorder (AUD) still fulfilled this diagnosis aged 25 (Sher & Gotham, 1999); thus, the timescale for 'maturing out' extends for many people into their mid 20s or beyond.

According to Kerr-Correa, Igami, Hiroce, and Tucci (2007), researchers use two main definitions of alcohol abuse: 'problematic drinking' is demonstrated by adverse consequences (e.g. failure to fulfil obligations, social/personal problems, physiological tolerance) one or more times per week, whereas 'binge drinking' is defined by the US National Institute on Alcohol Abuse and Alcoholism (NIAAA, 2008) as a "pattern of drinking alcohol that brings blood alcohol concentration (BAC) to 0.08 grams percent [per litre] or above" (2008); this typically corresponds to five or more drinks for men, or four or more drinks for women, within a two hour period. Since binge drinkers can drink in moderation, or even not at all, for long periods between binges, they differ from problematic drinkers, who are likely to drink more frequently and show more signs of physiological and psychological dependence (Borsari et al., 2007). A vast empirical research has identified various risk factors for problematic, non-problematic, and binge drinking.

The literature on psychological factors related to illicit substance use is also extensive; one review located more than 200 publications that reported longitudinal investigations (Macleod et al., 2004), and there is immeasurably more cross-sectional research. While there is comorbidity between the use of alcohol and illegal substances, the legal divide has often led to them being considered separately, and perhaps with good reason, given differences in accessibility and social acceptance. For the most part, as will be discussed, very similar risk factors have been identified for alcohol and illicit substance use.

The following pages will review evidence from the literature on alcohol and illicit substance use and abuse, considering risk factors relevant to each level of the IIC framework. Predictor variables of particular interest in the present cross-sectional student study are introduced briefly, and further details of the instruments used to assess them are given in the Methods section.

Level 1: Attitudinal risk factors

Level 1 of the IIC framework is concerned with factors related to an individual's attitudes towards, and future intentions regarding substance use. These factors include whether s/he considers substance use behaviours to be appropriate, and whether s/he actively pursues substance use as the result of a purposeful and rational intention. According to Ajzen's Theory of Planned Behaviour (TPB; Ajzen, 2002), beliefs lead to the development of attitudes; these, in combination with the individual's perceived pressure from social norms and of his/her own behavioural control, lead to the formation of intentions, which in turn directly influence the likelihood of a particular behaviour. The IIC framework likewise assumes an important role for cognitive factors related to attitudes and intentions in predicting substance use.

Risk factors for alcohol use

Alcohol, like other drugs of abuse, acutely increases dopamine activity in the brain's reward circuitry, which is thought to mediate positive reinforcement (Koob, 2000); therefore, it is unsurprising that drinkers have expectations of pleasure from alcohol use (e.g. Greenbaum, Del Boca, Darkes, Wang, & Goldman, 2005). Positive expectancies (e.g. for pleasure, social facilitation, and assertiveness) are associated with heavier alcohol use among students (e.g. Borsari et al., 2007; Greenbaum et al., 2005; Hartzler & Fromme, 2003). Heavier alcohol use has also been linked with lower perceived riskiness of drinking, implicating negative expectancies in the imposition of restraint (e.g. Hampson, Severson, Burns, Slovic, & Fisher, 2001; Ryb, Dischinger, Kufera, &

Read, 2006). More generally, positive attitudes towards drinking have been associated with greater alcohol use (e.g. Trafimow, 1996), and reported intentions to engage in future alcohol use have been found to mediate the relationship between attitudes towards drinking and actual alcohol consumption (Huchting et al., 2008). Boys, Marsden, and Strang (2001) interviewed 100 young drug and alcohol users and found that their reported intentions to use substances for a second time was predicted by their past substance use, suggesting that intentions can also be influenced by behaviour. Together, these findings suggest that attitudes and intentions towards alcohol use do indeed play an important role in explaining behaviour, though the causal direction of the association remains to be ascertained.

Religiosity has been identified in some studies as a strong protective factor against problematic alcohol use (e.g. Chu, 2007; T. J. Johnson et al., 2008). However, Patock-Peckham, Hutchinson, Cheong, and Nagoshi (1998) reported that although students without a religious affiliation drank more than those reporting some religiosity, their risk of problem drinking was not elevated. This suggested that whilst religiosity may be associated with less alcohol *use*, it does not affect the incidence of *abuse*. Elsewhere, Galen and Rogers (2004) found that believers who demonstrated a high personal commitment were less likely to drink than those who reported religious affiliations without a strong personal commitment. Similarly, Heath et al. (1997) found a higher risk for alcohol dependence in inactive Catholics than in weekly church attendees. Thus, it appears that religiosity is most strongly associated with reduced drinking when accompanied by a personal religious commitment – and thus, presumably with spiritually-motivated intentions not to engage in alcohol use. However, findings regarding whether religiosity is a protective factor against alcohol abuse are mixed.

Risk factors for illicit substance use

Attitudinal factors have been identified as important risk factors for illicit substance use. For example, studies have reported associations between positive attitudes towards, and actual substance use of, benzodiazepines (van Hulten et al., 2003) and ecstasy (Peters, Kok, & Abraham, 2008); and between intentions and actual smoking (Skara, Sussman, & Dent, 2001), MDMA use (Yu & Ko, 2006), and overall substance use (Wolford & Swisher, 1986). Negative expectancies have also been found to predict a reduced risk for the initiation of cannabis use (Chabrol, Mabila, Chauchard, Mantoulan, & Rousseau, 2008). Perron and Howard (2008) found that perceived risks did not attenuate intentions to use in current inhalant users, but this may reflect the well-recognised disjunction between beliefs and behaviour in people who are already psychologically or physically dependent on drugs.

Francis (1997) reported a negative association between personal religiosity and risk of substance use initiation, and a recent review included church attendance and intentions to engage in future use in a list of factors that have been robustly found to protect against or predict cannabis consumption (Guxens, Nebot, Ariza, & Ochoa, 2007). The protective role of religiosity has been corroborated by many studies (e.g. Kliewer & Murrelle, 2007); as with alcohol use, the evidence highlights the importance of active religious involvement, rather than purely nominal religious affiliation (e.g. Sanchez, De Oliveira, & Nappo, 2008). Very recently, a large-scale study of nearly three thousand Israeli adolescents highlighted the interrelatedness of substance use and religiosity, attitudes to substance use, risk perception, and behavioural intentions (Azaiza, Shoham, Bar-Hamburger, & Abu-Asbeh, 2008).

Predictor variables in the present study

Six predictors were of particular interest here: overall favourability of attitudes towards substance use (hereafter referred to as '**Attitudes**'); perceived riskiness of alcohol ('**Riskiness-Alcohol**') and illicit substance use ('**Riskiness-Illicit**'); and intentions regarding future alcohol ('**Alcohol-intentions**') and illicit substance use ('**Illicit-intentions**'). Although recent research into the protective effect of religiosity has highlighted the importance of personal commitment, the present study commenced before this literature came to light, and participants were asked only about any prohibitions of their religious affiliation on substance use ('**Religious Restrictions**').

It is hypothesised that each of these variables will be associated with alcohol and/or illicit substance use.

Level 2: Situational risk factors (Life stress)

Risk factors for alcohol use

A recent review of findings regarding the association between socio-economic status (SES) and problematic drinking found a surprising lack of consistency (Wiles et al., 2007). Several studies do, however, indicate that stress, or negative life events, are robustly associated with problematic drinking (e.g. Rutledge & Sher, 2001), though not with levels of alcohol use per se (Ham & Hope, 2003). Camatta and Nagoshi (1995) reported that both the frequency and severity of stressors were positively linked with problematic drinking, and that this link was mediated by psychological problems (e.g. depression). Research into gene-environment interactions suggests that a stress-dampening effect of alcohol may underlie the development of problematic drinking (Zimmermann, Blomeyer, Laucht, & Mann, 2007) and that there is genetic variation in the extent to which alcohol has such an effect. This may explain the increased risk of problem drinking in the offspring of alcoholics (Sher et al., 2005).

Risk factors for illicit substance use

Contrasting with the inconsistent evidence for an association between SES and alcohol use initiation, there is strong evidence for a link between SES and illicit substance abuse. One study followed a group of African Americans from the age of six to 32 years, and found that higher educational attainment and higher socio-economic status both predicted less risk of substance use problems (Fothergill & Ensminger, 2006). Guxen, Nebot, and Ariza (2007) found that both attending state schools (rather than private) and low academic performance predicted cannabis use amongst young girls. Fothergill and Ensminger (2006) suggest that drug use may in some cases be a coping mechanism borne out of the frustration and disappointment of not meeting social expectations of educational success. The link between SES and illicit drug use may reflect the effects of a general social disadvantage, which may include a lack of more adaptive sources of pleasure and differences in attitude towards illicit drug use.

Stress is also linked with use of substances as it is with alcohol. A stress-reduction model is supported by research that implicates emotional distress in the transition from controlled to problematic substance use (Marsh & Dale, 2005). Arellanex-

Hernandez, Diaz-Negrete, Wagner-Echeagaray, and Perez-Islas (2004) found that exposure to stressors was positively correlated with the severity of drug use among young adults. Likewise, Schilling, Aseltine, and Gore (2008) found that childhood adversities predicted drug use in early adulthood. Thus, as for alcohol use, there is evidence that life stress is a risk factor for illicit drug use.

Predictor variables in the present study

The present research focuses on the potential predictive influence of recent stress on both alcohol and illicit substance use, and participants completed an inventory of stressful life events occurring within the preceding 12 months (**'Life Stress'**). Although low SES has been identified as another situational factor that may particularly influence illicit substance use, this was not explored here: the sample includes young adults who are all university undergraduates and therefore relatively homogenous with respect to academic attainment and social values/aspirations. Although there is inevitably diversity in their social backgrounds, the fact that these participants all made the transition to university education suggests that the possible influence of familial SES is likely to be attenuated. Given the large number of other variables to be explores, a decision was made not to formally assess or investigate socio-economic influenced in this distinctive population.

Levels 3 & 4: Competing impulses and cognitive control

At Level 3, it is hypothesised that responses to appetitive and aversive substance-use related cues result in the generation of competing approach and avoidance action tendencies; and at the fourth level, that executive effortful control processes act to inhibit action tendencies that oppose the individual's intentions. Central to the IIC framework is the assumption that impulsive behaviour results from the combined functional activation of three systems: an approach system, an avoidance system, and a control system. The approach system is tapped by measures of reward sensitivity, and by measures designed to assess the activity of Reinforcement Sensitivity Theory's (RST) behavioural activation system. The avoidance system is tapped by measures of harm avoidance, and those designed to tap RST's behavioural inhibition system (BIS). The control system is tapped by more general impulsivity and novelty seeking questionnaires, and by measures that address the conflict between approach and avoidant impulses.

Risk factors for alcohol use

In 2002, Baer commented that research had not consistently shown specific aspects of impulsivity to be more risky than others for alcohol abuse. However, recent findings have linked problematic drinking with particular facets of impulsivity. Magid, MacLean, and Colder (2007) found that sensation seeking was directly associated with drinking levels, but was not directly associated with problematic drinking; on the other hand, a broad measure of impulsivity was not directly associated with alcohol use, and correlated only slightly with alcohol-related problems. Magid and Colder (2007) assessed alcohol use/abuse in a student sample, relating it to scores on Whiteside and Lyman's (2001) Urgency, Premeditation, Perseverance, and Sensation Seeking (UPPS) questionnaire. Premeditation was negatively, and Sensation Seeking positively, associated with level of alcohol use, but neither correlated with problematic drinking. On the other hand, Urgency and Perseverance did not predict alcohol use but both correlated with problematic drinking. The authors note that Urgency and Perseverance may reflect difficulties in remaining focused and avoiding risky behaviours; and conversely, that Sensation Seeking individuals and those low on Premeditation are likely to pursue the positive states associated with alcohol use, and perhaps fail to consider the negative consequences of heavier drinking. While the UPPS subscales do not discriminate between the approach, avoidance, and control systems highlighted in the IIC framework (e.g., Urgency appears to reflect control *and* avoidance), this study demonstrates differential relationships of particular subtraits with alcohol use and abuse.

Magid and Colder's findings are consistent with the thesis that an over-active approach system may lead an individual to pursue expected pleasurable effects of drinking, an under-active avoidance system may lead to him/her ignoring potentially negative consequences, and an under-active control system might reduce his/her ability to resist the urge to continue use despite a high probability of aversive consequences. Consistent with this, other studies have reported associations between self-reported reward sensitivity and alcohol use, directly implicating the approach system (e.g.

Dawe et al., 2004; Del Boca, Darkes, Greenbaum, & Goldman, 2004; Pardo et al., 2007; Sher et al., 2000). There is also evidence of an association between approach tendencies and alcohol abuse. Kane, Loxton, Staiger, and Dawe (2004) found that women comorbid for bulimia and alcohol use disorders scored higher on a behavioural test of reward responsiveness than bulimic-only women; the same group found higher self-reported reward sensitivity to predict alcohol misuse in a sample of young women (Loxton & Dawe, 2001). Thus, while Magid et al.'s findings suggest a stronger role for approach in alcohol consumption than in problematic drinking, there is evidence that it may be a risk factor for both.

Measures that tap control have been associated with alcohol use and abuse in past research. Positive associations have been found between self-reported impulsivity and alcohol consumption in non-alcoholics (e.g. Camatta & Nagoshi, 1995; Grano, Virtanen, Vahtera, Elovainio, & Kivimaki, 2004), suggesting the involvement of control in non-problematic alcohol use. Elsewhere, studies have examined 'behavioural undercontrol' - a term that is used to collectively refer to impulsivity, sensation seeking, aggressiveness and antisociality (Sher, Walitzer, Wood, & Brent, 1991); and which, reflecting a broad conceptualisation of impulsive behaviour, is likely to tap the control system. In a prospective study of student alcohol use, Grekin and Sher (2006) found that a composite measure of behavioural undercontrol derived from novelty seeking, conscientiousness, agreeableness, and conduct disorder questionnaires was a significant predictor of later alcohol dependence symptoms, even after controlling for age, gender, and pre-college drinking. Slutske et al. (2002) looked at conduct disorder and alcohol dependence in a cross-sectional study of 3,383 adult twin pairs, in relation to a measure of undercontrol derived from novelty seeking and psychoticism questionnaires. They found that genetic influences contributing to variance in behavioural undercontrol accounted for around 40% of the variation in alcohol dependence, and for about 90% of the common risk for both alcohol dependence and conduct disorder. The authors emphasised, however, that the causal nature of this association is not clear[†].

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† *See chapter 5 for further discussion on the issue of causality*

Possible links between the avoidance system and alcohol use, however, are more complicated. By any conceptualisation, avoidance systems are activated in the presence of aversive or potentially harmful stimuli, triggering feelings of anxiety. Indeed, in Gray's (1970) Reinforcement Sensitivity Theory (RST) – which is best known as an account of impulsivity *and* anxiety (Smillie, Pickering et al., 2006) - BIS represents the causal basis of anxiety. On the one hand, an *under*-active avoidance system might increase the likelihood of alcohol use because the individual will be less deterred by the prospect of possible harms. There is some evidence for this: Magid et al. (2007), Pardo et al. (2007) and Franken and Muris (2006) have all reported negative correlations between alcohol use and self-reported harm avoidance or BIS indices. However, on the other hand there is also a large literature on the high comorbidity between anxiety symptoms/disorders, and alcohol use disorders (e.g. Kushner & Sher, 1993; Kushner, Sher, & Erickson, 1999; Morris, Stewart, & Ham, 2005). These positive associations between anxiety and alcohol use suggest that an *over*-active avoidance system may be a risk for problem substance use.

It has been suggested that individuals who suffer from social anxiety - defined as the fear of negative evaluation by others (American Psychiatric Association, 2000) - drink to alleviate negative affect; that is, they self-medicate either to become more relaxed and sociable (Gilles, Turk, & Fresco, 2006), or perhaps because acute intoxication allows them to temporarily disregard their anxieties (West, 2006). Interestingly, Gilles at al. (2006) reported social anxiety to correlate positively with alcohol dependence, but not with drinking frequency or quantity in a student sample. Similarly, Jackson and Sher (2003) reported an association between trait neuroticism (closely related to anxiety) and problematic drinking in young adults. However, Ham and Hope (2005) report a small *negative* correlation between social anxiety and alcohol consumption in a sample of college students, and no relationship between anxiety and drinking problems; whilst Kambouropoulos and Staiger (2007) found no difference between hazardous drinkers and controls in self-reported punishment sensitivity.

It is noteworthy that the majority of studies into anxiety and alcohol use are in non-clinical samples. It may be that the relationship is curvilinear, such that initial recreational alcohol use is higher in individuals who are less risk-averse and who enjoy its disinhibiting effects, but that in people with clinically significant anxiety, alcohol is used for its mood suppressant effects. This argument has been made, for example, by Kushner et al. (1999). Schuckit and Hesselbrock (2004) conducted an extensive review of reports on anxiety and alcohol use published since 1975. Their conclusions were three-fold: firstly, the data did not conclusively support a close relationship between lifelong anxiety disorders and alcohol dependence; secondly, longitudinal studies have not provided compelling evidence that anxiety disorders predate alcohol dependence; and thirdly, observations of comorbidity likely reflect both true anxiety disorders among alcoholics, and alcohol-induced anxiety symptoms.

To summarise, there is empirical support for the hypotheses that alcohol use will be associated with an over-active approach system that motivates the pursuit of rewarding experiences, and with an under-active control system that reduces the ability to resist the urge to continue use or increase consumption. There is evidence that under-active avoidance systems may influence alcohol use, possibly reflecting lower concern about harm, but also that an over-active avoidance system may increase the use of alcohol in order to reduce anxiety.

The present study explores substance use in a sample of generally healthy young adults who have recently embarked on an undergraduate degree, and who are therefore unlikely to be characterised by sever or longstanding problems with either dependence or psychiatric/mood disorders; thus, the hypotheses pertains primarily to predictions of variation in substance use at the less problematic end of the spectrum. Specifically, it is hypothesised that amount/frequency of alcohol use and other drug use will be related to higher approach, lower avoidance, and lower control. If there is a sufficiently sizeable subset of individuals showing evidence of problem alcohol/drug use or dependence, then the possibility of a curvilinear relationship with avoidance will also be explored.

Risk factors for illicit substance use

Dispositional traits related to impulse control are robust correlates of illicit substance use. A study of 12-18 year olds found that high sensation-seekers were more likely to have used a range of illicit substances (Martins, Storr, Alexandre, & Chilcoat, 2008). Ecstasy users have been found higher in novelty seeking, impulsivity, and risk-taking than controls (Butler & Montgomery, 2004; Dafters, 2006). Wadsworth et al. (2004) found that high neuroticism was one risk factor for illicit drug use in a Welsh community-based population sample. As indicated earlier, the approach system is tapped by measures of reward sensitivity of BAS indices, the avoidance system by measures of harm avoidance or neuroticism, and the control system is tapped by more general impulsivity questionnaires. Therefore, these findings together implicate the involvement of all three systems in non-problematic drug use.

Studies of heavy and problematic drug use have identified similar risk factors. Genovese and Wallace (2007) found that students high in reward sensitivity and low in punishment sensitivity showed the highest levels on 13 out of 15 measures of substance abuse. Moran et al. (2006) report that problematic use among Australian teenagers is more common in those with Cluster B personality types, which are characterised by high novelty-seeking and low harm-avoidance. Quednow et al. (2007) tested heavy ecstasy users on a Go-No Go task (which taps inhibitory control) and the Iowa Gambling Task (IGT; a measure of impulsive decision-making); ecstasy users made more risky decisions on the IGT but did not differ from controls on the Go-No Go task. In a cross-sectional study of young adults, von Diemen et al. (2008) and found that self-reported impulsivity and age of first alcoholic drink were significantly associated with problematic use. Gerra et al. (2004) similarly reported an association between illicit substance use and higher sensation seeking, but found no difference in sensation seeking scores between experimenters and habitual users. These findings suggest consistent relationships between substance abuse and various indices of approach, avoidance, and control; however, they do not cast light on whether differential relationships exist between specific aspects of impulsivity and different patterns of substance use or abuse.

As with alcohol use, there are conflicting findings regarding the involvement of the avoidance system in illicit substance use. Implicating *under*-activity of the avoidance system as a risk factor, Moran et al's (2006) study reported an association between low harm avoidance and problematic substance use; likewise, Dughiero, Shifano, and Forza

(2001) found that ecstasy abusers scored lower on harm avoidance than ecstasy experimenters, but found no differences between ecstasy users (both experimenters and abusers) and non-ecstasy using controls. Interestingly, however, some non-clinical studies report no association between illicit drug use and variation in anxiety-related traits: Franken and Muris (2006) found no correlation between BIS and illicit substance use, and Butler and Montgomery (2004) reported no differences on harm avoidance scores between non-drug users, cannabis users, ecstasy users, polydrug users, low ecstasy users or high ecstasy users. Conversely, suggesting that *over*-activity of the avoidance system be implicated in substance use, Vink et al (2007) reported that high neuroticism was associated with cannabis use. A compelling literature also links anxiety disorders and illicit substance use: Kessler et al. (1997) reported that the lifetime prevalence rates for substance use disorders are three times higher for individuals with generalised anxiety disorder and twice as high for those with panic disorders, than for the general population; Buckner et al. (2008) reported that adolescents with mood disorders who were diagnosed with social anxiety were six times more likely to be diagnosed with cannabis dependence; and a review by Moutier and Stein (1999) comments on a robust comorbidity between substance abuse and social anxiety disorders. Thus, there is evidence that both under-active and over-active avoidance systems may be associated with substance use. As with alcohol, there may be a curvilinear relationship between illicit substance use/abuse and measures that tap the avoidance system.

Predictor variables in the present study

This study will explore the utility of the self-report and laboratory indices of the three systems investigated in chapter 2 in predicting alcohol and illicit substance use. The measures derived using factor analysis in the previous study comprised self-reported trait indices of the approach system (henceforth referred to as **'Trait-Approach'**), avoidance system (**'Trait-Avoidance'**), and control system (**'Trait-Control'**). In addition, four laboratory tasks previously found to be associated with substance use* are included: poor inhibitory control on the **Go-No Go task** (GNG) has been linked with more frequent drinking (Colder & O'Connor, 2002), and with early onset alcohol

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* *See pages 64-69 for details of task indices*

use (G. Dom et al., 2006); performance deficits on the **Anti-Saccade Task** (AST) characterise boys at high-risk of developing substance use disorders (Iacono, 1998); students reporting more illicit substance use demonstrated elevated discounting rates on the **Delay Discounting task** (DDT; Kollins, 2003); and cocaine and cannabis users show performance deficits on the **Iowa Gambling task** (IGT; Verdejo-Garcia et al., 2007), as do binge drinkers (Goudriaan et al., 2007).

Evidence for the involvement of the approach, avoidance, and control systems in alcohol and illicit substance use has been reviewed. There is some evidence that risk factors for problematic substance use may differ from those for initiation and experimentation and that the two aspects of use should be examined separately. Magid et al.'s (2007) findings suggest that approach is associated with alcohol use, but not problematic drinking; while control is more strongly implicated in alcohol-related problems, rather than alcohol use. However, other evidence has associated both approach and control with non-dependent *and* problematic substance use. It is hypothesised here that high approach influences substance use initiation and experimentation via increased reward sensitivity, whereas low control increases the risk of both problematic and non-problematic substance use by means of a reduced ability to desist from use; and therefore substance use will be positively associated with approach and negatively associated with control.

It has previously been argued that a curvilinear (inverted-U shaped) relationship may be found between measures of anxiety/ avoidance and both level of alcohol consumption and illicit substance use, whereby low avoidance leads to substance use via a reduced concern for harm avoidance, and high avoidance leads to substance use in order to reduce anxiety. While a curvilinear relationship might be apparent in a large population-based sample, the student sample in this study is likely to include very few participants who demonstrate clinical levels of anxiety or dependence. Thus, in the present sample, a negative association is hypothesised between indices of avoidance and non-problematic substance use; if there is a sizeable sub-group for whom substance use become problematic, a negative relationship with avoidance indices is predicted.

Combining risk factors

A broad range of risk factors has been identified for alcohol and illicit substance use, including demographic factors, personality, history of substance use, expectancy, intentions, motives, stress, and peer/family influence. To date, no single variable or cluster of variables has been identified as critical or sufficient for the initiation of substance use. Methodological choices often limit the conclusions that can be drawn from any given study; for instance, von Sydow et al. (2002) notes that many studies consider only categorical measures of substance use, rather than continuous measures of frequency or use, and that many treat group substance use and abuse as a single variable, when in fact their predictors are likely to differ considerably. Elsewhere, Compton, Thomas, Conway, and Colliver (2005) observe in a wide-ranging review that studies of the epidemiology of substance use have generally focused on risk factors at either individual, family, or societal levels, but have rarely considered their interrelationships.

It is of particular theoretical interest in the context of this thesis to explore certain additive effects and interactions. The IIC framework proposes that, when presented with an opportunity to engage in substance use, an individual is likely to perceive the substance as having both appetitive and aversive effects by varying degrees, thus simultaneously triggering the activity of approach and avoidance systems (Level 3); depending upon the relative strengths of these impulses, the resultant dominant action tendency will be either to use or to avoid substance use. If the resulting action tendency is congruent with his/her attitude towards substance use, there is no conflict and the individual will either engage in substance use or reject the opportunity to do so. However, if a conflict arises between the action tendency and attitudinal factors (Level 1), it is proposed that cognitive control processes come into play to resolve such conflicts (Level 4).

This account proposes multiple interactions. For example, consider those individuals for whom approach is the dominant action tendency, but whose intentions oppose substance use; according to the framework, it is assumed in such cases that individual variation in the strength of inhibitory control processes will predict variation in actual substance use. In other words, impulsivity will emerge as a strong predictor specifically in the subgroup of participants who express negative attitudes to drug use but who are reward sensitive. Whilst statistical power limits the extent to which such complex interactions can be investigated here, it is hypothesised that predictors at different levels will exert partially separate and therefore additive effects on substance use. Multiple regressions will therefore assess the combined influence of variables that individually predict substance use.

Purposes of the current study

The objectives of this cross-sectional study of students' recreational substance use are two-fold: 1) to test a series of hypotheses regarding the associations of alcohol and illicit substance use with individual attitudinal factors, Life Stress, and indices of the approach, avoidance, and control systems; 2) to assess the combined influence of individually significant predictors.

The sample

New university students experience increased opportunities to experiment with alcohol and drug use, since, for many, this is the first time that they are free from parental influence or restraint and have control over their own budget, and are exposed to a peer group and social scene in which drugs and alcohol are available and socially acceptable. This makes young students an interesting population in which to investigate substance and alcohol use (Borsari et al., 2007). The present study has therefore recruited over 400 undergraduate students from two universities, Goldsmiths in London, UK, and Griffith University in Brisbane, Australia.

Outcome measures

In line with von Sydow et al.'s (2002) recommendations, substance use and abuse are considered separately, and wherever possible continuous measures of substance use are used. Seven indices of substance use are assessed*. The Alcohol Use & Disorders Identification Test (AUDIT: Babor, de la Fuente, Saunders, & Grant, 1992) provides three: '**Alcohol use status**' (i.e. current drinker vs. teetotaller) is established using

* *Detailed information about these variables is given on page 101-105*

responses regarding drinking frequency; '**AUDIT-Total**', which reflects both alcohol use and abuse – though in the current sample, this is likely to principally tap non-problematic drinking – with high scores indicating risky consumption, high risk use, and alcohol dependence; and '**AUDIT-Binge**' indicating the frequency with which participants consume more than six drinks on one occasion. In addition, after excluding measures of tobacco and alcohol use, the Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST; WHO ASSIST Working Group, 2002) yields four indices: '**Illicit drug use status**' identifies participants as current, former or never users; the current frequency of illicit substance use (**'ASSIST-Freq'**), the number of illicit substances ever used ('**ASSIST-Count**'), and a measure of harmful or problematic illicit substance use ('**ASSIST-Prob**').

Study hypotheses

The following hypotheses are summarised in Table 3.14 (page 117), and will be tested in relation to the seven measures of substance use just described.

Level 1: Attitudinal risk factors

I. Substance use and abuse measures will be positively associated with more favourable attitudes towards substance use (Attitudes)

II. Alcohol use/abuse measures will be positively associated with lower perceived risks for alcohol use (Riskiness-Alcohol), and illicit substance use/abuse measures will be positively associated with lower perceived risks for substance use (Riskiness-Illicit).

III. Alcohol use/abuse measures will be positively associated with higher future intended alcohol use (Alcohol-intentions), and illicit substance use/abuse measures will be positively associated with higher future intended use (Illicit-intentions).

IV. Students reporting religious affiliations that prohibit substance use (Religious Restrictions) will, on average, score lower on all substance use and abuse measures than students who do not.

Level 2: Life Stress

V. Substance use and abuse measures will be positively associated with greater reported Life Stress during the previous 12 months.

Level 3: The approach system

VI. The following indices of the approach system will be positively associated with all substance use and abuse measures.

   a. Trait-Approach

   b. Laboratory task indices of approach:

      - Faster reward learning on the Go-No Go (GNG) task

Level 3: The avoidance system

VII. The following indices of the avoidance system will be negatively associated with AUDIT-Total, ASSIST-Freq and ASSIST-Count, and positively associated with AUDIT-Binge and ASSIST-Prob:

   a. Trait-Avoidance

   b. Laboratory task indices of avoidance:

      - Faster punishment learning on the GNG task

Level 4: The control system

VIII. The following indices of the control system will be negatively associated with all substance use and abuse measures:

   a. Trait-Control

   b. Laboratory task indices of control:

      - Fewer commission errors on the GNG task
      - Less steep discounting rates on the delay discounting task (DDT)
      - Higher accuracy on the oculomotor antisaccade task (AST)
      - Less interference on the AST
      - More advantageous decisions on the Iowa gambling task (IGT)

Method

Participants

In Chapter 2, self-report indices of the approach, avoidance, and control systems were derived for 438 students who varied in age from 16 to 57. Given the present focus on the behaviour of young adults, only 410 participants aged between 17 and 25 were retained in the present study. Attitudinal and Life stress data are available for London participants only.

Design and Analyses

This is a cross-sectional study exploring interrelationships between six attitudinal variables, life stress, three self-report and ten laboratory task indices of the approach, avoidance, and control systems, and indices of substance use and abuse. Demographic data are reported for descriptive purposes (age, gender, ethnicity, socio-economic status [SES]), but are not analysed.

Participants who abstain from alcohol or illicit drug use are likely to be categorically different from participants who use alcohol or drugs on at least some occasions, since this group could in principle include those who have strong attitudinal or religious beliefs that preclude substance use on the one hand, and reformed addicts on the other. It is therefore of interest to separately explore which risk factors are relevant to variation in alcohol and drug consumption among users, and which factors are associated with whether individuals are abstinent or not.

The measure of alcohol use used in the present study (AUDIT-Total) identifies whether participants are current abstainers, but not whether these individuals have always abstained, are former users or are reformed addicts. To test which factors are associated with current abstinence, initial analyses will compare all currently abstinent individuals with current alcohol users across predictor variables. The subsequent analyses of AUDIT-Total scores and AUDIT-Binge responses will then include only alcohol users, and exclude abstinent participants.

ASSIST-Freq scores estimate the frequency of current drug use, while ASSIST-Count scores reflect the total number of illicit drugs ever used, regardless of current use. Thus, by considering these measures in parallel, it is possible to identify which currently abstinent individuals have engaged in past drug use, and which have never used any illicit drugs. Initial analyses will therefore compare current users, never users, and former users. Subsequent analyses of ASSIST-Count, ASSIST-Freq and ASSIST-Prob scores will explore risk factors for level of use in current users only.

A range of analytical techniques are used; Table 3.9 (page 117) lists all planned analyses in the order in which they will be reported. Where directional hypotheses are made, one-tailed tests ($p<0.10$) are used; two-tailed tests ($p<0.05$) are used for all other analyses. Conservative Bonferroni corrections are applied to reduce the risk of Type I errors resulting from multiple comparisons; the corrected significance levels are presented in footnotes throughout the text. Emboldened text is used in tables to highlight all trends that reach conventional uncorrected significance levels ($p<0.05$). SPSS Version 14 is used in all analyses.

Measures

a) Alcohol and illicit substance use measures

Alcohol Use & Disorders Identification Test (AUDIT: Babor et al., 1992)

This ten-item self-report questionnaire was developed to identify persons 'at risk' of developing alcohol use disorders. The questionnaire – items and scoring shown in Figure 3.15 - taps alcohol consumption and alcohol dependency.

Total score (AUDIT-Total, max. 40) represents the participant's position on a spectrum from no use to dependency. Scores of zero indicate abstinence. Scores above seven indicate risky consumption, above 15 indicate harmful high risk use, and above 20 signify likely alcohol dependence (Kerr-Correa et al., 2007). Reponses to Q1 ("How often do you consume a drink containing alcohol?") were used to classified participants as current users or non-users (Alcohol use status). In addition, responses to Q3 ("How often do you have 6 or more drinks on one occasion?") index frequency of current 'binge' drinking (AUDIT-Binge) and range from 0 (never) to 4 (daily).

Q1. How often do you consume a drink containing alcohol?	
Never	(0)
Monthly or less	(1)
2 to 4 times a month	(2)
2 or 3 times a week	(3)
4 or more times a week	(4)

Q2. How many drinks containing alcohol do you have on a typical day when you are drinking?	
1 or 2	(0)
3 or 4	(1)
5 or 6	(2)
7 to 9	(3)
10 or more	(4)

Q3. How often do you have 6 or more drinks on one occasion?	
Never	(0)
Less than monthly	(1)
Monthly	(2)
Weekly	(3)
Daily or almost daily	(4)

Q4. How often during the last year have you found that you were not able to stop drinking once you had started?	
Never	(0)
Less than monthly	(1)
Monthly	(2)
Weekly	(3)
Daily or almost daily	(4)

Q5. How often during the last year have you failed to do what was normally expected from you because of drinking?	
Never	(0)
Less than monthly	(1)
Monthly	(2)
Weekly	(3)
Daily or almost daily	(4)

Q6. How often during the last year have you needed a drink in the morning to get yourself going after a heavy drinking session the night before?	
Never	(0)
Less than monthly	(1)
Monthly	(2)
Weekly	(3)
Daily or almost daily	(4)

Q7. How often during the last year have you had a feeling of guilt or remorse after drinking?	
Never	(0)
Less than monthly	(1)
Monthly	(2)
Weekly	(3)
Daily or almost daily	(4)

Q8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?	
Never	(0)
Less than monthly	(1)
Monthly	(2)
Weekly	(3)
Daily or almost daily	(4)

Q9. Have you or someone else been injured as a result of your drinking?	
No	(0)
Yes, but not in the last year	(2)
Yes, during the last year	(4)

Q10. Has a relative, a friend, or a physician or other healthcare worker been concerned about your drinking or suggested that you cut down?	
No	(0)
Yes, but not in the last year	(2)
Yes, during the last year	(4)

Figure 3.15: AUDIT questions, responses, and scoring (Babor et al., 1992)

Alcohol, Smoking and Substance Involvement Screening Test (WHO ASSIST Working Group, 2002)

The ASSIST is a structured interview-based assessment of lifetime use of tobacco, alcohol, and seven groups of illicit substances: cannabis, cocaine (i.e. coke or crack), amphetamines (e.g. ecstasy), inhalants (e.g. amyl-nitrates), sedatives, hallucinogens (e.g. LSD or magic mushrooms), and opiates. For the purposes of the present chapter, only data pertaining to illicit drugs are considered.

Figure 3.16 shows the original instructions, questions, responses, and scoring.

Thank you for agreeing to take part in this brief interview about alcohol, tobacco products and other drugs. I am going to ask you some questions about your experience of using these substances across your lifetime and in the past three months. These substances can be smoked, swallowed, snorted, inhaled, injected or taken in the form of pills (show drug card). Some of the substances listed may be prescribed by a doctor (like amphetamines, sedatives, pain medications). For this interview, we will not record medications that are used as prescribed by your doctor. However, if you have taken such medications for reasons other than prescription, or taken them more frequently or at higher doses than prescribed, please let me know. While we are also interested in knowing about your use of various illicit drugs, please be assured that information on such use will be treated as strictly confidential.

Q1: In your life, which of the following substances have you EVER USED?
YES (3) or NO (0)

Q2: In the past three months, how often have you used the substance you mentioned (1st drug, 2nd drug, etc)
NEVER (0), ONCE/TWICE (2), MONTHLY (3), WEEKLY (4), DAILY/ALMOST DAILY (6)

Q3: During the past three months, how often have you had a strong desire or urge to use (1st drug, 2nd drug, etc)?
NEVER (0), ONCE/TWICE (3), MONTHLY (4), WEEKLY (5), DAILY/ALMOST DAILY (6)

Q4: During the past three months, how often has your use of (1st drug, etc) led to health, social, legal or financial problems?
NEVER (0), ONCE/TWICE (4), MONTHLY (5), WEEKLY (6), DAILY/ALMOST DAILY (7)

Q5: During the past three months, how often have you failed to do what was normally expected of you because of your use of (1st drug, etc)
NEVER (0), ONCE/TWICE (5), MONTHLY (6), WEEKLY (7), DAILY/ALMOST DAILY (8)

Q6: Has a friend or relative or anyone else EVER expressed concern about your use of (1st drug, etc)
NEVER (0); YES, IN THE PAST 3 MONTHS (6); YES, NOT IN THE PAST 3 MONTHS (3)

Q7: Have you EVER tried and failed to control, cut down or stop using (1st drug, etc)
NEVER (0); YES, IN THE PAST 3 MONTHS (6); YES, NOT IN THE PAST 3 MONTHS (3)

Q8: Have you ever used any drug by injection? (NON-MEDICAL USE ONLY)
NEVER (0); YES, IN THE PAST 3 MONTHS (2); YES, NOT IN THE PAST 3 MONTHS (1)

Figure 3.16: ASSIST questions, responses, and scoring (WHO ASSIST Working Group, 2002)

For each substance, participants indicated their frequency of use, problematic use, and impaired control. Four measures were derived for the purposes of the present study.

Firstly, responses to Q1 were used to count how many from the seven classes of substances listed were ever used ('ASSIST-Count'), yielding a score between 0 and 7.

Secondly, responses to Q2 were summed across the seven classes of substances to reflect the frequency of illicit substance use over the previous three months ('ASSIST-Freq'). Scoring was adjusted to reflect the approximate actual number of occasions each participant had used each class of drugs during the past three months: never (0), once or twice (1), monthly (3), weekly (12), and daily/almost daily (45). These were summed across all seven drug classes, yielding a total score between 0 and 315. Scores of zero indicate abstinence.

Thirdly, ASSIST-Count and ASSIST-Freq scores were considered in parallel to identify 'illicit drug use status'; participants who reported some current drug use were labelled 'current users', those who had used some illegal drugs in the past but reported no current use were labelled 'former users', and participants who had never used illicit drugs were labelled 'never users'.

Lastly, responses to Q4, Q5, & Q7 were summed across the seven classes of substances to reflect a measure of harmful and problematic illicit substance use in the last 3 months ('ASSIST-Prob'). Reponses to Q4 and Q5 were scored exactly as in the original (see Figure 3.16); for Q7, participants received a score of 6 (as indicated) if someone had tried and failed to control, cut down or stop drug use in the last 3 months; otherwise their score was 0. Each participant's highest score for each question across all seven drug classes were summed, yielding a total score between 0 and 21. In order to index the level of each participants' maximum problematic engagement in use of *any* illicit drug, rather than a cumulative total across *all* classes of drugs, for each of these 3 questions the participants was given the score relating to the substance used most problematically. So, if they indicated that use of one of the drugs had caused them problems on a daily basis (score=7) and another had lead to problems once of twice in the 3 month period (score=4), and they had not used any other drug (i.e. no problems; score=0), their overall score was 7 rather than 11 (7+4). Using this approach, an individual with highly problematic use of a single drug would score the maximum, and higher than another individual with occasional problems from the use of two or more different substances. This method is not sensitive to variations in the number of drugs used problematically, though the overall frequency of drug use across types is captured in ASSIST-Freq. It also does not capture the absolute frequency of drug use problems, accumulated across all substances, but neither is this achieved using the existing coding system and adopting a single summative approach. Thus, whilst the present approach is imperfect, it does provide a crude index of the extent to which each participant uses his/her main drug problematically.

b) Attitudinal indices

The Evaluation Instruments Bank (EIB, 2008) of the European Monitoring Centre for Drugs and Drug Addiction provided questionnaires to assess Attitudes, Riskiness, and Intentions (http://eib.emcdda.europa.eu/).

Attitudes to drug use questionnaire *('Attitudes': EIB, 2008)*

This 12-item scale lists six statements in favour of drug use and six against it (negatively scored). The items are listed in Figure 3.17. Respondents rated each statement on a five-point scale from "strongly disagree" (1) to "strongly agree" (5). Item-scores were summed and divided by 10, and final scores ('Attitudes') range from 1-6, with one indicating very negative, and 6 indicating very positive attitudes towards substance use. This scale has been used elsewhere (e.g. Harrmon, 1993), but no data on internal consistency have been reported; in the present study, the scale showed good internal consistency (Cronbach α=0.89).

Here are some statements that people have made about drug use. Tick the answer that is closest to your opinion:

	Strongly agree	Agree	Hard to say	Disagree	Strongly Disagree
Using illegal drugs can be a pleasant activity					
A young person should never try drugs					
There are few things more dangerous than experimenting with drugs					
Using drugs is fun					
Many things are much more dangerous than trying drugs					
Everyone who tries drugs eventually regrets it					
The law about illegal drugs should be made stronger					
Drug use is one of the biggest evils in the country					
Drugs help people to experience life in full					
Schools should teach about the real hazards of taking drugs					
The police should not be annoying young people who are trying drugs					
To experiment with drugs is to give away control of your life					

Figure 3.17: Attitudes to drug use questionnaire

Perceptions of riskiness associated with substance use ('Riskiness': EIB, 2008)

The full Riskiness scale is displayed in Figure 3.18 and was adapted from a simple questionnaire provided by the EIB (2008) and used in one previous study (Harrmon, 1993). Participants reported the amount of risk ('no risk'-0, 'small risk'-1, 'moderate risk'-2, or 'great risk'-3) associated with (a) occasional and (b) frequent use of 12 substances of interest here. Two scores were thus derived for each substance. An overall score for perceived riskiness of illicit drugs (Riskiness-Illicit) was obtained by summing responses across the 20 items pertaining to illicit drug use; this could range from 0-60. Separately, the two responses pertaining to alcohol use were summed, providing a score for the perceived riskiness of alcohol use (Riskiness-Alcohol), ranging from 0-6.

Listed below are some substances which many adolescents and adults have used at some point in their lives. In your opinion, how much risk is there that someone will harm themselves if they...				
	No risk	Small risk	Moderate risk	Great risk
...drink alcohol occasionally				
...drink alcohol frequently				
...smoke cigarettes occasionally*				
...smoke cigarettes frequently*				
...take cannabis occasionally				
...take cannabis frequently				
...take cocaine occasionally				
...take cocaine frequently				
...take ecstasy occasionally				
...take ecstasy frequently				
...take amphetamines (or speed) occasionally				
...take amphetamines (or speed) frequently				
...take amyl nitrate (or poppers) occasionally				
...take amyl nitrate (or poppers) frequently				
...take magic mushrooms occasionally				
...take magic mushrooms frequently				
...take LSD (or acid) occasionally				
...take LSD (or acid) frequently				
...take glues (e.g. aerosols) occasionally				
...take glues (e.g. aerosols) frequently				
...take crack occasionally				
...take crack frequently				
...take opiates (e.g. heroin) occasionally				
...take opiates (e.g. heroin) frequently				

*not included in the present analyses

Figure 3.18: Perceptions of riskiness associated with substance use

Intentions to engage in substance use ('Intentions': EIB, 2008)

The full Intentions scale again taken from the EIB (2008), is displayed in Figure 3.19. Participants were asked to indicate whether they intended to use any of 12 substances (the same as those included in the Riskiness scale) during the next year. Responses ranged from "No, I definitely do not intend to try this substance" (scored 0) to "Yes, I definitely intend to try this substance" (scored 4). Two indices were extracted, one relating to the intention to use alcohol (Alcohol-Intentions) based on the corresponding single item and thus with a possible score range of 0-4; the other pertaining to illicit substances (Illicit-Intentions) and was the total of scores across the 10 substances of this type (score range 0-40).

Listed below are a variety of substances which many adolescents and adults have used at some point in their lives. **Please indicate whether you intend to use or experiment with any of the following substances during the next year.** Please select one of the five options.					
	No, I definitely do not intend to try this substance	It is unlikely that I will try this substance	I am undecided, or have no specific intentions	It is possible that I will try this substance	Yes, I definitely intend to try this substance
Alcohol					
Cigarettes *					
Cannabis					
Cocaine					
Ecstasy					
Amphetamines (or speed)					
Amyl Nitrate (or poppers)					
Magic Mushrooms					
LSD (or acid)					
Glues (e.g. aerosols)					
Crack					
Opiates (e.g. heroin, etc)					

*not included in the present analyses

Figure 3.19: Intentions to engage in substance use (Intentions)

Religious Restrictions

Participants were asked to identify their religious affiliation from six options: 'Protestant', 'Catholic', 'Jewish', 'Islamic', 'none' or 'other'; participants who selected 'other' were asked to specify their religion. Separately, participants were asked, "Does your religion limit/prohibit the use of alcohol or drugs?" All who responded in the affirmative were requested to describe the limitation/prohibition. Respondents were then categorised as follows: 'No limitation' (including students who reported no religion), 'No alcohol', 'No alcohol or drugs', 'No drugs', and 'Discretion in use'. This categorical variable is designated 'Religious Restrictions'.

c) Life stress

The Revised Life Changes Questionnaire (RLCQ; Miller & Rahe, 1997)

This extensively researched scale lists 74 life events, each of which has an estimated relative magnitude of stress or 'life change'. For example, the death of a child carries the maximum 123 life change units (LCU); experiencing an injury or illness that resulted in hospitalisation 74 LCUs; and moving house to a different city 47 LCUs. Each participant identified which if any of the events had occurred during the past 12 months, and the corresponding LCUs were summed to give a total score (henceforth referred to as 'Life Stress').

d) Trait and laboratory indices of approach, avoidance, and control

Factor analysis was used (in chapter 2) to extract self-report measures corresponding to the approach, avoidance, and control systems, which are here referred to here as Trait-Approach, Trait-Avoidance, and Trait-Control, and ten indices were obtained from four laboratory tasks; these measures are described in detail on pages 60-69.

In chapter two, it was hypothesised that the Iowa Gambling Task (IGT) and Delay Discounting task (DDT) included elements of both reward and punishment, and thus tapped more than one of the three systems. However, intercorrelations did not support this hypothesis and, in the present study, IGT and DDT measures are proposed as indices of the control system.

Go-No Go (GNG) Task – page 64

Self-reported expectancies and behavioural responses are used to index speed of learning; the participant first learns to discriminate between reward and punishment cues in an initial learning phase, and must then inhibit previously learned associations and learn new punishment cues in a subsequent reversal phase. 'GNG Reward expectancy' and 'GNG Reward responses' reflect the speed of learning in response to reward cues; 'GNG Punishment expectancy' and 'GNG Punishment responses' reflect the speed of learning in response to punishment cues; lastly, 'GNG Reversal expectancy' and 'GNG Reversal responses' reflect the speed of learning in response to punishment cues in the reversal task phase. It was previously argued (p ##) that GNG Reward expectancy and GNG Reward responses tap approach tendencies; GNG Punishment expectancy and GNG Punishment responses tap underlying avoidance tendencies; and GNG Reversal expectancy and GNG Reversal responses tap the efficiency of the control system.

Oculomotor antisaccade task (AST) – page 66

In the antisaccade phase of the AST, where the respondent has to inhibit reflexive eye movements towards a visual stimulus and instead look away from it, the proportion of correct eye-movements ('AST-Accuracy') and amount by which reaction times are slowed in the antisaccade, compared to the prosaccade phase ('AST-Interference') are argued to reflect inhibitory control.

Iowa Gambling Task (IGT) – page 68

A bias towards less risky decision-making is measured by the number of selections made from advantageous vs. disadvantageous decks of cards ('IGT Net Score'). This is proposed to index control, since the individual has to inhibit the temptation to seek high individual rewards.

Delay Discounting Task (DDT) – page 67

The extent to which reward loses its perceived value as the delay to its delivery increases (DDT-Discounting Rate) reflects a preference for immediate rather than delayed reward, and is widely viewed as an index of inhibitory control since it taps the ability/willingness to delay gratification in order to optimise overall gain.

e) Demographics

All participants provided details regarding their age, gender, and ethnicity. Parental occupation was used to index socio-economic status (SES) and participants were classified using the International Standard Classification of Occupations (ISCO: Economic and Social Statistical Classifications, 1988). This grouped occupations into nine major groups, as listed in Table 3.2. The highest classification (for mother or father) was recorded.

f) Anxiety

London participants additionally completed the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). This is a widely used 14-item questionnaire on which respondents rate the frequency of severity of symptoms (e.g. "worrying thoughts go through my mind"). Only anxiety scores ('Anxiety') are reported here; these can range from 0-21, with higher scores indicating greater anxiety. Scores from 0-10 are within the normal range; 11 or higher is suggestive of clinically significant mood disturbance.

Procedure

The full testing procedure is described in Chapter 2.

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Results

Data screening

Prior to analysis, all variables were screened for missing data and assumptions of univariate and multivariate normality. The approach to missing and excluded data for trait and laboratory indices of the approach, avoidance, and control systems was described in Chapter 2 (p.70-71). Here, only participants aged 17 to 25 were included. After data screening, there were 410 cases with data for Trait-Approach, Trait-Avoidance, and Trait-Control. Of these, 315 had GNG data, 124 AST data, 160 DDT data, and 274 IGT data; consequently, sample sizes vary between analyses.

Of the 165 London cases, two participants were missing more than 5% of items on Riskiness, one participant did not provide Religious-Restrictions, another did not provide his/her parental occupation, two did not complete the HADS, and, due to experimenter error, 24 did not complete the Revised Life Changes Questionnaire (RLCQ). All of these cases were excluded only from those analyses involving the missing measures.

Forty-eight Brisbane participants did not report their ethnicity. One Brisbane case was a multivariate outlier and another did not provide any data on substance use; these two cases were excluded, leaving 243 Brisbane participants and 408 cases in total.

Descriptive Statistics

Participants

Of the 408 cases, 165 London cases comprised 40 male (24.2%) and 125 female (75.8%) students, aged 18 to 22 (mean 19.0 years; s.d. 1.0), and 243 Brisbane cases comprised 68 males (28.0%) and 175 (72.0%) females, aged 17 to 25 (mean 19.5 years, s.d. 2.0). The combined sample comprised 108 males (26.5%) and 300 females (73.5%), aged between 17 and 25 (mean 19.30 years, s.d. 1.7).

Table 3.6 provides descriptive statistics for ethnicity in both samples.

Table 3.6: Descriptive statistics for ethnicity for Brisbane, London, and total samples

	Brisbane		London		Total	
Ethnicity						
White (UK or Australian)	154	63.4%	76	46.1%	230	56.4%
White Other	0	-	24	14.5%	24	5.9%
Black Afro-Caribbean	2	1.0%	16	10.0%	18	4.4%
Asian	28	11.5%	31	18.8%	59	14.5%
Mixed or other	11	4.5%	18	10.9%	29	7.1%
Missing	*48*	*20.0%*	*0*	-	*48*	*11.8%*
Total	*243*		*165*		*408*	

Table 3.7 shows descriptive statistics for socio-economic status in the London sample.

Table 3.7: Frequency data for socio-economic status (London sample; n=164)

Highest parental ISCO score*		
Managers	36	22.0%
Professionals	68	41.5%
Technicians and associate professionals	19	11.6%
Clerical support workers	12	7.3%
Service and sales workers	14	8.5%
Skilled agricultural forestry & fishery workers	-	-
Craft and related trades workers	5	3.0%
Plant/machine operators & assemblers	-	-
Elementary occupations	2	1.2%
No occupation	8	4.9%

*1 missing case

Predictor variables

Table 3.8 presents descriptive statistics for religious affiliation and Religious Restrictions. Due to some low frequencies in some response categories for Religious Restrictions, responses were collapsed into either 'restricted use' (n=39), which included any form of restriction on substance use, or 'unrestricted use' (n=125).

Table 3.8: Descriptive statistics for Religious Restrictions (London sample; n=164)

Religious affiliation		
None	84	50.1%
Protestant	17	10.4%
Catholic	22	13.4%
Hindu	2	1.2%
Islamic	13	7.9%
Jews	4	2.4%
Other Christian	11	6.7%
Other	11	6.7%
Restrictions (Religious Restrictions)		
No restrictions	125	76.2%
Restrictions	39	23.8%
Alcohol and drugs prohibited	*13*	*7.9%*
Alcohol prohibited	*9*	*5.5%*
Drugs prohibited	*12*	*7.3%*
Discretional use	*5*	*3.1%*

Table 3.9 presents descriptive and reliability statistics for Attitudes, Riskiness, Intentions, Life Stress, and Anxiety in the London sample. Transformations could not improve skews in Riskiness and Intentions data and non-parametric analyses are therefore used for these variables. The others were normally distributed.

Table 3.9: Descriptive statistics for Anxiety, Attitudes, Riskiness, Intentions, and Life Stress.

	Cronbach's α	Range	*n**	mean	s.d.
Attitudes	0.89	1.25 - 4.50	165	2.72	0.79
Riskiness-alcohol	-	0-5	165	2.39	1.33
Riskiness-illicit	0.93	11-60	163	48.09	9.47
Alcohol-intentions	-	0-4	165	3.35	1.26
Illicit-intentions	0.90	0-36	165	6.40	8.49
Life Stress	-	0 - 1171	141	459.74	216.97
Anxiety	0.80	0 - 16	163	6.90	3.68

*2 missing on Anxiety; 2 missing on Riskiness-illicit; 24 missing on Life Stress

Table 3.10 shows descriptive statistics for indices of impulse control for both samples.

Table 3.10: Descriptive statistics for indices of approach, avoidance, and control.

	Range	*n*	mean	s.d.
Indices of the approach system				
Trait-Approach	-2.4 – 2.5	408	0.03	0.84
GNG Reward expectancy	0.0 – 0.7	315	0.12	0.16
GNG Reward responses	0.0 – 0.7	315	0.09	0.13
Indices of the avoidance system				
Trait-Avoidance	-2.0 – 2.4	408	0.02	0.93
GNG Punishment expectancy	-0.7 – 0.0	315	-0.12	0.15
GNG Punishment responses	-1.0 – 0.0	315	-0.20	0.22
Indices of the control system				
Trait-Control	-2.3 – 2.3	408	0.00	1.00
GNG Reversal expectancy	-0.6 – 0.0	315	-0.08	0.11
GNG Reversal responses	-0.7 – 0.0	315	-0.12	0.16
IGT Net Score	-68.0 – 82.0	274	11.98	28.93
AST Accuracy	0.0 – 102.5	125	47.35	19.75
AST Interference	-0.1 – 0.25	125	0.10	0.06
DDT Discounting Rate	-2.7 – 0.7	160	-1.30	0.68

GNG=Go-No Go; IGT=Iowa Gambling Task; AST=Antisaccade Task; DDT=Delay discounting Task

Outcome measures: alcohol use

Alcohol use status

Of the 408 participants, 40 scored zero on the AUDIT-Total, indicating abstinence. Because teetotallers are an unusual group, and are likely to differ in important ways from people who do not exclude the possibility of drinking, predictors of AUDIT-Total and AUDIT-Binge scores are analysed only within the 368 current alcohol users.

AUDIT-Total

AUDIT-Total scores among current users ranged from 1, indicating infrequent use, to 34, indicating possible alcohol dependence. The mean AUDIT-Total score was 8.8 (s.d.=6.15; median=8). A log transformation improved a strong positive skew in these data.

AUDIT-Binge

Figure 3.20 shows the number of current alcohol users who reported binge drinking 'never', 'less than monthly', 'monthly', 'weekly', and 'daily'.

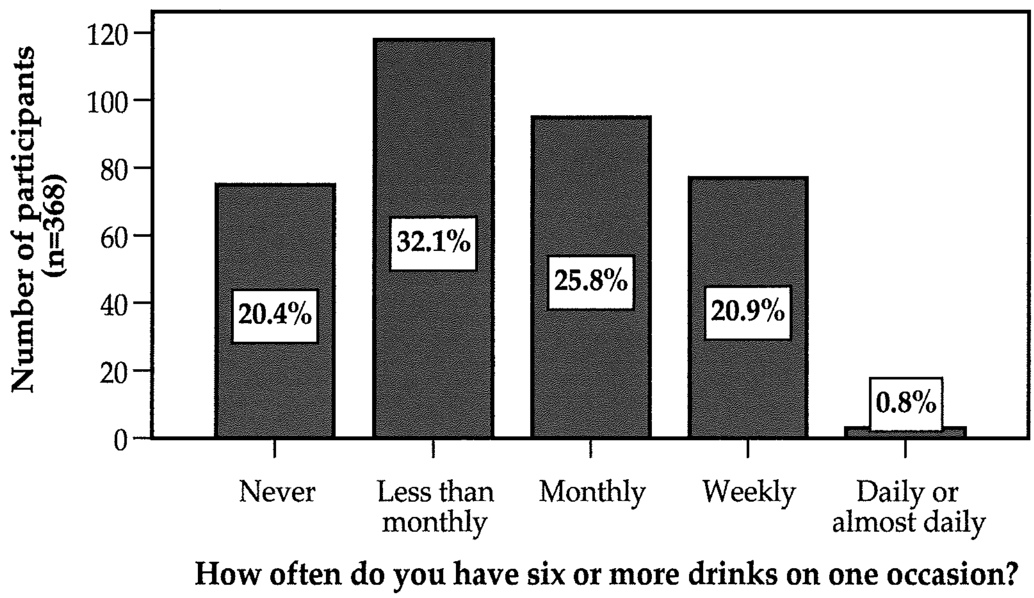

Figure 3.20: Frequency with which participants drank six or more drinks on one occasion

As very few respondents reported daily binges, they have been combined with weekly bingers in all analyses. The median AUDIT-Binge response was 'less than monthly'. AUDIT-Binge responses will be analysed as categorical data.

Outcome measures: illicit drug use

Table 3.11 details the number of students reporting illicit substance use ever and at various frequencies during the previous three months.

Table 3.11: Number of students in the total sample (n=408) reporting illicit substance use at any time in their past, at any time during the last three months; and the number of students reporting weekly or daily substance use during the last three months

	Any Use				Weekly use		Daily use	
	Ever		Last 3 months		Last 3 months		Last 3 months	
Cannabis	204	50.0%	112	27.4%	25	6.1%	11	2.7%
Amphetamines *(e.g. ecstasy, speed)*	10	24.8%	60	14.7%	4	1.0%	3	0.7%
Hallucinogens *(e.g. LSD, Ketamine)*	58	14.2%	21	5.1%	1	0.2%	-	-
Cocaine *(e.g. coke or crack)*	56	13.7%	28	6.9%	1	0.2%	-	-
Inhalants *(e.g. nitrous oxide)*	54	13.2%	17	4.2%	1	0.2%	-	-
Sedatives *(e.g. benzodiazepines)*	52	12.7%	28	6.9%	4	1.0%	4	1.0%
Opioids *(e.g. heroine, morphine)*	15	3.7%	5	1.2%	-		-	-
Any one or more of these substances	227	55.6%	147	36.0%	33	8.1%	16	3.9%

Illicit drug use status

In total, 261 participants scored zero on ASSIST-Freq, indicating abstinence over the last three months; ASSIST-Count scores indicate that 181 of these had never used any illicit drugs (never users), while 80 previously used one or more illicit drugs (former users). For the same reasons as for alcohol, predictors of ASSIST-Count, ASSIST-Freq and ASSIST-Prob scores are analysed only within the 147 current drug users.

ASSIST-Freq

ASSIST-Freq scores among current drug users ranged from one to 116, (mean=3.00, s.d.=18.0; median=3). Transformations failed to improve a strong positive skew in these data. ASSIST-Freq scores were therefore dichotomised; one group included participants who scored five or less (*n*=92; 62.3%); the other comprised those who scored at least six (*n*=55; 37.4%) indicating that they had used drugs on six or more occasions over that period, which equates to an average of at least fortnightly use.

ASSIST-Count

Figure 3.21 presents the number and percentage of current drug users who reported ever having tried various numbers of illicit substances (1-7).

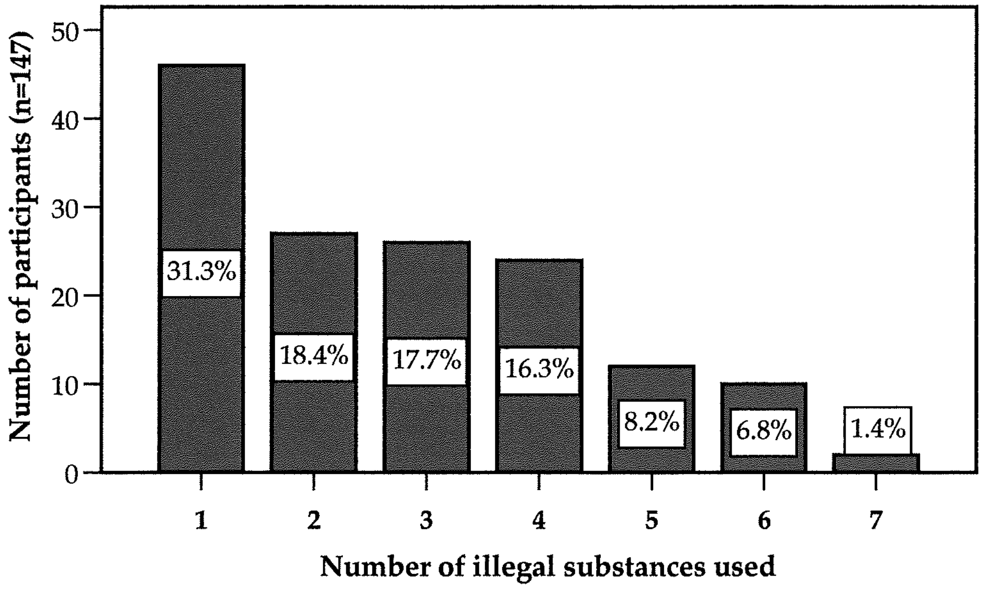

Figure 3.21: Frequency data for the number of drug classes reportedly ever used (max. 7) (n=147)

Transformations could not improve the positive skew in ASSIST-Count data. Consequently, participants were divided into two even-sized groups: participants who had used only one or two illicit drugs in their life (*n*=73; 49.7%) and participants who had used three or more illicit drugs (*n*=74; 50.3%).

ASSIST-Prob

Table 3.12 details the number of current drug users reporting that substance use had led to three types of problems: health, social, legal, financial problems; failure to perform expected tasks; and failed attempts to control or cut down use in the preceding three months.

Table 3.12: Number of current drug users (n=147) who reported that substance use led to health, social, legal, or financial problems, failure to perform expected tasks, or failure to control /cut down use during the past 3 months.

	Health, social, legal, financial problems		Failure to perform expected tasks		Failure to control, cut down or quit use	
	n	%	*n*	%	*n*	%
Cannabis	15	3.7%	27	6.6%	11	2.7%
Amphetamines	12	2.9%	20	4.9%	7	1.7%
Cocaine	7	1.7%	6	1.5%	3	0.7%
Sedatives	5	1.2%	6	1.5%	3	0.7%
Hallucinogens	3	0.7%	4	1.0%	1	0.2%
Inhalants	1	0.2%	2	0.5%	1	0.2%
Opioids	4	1.0%	0	-	0	-
Any one or more of these substances	27	6.6%	46	11.3%	20	4.9%

Among current drug users, ASSIST-Prob scores ranged from zero to 21, (mean=3.26, s.d.=5.15). The sample of participants reporting any problems (*n*=56; 38.1%) was not considered large enough to explore predictors of the level of problematic drug use. Instead, participants were dichotomised into two groups: drug users who report some problems (i.e. scores ≥1; *n*=56), and drug users who scored zero (*n*=91; 61.9%).

London and Brisbane site differences

There were no differences between sites in the number of students using cannabis [$\chi^2(1)=2.29$, *ns*], or amphetamines [$\chi^2(1)=0.81$, *ns*], but London students were more likely to have tried cocaine [20.0% vs. 9.5%; $\chi^2(1)=9.21$, $p<0.01$], inhalants [26.9% vs. 7.8%; $\chi^2(1)=15.35$, $p<0.001$], and hallucinogens [26.9% vs. 9.5%; $\chi^2(1)=11.12$, $p<0.01$], whereas Brisbane students were more likely to have used sedatives [16.5% vs. 7.3%; $\chi^2(1)=7.46$, $p<0.01$], and opiates [5.7% vs. 1.2%; $\chi^2(1)=4.75$, $p<0.05$].

As shown in Table 3.13, Brisbane students were significantly more likely to be current alcohol users, had significantly high AUDIT-Total scores, and showed a pronounced trend towards reporting more binge drinking; there were no significant differences between sites on illicit substance use/abuse measures, thought there was a trend for London students to use more illicit drugs.

Table 3.13: Tests for site differences on substance use measures.

	n	London vs. Brisbane
Alcohol use		
Alcohol use status *(368 users, 40 non-users)*	408	$\chi^2(1)=8.96$, $\mathbf{p=0.003}$*
AUDIT-Total	368	$t(366)=-3.82$, $\mathbf{p=0.000}$*
AUDIT-Binge *(75 never, 118 less than monthly, 95 monthly, 80 weekly or more)*	368	$\chi^2(3)=11.65$, $\mathbf{p=0.009}$
Illicit drug use		
Drug use status *(80 former, 181 never, 147 current users)*	408	$\chi^2(2)=0.30$, $p=0.860$
ASSIST-Count *(1 or 2 drugs [n=73], 3 or more [n=74])*	147	$\chi^2(1)=0.87$, $p=0.352$
ASSIST-Freq *(< 6 [n=92], 6 or more [n=55])*	147	$\chi^2(1)=4.01$, $\mathbf{p=0.045}$
ASSIST-Prob *(56 problem users, 91 non-problem users)*	147	$\chi^2(1)=0.05$, $p=0.831$

*Correlation is significant at $p<0.007$[†]

Table 3.14 summarises all planned analyses in the order in which they will be reported.

[†] Bonferroni-correction: $p<0.05$ divided by 7 analyses gives $p<0.007$ (two-tailed)

Table 3.14: Planned analyses for hypotheses outlined for each substance use variable

		Alcohol use Dependent Variables			Illicit Drug use Dependent Variables			
		Alcohol Use Status	***AUDIT-Total***	***AUDIT-Binge***	***Illicit Drug Use Status***	***ASSIST-Count***	***ASSIST-Freq***	***ASSIST-Prob***
General Hypothesis:	***Predictor Variables***	*Alcohol users vs. Non-users*		*Never, Less than monthly, Monthly, Weekly or more*	*Never vs. Former vs. Current users*	*1/2 vs. 3 or more drugs*	*5 or less vs. 6 or more*	*Problem users vs. Non-problem users*
I. Positive associations between substance use and Attitudes	*Attitudes*	T-Test	Correlations	ANOVA	ANOVA	T-Test	T-Test	T-Test
II. Negative associations between substance use and Riskiness	*Riskiness-Alcohol/Illicit*	Mann-Whitney *U*	Correlations	Kruskal-Wallis	Kruskal-Wallis	Mann-Whitney *U*	Mann-Whitney *U*	Mann-Whitney *U*
III. Positive associations between substance use and Intentions	*Alcohol/ Illicit-Intentions*	Mann-Whitney *U*	Correlations	Kruskal-Wallis	Kruskal-Wallis	Mann-Whitney *U*	Mann-Whitney *U*	Mann-Whitney *U*
IV. Lower scores for participants reporting religious affiliations	*Religious Restrictions*	χ^2 test	T-Test	χ^2 test	χ^2 test	χ^2 test	χ^2 test	χ^2 test
V. Positive associations between substance use and Life Stress	*Life Stress*	T-Test	Correlations	ANOVA	ANOVA	T-Test	T-Test	T-Test
VI. Positive associations between approach indices and all substance use/abuse measures	*Trait-Approach* *GNG Reward expectancies* *GNG Reward responses*	T-Test & Mann-Whitney *U*	Correlations	ANOVA & Kruskal-Wallis	ANOVA & Kruskal-Wallis	T-Test & Mann-Whitney *U*	T-Test & Mann-Whitney *U*	T-Test & Mann-Whitney *U*
VII. Negative associations for avoidance indices with AUDIT-Total, ASSIST-Freq & ASSIST-Count and positive associations with AUDIT-Binge & ASSIST-Prob	*Trait-Avoidance* *GNG Punish. responses* *GNG Punish. expectancies*	T-Test & Mann-Whitney *U*	Correlations	ANOVA & Kruskal-Wallis	ANOVA & Kruskal-Wallis	T-Test & Mann-Whitney *U*	T-Test & Mann-Whitney *U*	T-Test & Mann-Whitney *U*
VIII. Negative associations between control indices and all substance use/abuse measures	*Trait-Control* *GNG Reversal expectancies* *GNG Reversal responses* *IGT Net score* *DDT Discounting Rate,* *AST-Accuracy,* *AST-Interference*	T-Test & Mann-Whitney *U*	Correlations	ANOVA & Kruskal-Wallis	ANOVA & Kruskal-Wallis	T-Test & Mann-Whitney *U*	T-Test & Mann-Whitney *U*	T-Test & Mann-Whitney *U*

GNG=Go-No Go; DDT=Delay Discounting Task; AST=Antisaccade Task; IGT=Iowa Gambling Task; ANOVA=Analysis of variance

Level 1: Attitudinal risk factors

Hypothesis I: Substance use and abuse measures will be positively associated with more favourable attitudes towards substance use (Attitudes)

Table 3.15 shows analyses of associations between Attitudes (n=165) and substance use/abuse measures in the London sample.

Table 3.15: Tests of associations between Attitudes and substance use

	n	Attitudes	
Alcohol use			
Alcohol use status *(140 users, 25 non-users)*	165	t(163)=-2.89,	***p=0.004****
AUDIT-Total	140	*r*=0.47,	***p=0.000****
AUDIT-Binge *(41 never, 43 less than monthly, 30 monthly, 26 weekly or more)*	140	F(3,136)=14.98,	***p=0.000****
Illicit drug use status			
Drug use status *(32 former, 71 never, 62 current users)*	165	F(2,162)=94.72,	***p=0.000****
ASSIST-Count *(28 one/two drugs, 34 three or more drugs)*	62	t(60)=-5.61,	***p=0.000****
ASSIST-Freq *(33 less than six, 29 six or more)*	62	t(60)=-4.45,	***p=0.000****
ASSIST-Prob *(23 problem users, 39 non-problem users)*	62	t(60)=-2.01,	***p=0.049***

*Test is significant at p<0.014[†]

After Bonferroni corrections, all tests involving alcohol measures were significant. As predicted, alcohol users had significantly more positive attitudes towards substance use than non-users and AUDIT-Total scores were significantly positively correlated with Attitudes. There was a significant association between AUDIT-Binge responses and Attitudes, which trend analyses revealed to be a significant linear relationship [F(1,136)=42.01, p<0.001]. As shown in Figure 3.22, attitudes became increasingly more favourable as frequency of binge drinking increased.

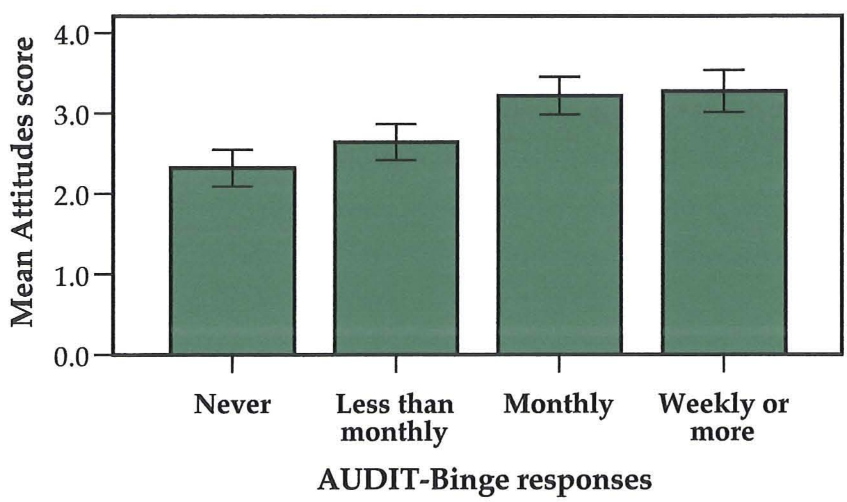

Figure 3.22: Attitudes scores by AUDIT-Binge responses (n=140)(error bars=95% CIs)

[†] Bonferroni-correction: p<0.10 divided by 7 analyses gives p<0.014 (one-tailed)

The significant association between Attitudes and illicit drug use status also demonstrated a strong significant linear trend [$F(1,162)=188.98$, $p<0.001$]. As shown in Figure 3.23, current users had more positive attitudes towards substance use than former users, who in turn had more positive attitudes than never users.

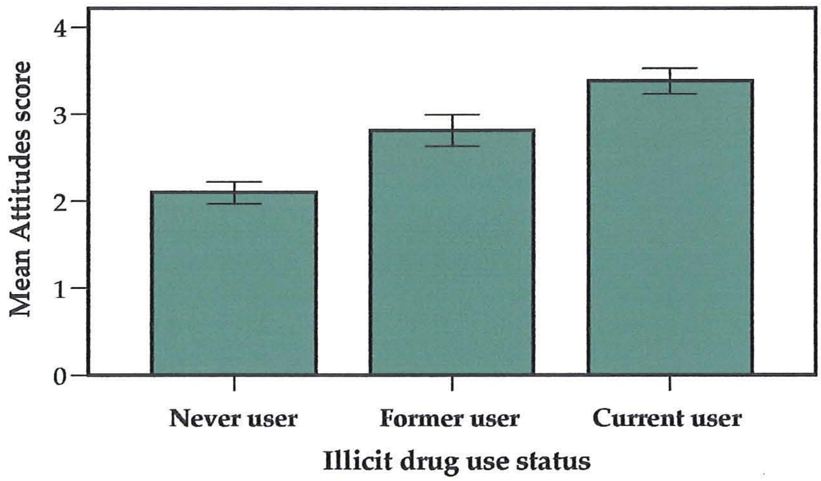

Figure 3.23: Attitudes scores by illicit drug use status (n=165)(error bars=95% CIs)

As shown in Table 3.15, attitudes towards substance use were significantly more positive among participants who used several drugs, rather than only one or two, and among more frequent drug users. There was a trend for users with drug-related problems to have more positive attitudes than non-problem drug users; however, this difference fell short of significance following Bonferroni corrections.

Hypothesis II: Higher scores on alcohol use/abuse measures will be associated with lower perceived risks for alcohol use (Riskiness-Alcohol); and higher scores on illicit substance use/abuse measures will be associated with lower perceived risks for substance use (Riskiness-illicit).

Table 3.16 shows analyses of associations between alcohol use measures and Riskiness-Alcohol, and between illicit drug use measures and Riskiness-Illicit. As hypothesised, alcohol users perceived alcohol use to be significantly less risky than non-users.

Within alcohol users, there was no significant correlation of perceived riskiness with AUDIT-Total scores, though there was a pronounced trend towards an association with AUDIT-Binge responses; Figure 3.24 presents these data. Post-hoc tests revealed significantly lower Riskiness-Alcohol scores for 'weekly or more' bingers than 'never

Table 3.16: Tests of associations between Riskiness and substance use

Alcohol use	n	Riskiness-Alcohol
Alcohol use status *(140 users, 25 non-users)*	165	U=975.0, ***p=0.000****
AUDIT-Total	140	*Rho*=-0.14, *p=0.104*
AUDIT-Binge *(41 never, 43 less than monthly, 30 monthly, 26 weekly or more)*	140	χ^2(3)=10.42, ***p=0.015***
Illicit drug use status	n	**Riskiness-Illicit**
Drug use status *(32 former, 70 never, 61 current users)*	163	χ^2(2)=42.94, ***p=0.000****
ASSIST-Count *(28 one/two drugs, 33 three or more)*	61	U=101.0, ***p=0.000****
ASSIST-Freq *(33 less than six, 28 six or more)*	61	U=167.5, ***p=0.000****
ASSIST-Prob *(23 problem users, 38 non-problem users)*	61	U=315.0 *p=0.070*

*Test is significant at p<0.014[†]; Riskiness-Illicit missing 2 cases

bingers' [U=339.0, p<0.01], and significantly higher scores for 'less than monthly' bingers than 'weekly or more' bingers [U=310.0, p<0.002]. All other group comparisons were non-significant. Interestingly, these data did not follow a clear negative linear trend; mean Riskiness-Alcohol scores were relatively similar across never, monthly and less than monthly bingers, all three groups differing from 'weekly or more' bingers.

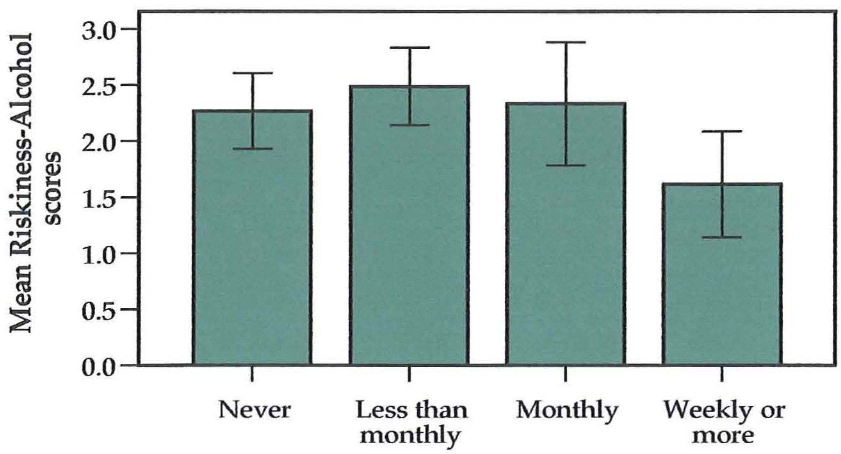

Figure 3.24: Riskiness-Alcohol scores by AUDIT-Binge responses (n=163)(error bars=95% CIs)

Consistent with hypotheses, higher drug use frequency and using more illicit drugs were both significantly associated with lower Riskiness-Illicit scores within current drug users. Illicit drug use status was also significantly associated with Riskiness-Illicit. Figure 3.25 presents mean scores for the three groups. Post-hoc tests revealed that current users scored significantly lower than former users [U=610.0, p<0.005], who in turn scored significantly lower than never users [U=710.5, p<0.005]. However, contrary to hypotheses, Riskiness-Illicit scores were not significantly lower in drug users reporting problems than in those reporting no problems associated with their drug use.

[†] Bonferroni-correction: p<0.10 divided by 7 analyses gives p<0.014 (one-tailed)

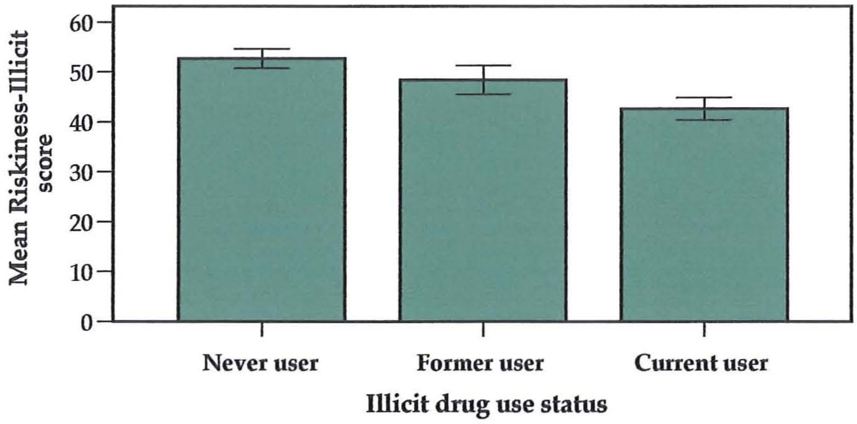

Figure 3.25: Riskiness-Illicit scores by illicit drug use status (n=163)(error bars=95% CIs)

Hypothesis III: Alcohol use/abuse will be positively associated with higher future intended alcohol use (Alcohol-intentions), and illicit substance use/abuse will be positively associated with higher future intended use (Illicit-intentions).

Table 3.17 shows analyses of associations between alcohol use measures and Alcohol-Intentions, and between illicit drug use measures and Illicit-Intentions.

Table 3.17: Tests of associations between Intentions and substance use

Alcohol use	*n*	Alcohol-Intentions	
Alcohol use status *(140 users, 25 non-users)*	165	U=245.5,	***p=0.000****
AUDIT-Total	140	*Rho*=-0.37,	***p=0.000****
AUDIT-Binge *(41 never, 43 less than monthly, 30 monthly, 26 weekly or more)*	140	χ^2(3)=20.81,	***p=0.000****
Illicit drug use status	*n*	Illicit-Intentions	
Drug use status *(32 former, 71 never, 62 current users)*	165	χ^2(2)=92.94,	***p=0.000****
ASSIST-Count *(28 one/two drugs,34 three or more)*	62	U=180.0,	***p=0.000****
ASSIST-Freq *(33 less than six,29 six or more)*	62	U=282.5,	***p=0.006****
ASSIST-Prob *(23 problem users, 39 non-problem users)*	62	U=357.5	*p=0.184*

*Test is significant at $p<0.014$[†]

As predicted, stronger intentions to use alcohol were significantly associated with current alcohol use, and were significantly positively correlated with AUDIT-Total scores. Bonferroni-corrected post hoc tests exploring the significant association between Alcohol-Intentions and AUDIT-Binge responses revealed that 'weekly or more' binge drinkers had the strongest intentions to drink; they reported significantly stronger intentions to drink than did never bingers [U=338.0, p<0.002], who showed the weakest intentions to drink. Drinking intentions increased in strength between increasing frequencies of binge drinking, although these differences were not statistically significant.

[†] Bonferroni-correction: p<0.10 divided by 7 analyses gives p<0.014 (one-tailed)

As hypothesised, intentions to use drugs were significantly higher in more frequent drug users and in those who used more classes of drug. However, intentions to use drugs did not significantly differ between drug users who did or did not report problem use. Drug use status was significantly associated with intentions to use drugs. Figure 3.26 presents these data. Post-hoc tests showed that current users had significantly stronger intentions than former users [U=440.5, $p<0.001$], and never users had significantly lower intentions that current [U=208.0, $p<0.001$] or former users [U=517.0, $p<0.001$].

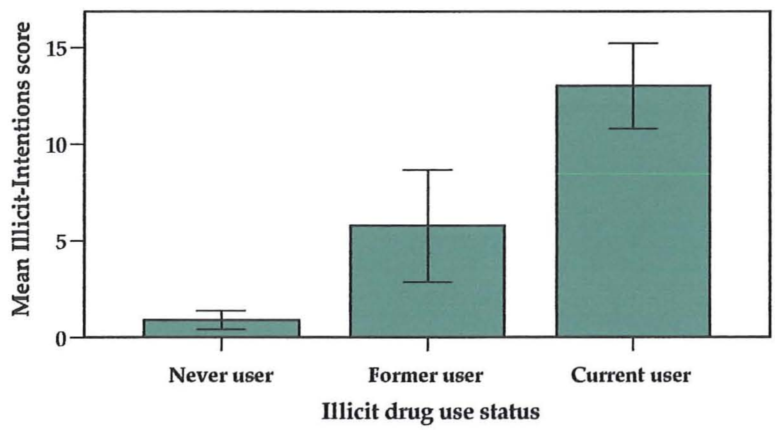

Figure 3.26: Intentions-Illicit scores by illicit drug use status (n=165)(error bars=95% CIs)

Hypothesis IV: Students reporting religious affiliations that prohibit substance use (Religious Restrictions) will, on average, score lower on all substance use/abuse measures than students who do not.

Participants in the London sample were categorised as either 'religion-restricted' (n=39) or 'no religion-restriction' (n=125). Twenty-four participants with religious restrictions reported current alcohol use, but only three reported current drug use; thus, Table 3.18 presents the results of tests examining differences between these groups across alcohol use measures and current drug use status, but associations between religious restrictions and other illicit drug use indices could not be analysed.

Table 3.18: Tests of associations between Religious Restrictions (yes/no) and substance use

	n	Religious Restrictions	
Alcohol use			
Alcohol use status *(140 users, 25 non-users)*	165	$\chi^2(1)$=23.25,	***p=0.000****
AUDIT-Total	140	t(138)=1.71,	*p=0.089*
AUDIT-Binge *(41 never, 43 less than monthly, 30 monthly, 26 weekly or more)*	140	$\chi^2(3)$=4.66,	*p=0.199*
Illicit drug use status			
Drug use status *(32 former, 71 never, 62 current users)*	165	$\chi^2(2)$=21.06,	***p=0.000****

*Test is significant at $p<0.014$[†]

[†] Bonferroni-correction: $p<0.10$ divided by 7 analyses gives $p<0.014$ (one-tailed)

As predicted, participants with religious restrictions were significantly less likely to be alcohol users; indeed, those without restrictions were eight times more likely to be alcohol users. However, while religious restrictions were associated with whether individuals were current drinkers, contrary to hypotheses they were not significantly associated with alcohol consumption or frequency of binge drinking among current alcohol users.

There was a significant association between drug use status and religious restrictions. Participants reporting religious restrictions were more than 12 times less likely to be current drug users than never users [χ^2 (1)=21.30, $p<0.001$] and nearly eight times less likely to be current users than former users [χ^2 (1)=10.28, $p<0.005$], but interestingly were not significantly less likely to be never users than former users [χ^2 (1)=1.05, *ns*]. Thus, religious restrictions were associated with a reduced likelihood of being a current drug user, but not of having ever used drugs.

Level 2: Life stress

Hypothesis V: All substance use and abuse measures will be positively associated with greater reported Life Stress during the previous 12 months.

Table 3.19 summarises the results of analyses conducted to test associations between Life Stress and substance use/abuse in the London sample (n=141; 24 missing cases). Life Stress did not significantly differ between current alcohol users and non-users. Within the drinkers, there was only a slight trend towards an association with AUDIT-Binge responses, but a small positive correlation with AUDIT-Total scores.

Table 3.19: Tests of associations between Life Stress and substance use

	n	Life Stress	
Alcohol use			
Alcohol use status *(117 users, 24 non-users)*	141	t(139)=-0.92,	*p=0.357*
AUDIT-Total	117	*r*=0.23,	***p=0.011****
AUDIT-Binge *(38 never, 36 less than monthly, 21 monthly, 22 weekly or more)*	117	F(3,113)=2.62,	*p=0.055*
Illicit drug use status			
Drug use status *(27 former, 66 never, 48 current users)*	141	F(2,138)=6.69,	***p=0.002****
ASSIST-Count *(22 one/two drugs, 26 three or more)*	48	t(46)=-1.23,	*p=0.223*
ASSIST-Freq *(27 less than six, 21 six or more)*	48	t(46)=-1.37,	*p=0.178*
ASSIST-Prob *(17 problem users, 31 non-problem users)*	48	t(46)=-0.77,	*p=0.445*

*Test is significant at *p<0.014*[†]

[†] Bonferroni-correction: $p<0.10$ divided by 7 analyses gives $p<0.014$ (one-tailed)

As hypothesised, illicit drug use was significantly associated with Life Stress; Figure 3.27 presents these data.

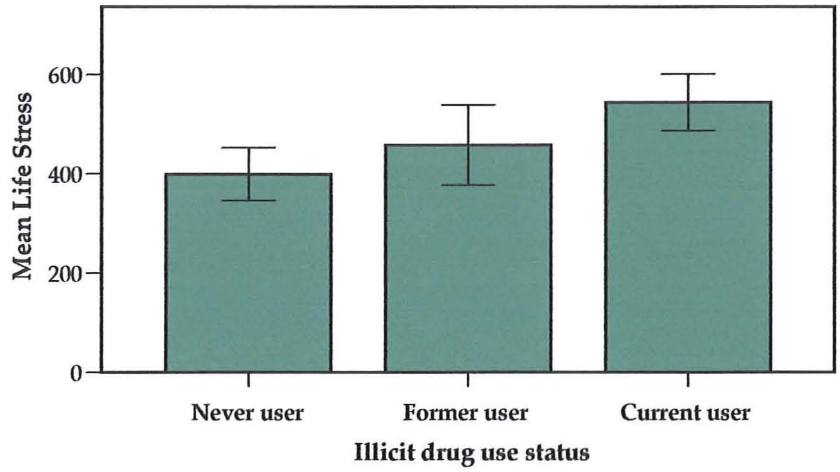

Figure 3.27: Life Stress scores by illicit drug use status (n=141)(error bars=95% CIs)

Further analyses revealed a significant linear relationship [$F(1,138)=13.28$, $p<0.001$]; as shown in Figure 3.27, current users reported higher Life Stress in the previous year than did former users, who in turn reported higher Life Stress than never users.

However, within current drug users, there were no significant associations between Life Stress and drug use frequency, number of drugs used, or problem drug use. Thus, Life Stress in this sample is associated with whether an individual is a current drug user or not, but is not associated with level of drug use by current users.

Level 3: The approach system

Hypothesis VI: Trait-Approach and laboratory task indices of the approach system will be positively associated with all substance use/abuse measures.

Table 3.20 presents the results of analyses testing associations between indices of approach and substance use/abuse. There were no significant associations between either Trait-Approach or GNG Reward Responses and any of the seven alcohol or illicit substance use measures. There was a significant association between GNG Reward Expectancies and illicit drug use status; Figure 3.28 presents mean scores for the three groups. Bonferroni-corrected post-hoc tests revealed that current drug users had significantly *lower* expectancies of reward on the Go-No Go task than either former [$U=3013.5$, $p<0.02$] or never users [$U=6356.5$, $p<0.01$]; thus, this association is in the opposite direction to that predicted.

Table 3.20: Tests of associations between indices of approach and substance use

	Trait-Approach			GNG Reward Expectancies			GNG Reward Responses		
Alcohol use	*n*			*n*			*n*		
Alcohol use status *(368 users, 40 non-users)*	408	t(406)=-1.01,	*p=0.315*	315	*U*=5248.0,	*p=0.977*	315	*U*=4951.0,	*p=0.977*
AUDIT-Total	368	*r*=0.01,	*p=0.925*	277	*Rho*=-0.11,	*p=0.066*	277	*Rho*=--0.03	*p=0.669*
AUDIT-Binge *(75 never, 118 less than monthly, 95 monthly, 80 weekly or more)*	368	F(3,364)=0.88,	*p=0.451*	277	χ^2 (3)=2.34,	*p=0.506*	277	χ^2 (3)=1.42,	*p=0.700*
Illicit drug use status									
Drug use status *(80 former, 181 never,147 current users)*	408	F(2,405)=0.13,	*p=0.879*	315	χ^2 (2)=9.75,	***p=0.008****	315	χ^2 (2)=2.72,	*p=0.257*
ASSIST-Count *(73 one/two drugs, 74 three or more)*	147	t(145)=0.95,	*p=0.343*	121	*U*=1695.0	*p=0.461*	121	*U*=1737.5	*p=0.591*
ASSIST-Freq *(92 less than six, 55 six or more)*	147	t(145)=-0.76,	*p=0.451*	121	*U*=1558.5	*p=0.496*	121	*U*=4805.0	*p=0.773*
ASSIST-Prob *(56 problem users, 91 non-problem users)*	147	t(145)=1.68,	*p=0.095*	121	*U*=1649.5	*p=0.799*	121	*U*=1556.5	*p=0.401*

*Test is significant at *p<0.014*†; GNG task missing 93 cases

† Bonferroni-correction: *p*<0.10 divided by 7 analyses gives *p*<0.014 (one-tailed)

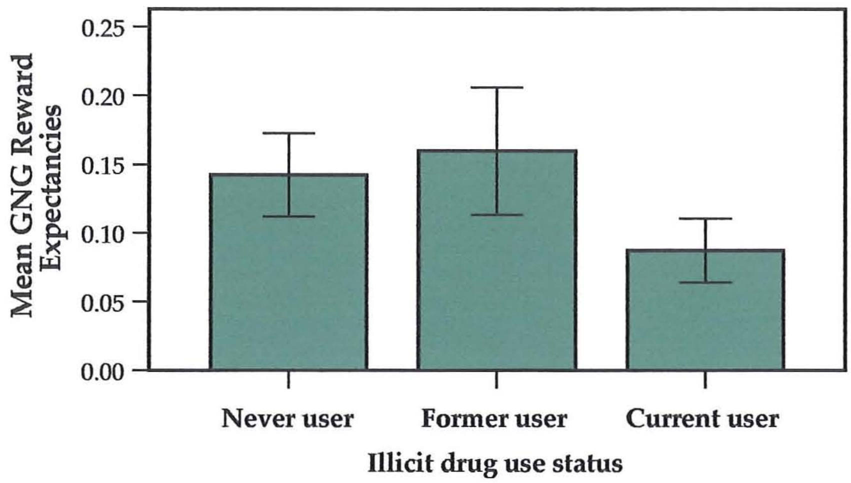

Figure 3.28: GNG Reward Expectancies by illicit drug use status (n=141)(error bars=95% CIs)

There were also very weak trends towards associations between GNG Reward Expectancies and AUDIT-Total, and between Trait-Approach and ASSIST-Prob, but in the context of so many correlations these is very likely to be spurious. Scatter plots were examined (not shown), but there was no evidence of curvilinearity in these relationships.

Level 3: The avoidance system

Hypothesis VII: Trait-Avoidance and laboratory task indices of the avoidance system will be negatively associated with alcohol/drug use status, AUDIT-Total, ASSIST-Freq and ASSIST-Count, and positively associated with AUDIT-Binge and ASSIST-Prob.

In the present sample, a negative association was hypothesised between indices of avoidance and measures of non-problematic substance use (e.g. AUDIT-Total, ASSIST-Count, ASSIST-Use); when substance use becomes problematic, the likelihood of associated elevations in anxiety appears to increase. A positive relationship was therefore predicted between problematic alcohol/drug use (AUDIT-Binge/ASSIST-Prob) and anxiety/avoidance indices. Correlations of substance use and avoidance with anxiety were also explored in the London sample.

Indices of avoidance and anxiety were expected to intercorrelate. In the London sample (n=163), Anxiety correlated moderately with Trait-Avoidance (r=0.43, p<0.001), but did not correlate with GNG Punishment Expectancy (r=-0.00, *ns*) or GNG Punishment Responses (r=0.07, *ns*); the latter findings reflect the general lack of association between self-report and laboratory task measures noted in chapter 2.

Table 3.21 presents the results of analyses of associations between indices of avoidance, anxiety, and substance use. There were no significant associations between Trait or laboratory task measures of avoidance and substance use. There was a slight trend towards a positive association between Anxiety and AUDIT-Total scores, but no associations with any index of illicit drug use.

Scatter plots were examined for evidence of curvilinear relationships with avoidance/anxiety. Plots for AUDIT-Total (which includes both non-problematic and problematic alcohol use and is therefore most likely to reveal any curvilinearity) are presented in Figure 3.29.

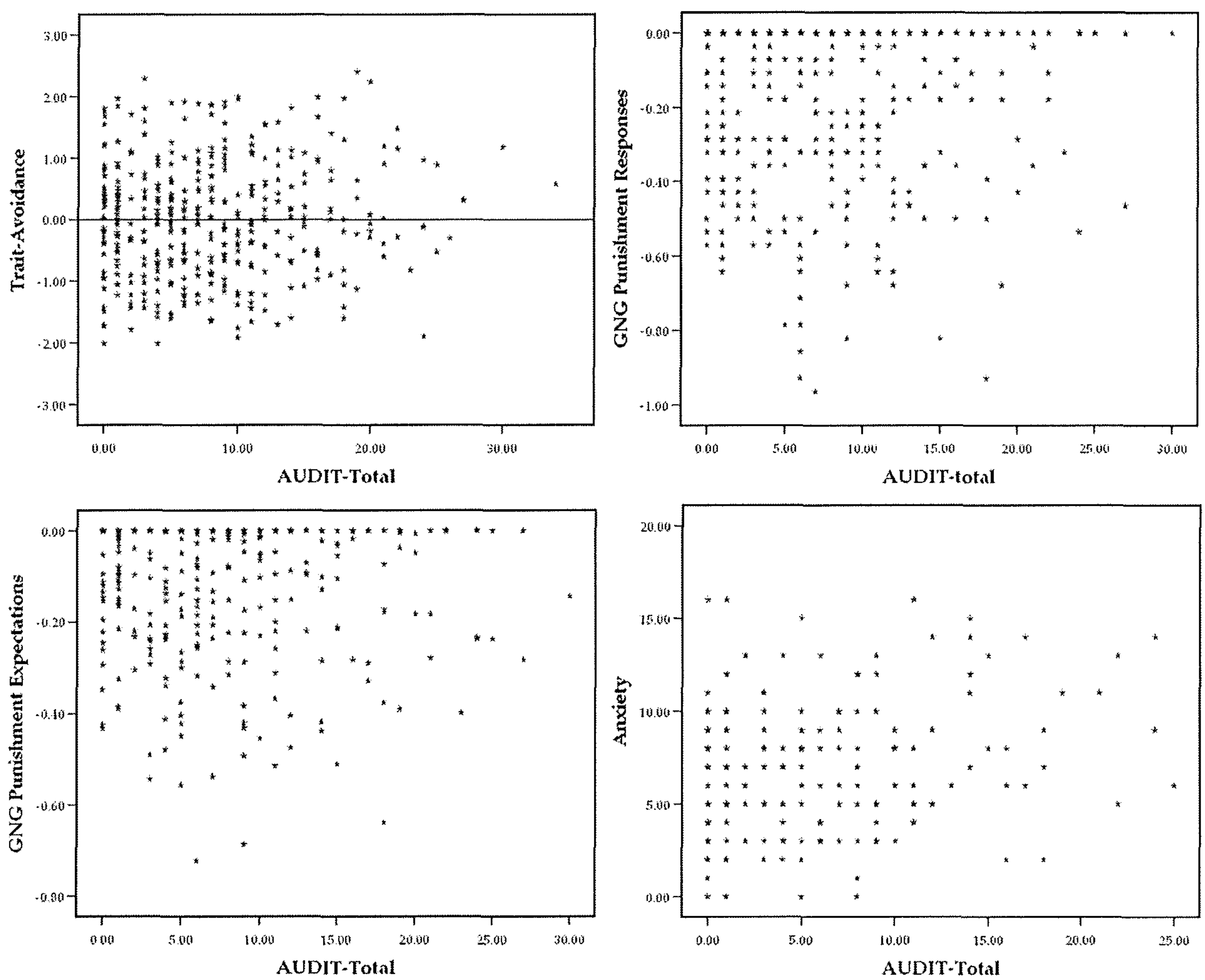

Figure 3.29: Scatter plots of AUDIT-Total scores by indices of avoidance (n=368) and Anxiety (n=163)

None of the scatter plots showed evidence of curvilinearity in the relationship between avoidance or anxiety and substance use/abuse.

Table 3.21: Tests of associations between indices of avoidance and substance use

	Anxiety		Trait-Avoidance		GNG Punishment Expectancies		GNG Punishment Responses	
	n		*n*		*n*		*n*	
Alcohol use								
Alcohol use status *(368 users, 40 non-users)*	163	*U*=1341.5, *p=0.076*	408	t(406)=0.07, *p=0.947*	315	*U*=4087.0, *p=0.022‡*	315	*U*=3990.0, *p=0.012‡*
AUDIT-Total	138	*Rho=0.16*, *p=0.057*	368	*r*=0.04, *p=0.412*	277	*Rho*=-0.04, *p=0.559*	277	*Rho=-0.03* *p=0.627*
AUDIT-Binge *(75 never, 118 less than monthly, 95 monthly, 80 weekly or more)*	138	$\chi^2(3)$=2.26, *p=0.521*	368	F(3,364)=0.66, *p=0.576*	277	$\chi^2(3)$=1.50, *p=0.682*	277	$\chi^2(3)$=0.60, *p=0.897*
Illicit drug use status								
Drug use status *(80 former, 181 never, 147 current users)*	163	$\chi^2(2)$=1.62, *p=0.436*	408	F(2,405)=0.16, *p=0.854*	315	$\chi^2(2)$=1.11, *p=0.573*	315	$\chi^2(2)$=3.52, *p=0.172*
ASSIST-Count *(73 one/two drugs, 74 three or more)*	61	*U*=453.0 *p=0.896*	147	t(145)=0.70, *p=0.487*	121	*U*=1802.0 *p=0.886*	121	*U*=1668.0 *p=0.380*
ASSIST-Freq *(92 less than six, 55 six or more)*	61	*U*=391.0 *p=0.302*	147	t(145)=0.78, *p=0.330*	121	*U*=1536.5 *p=0.433*	121	*U*=1633.0 *p=0.802*
ASSIST-Prob *(56 problem users, 91 non-problem users)*	61	*U*=420.0 *p=0.892*	147	t(145)=0.48, *p=0.630*	121	*U*=1443.0 *p=0.165*	121	*U*=1542.0 *p=0.389*

*No test is significant at *p<0.014*[†]; ‡ Result is in opposite direction to the 1-tailed hypothesis; GNG task missing 93 cases; Anxiety missing 2 cases

[†] Bonferroni-correction: *p*<0.10 divided by 7 analyses gives *p*<0.014 (one-tailed)

Level 4: The control system

Hypothesis VIII: Trait-Control and laboratory task indices of the control system will be negatively associated with all substance use and abuse measures.

Table 3.22 presents tests of associations between indices of control and substance use. As hypothesised, Trait-Control was significantly lower in alcohol users than non-drinkers and modestly negatively correlated with AUDIT-Total in current drinkers. Analyses revealed the significant association between Trait-Control and AUDIT-Binge to be a significant linear relationship [$F(1,364)=24.24$, $p<0.001$], whereby control decreased across increasing frequencies of binge drinking. Figure 3.30 presents these data.

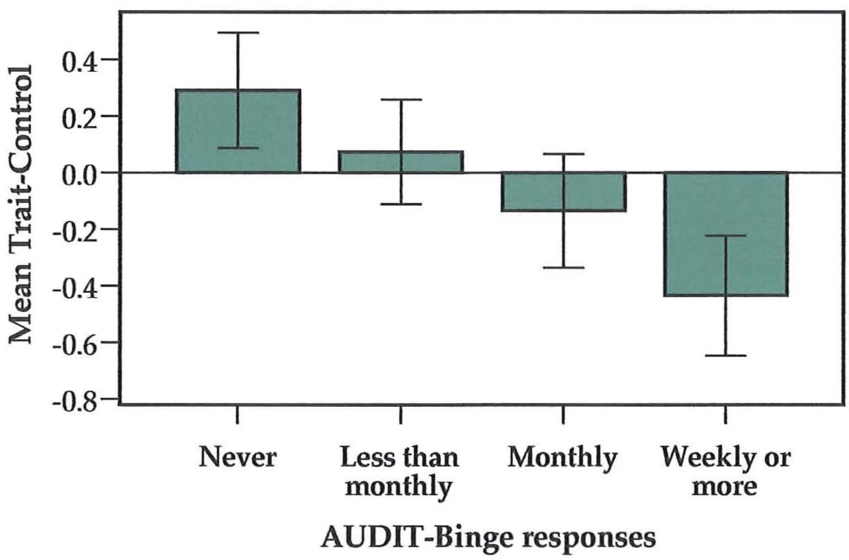

Figure 3.30: Trait-Control scores by AUDIT-Binge responses among current drinkers (n=368)

Illicit drug use was also significantly associated with Trait-Control, and these data are shown in Figure 3.31. Trend analyses revealed a significant linear relationship [$F(1,405)=34.24$, $p<0.001$], with never users scoring highest on Trait-Control and current users scoring lowest. However, Bonferroni-corrected post-hoc tests revealed no significant difference between former and current users [$t(405)=0.69$, *ns*], indicating that these groups were similar in Trait-Control.

Table 3.22: Tests of associations between indices of control and substance use

	Trait-Control		GNG Reversal Expectancies		GNG Reversal Responses	
Alcohol use	*n*		*n*		*n*	
Alcohol use status *(368 users, 40 non-users)*	408	t(406)=2.83, ***p=0.005****	315	*U*=5074.5, *p=0.712*	315	*U*=4832.0, *p=0.403*
AUDIT-Total	368	*r*=-0.33, ***p=0.000****	277	*Rho*=0.08, *p=0.176*	277	*Rho*=0.02, *p=0.801*
AUDIT-Binge *(75 never, 118 less than monthly, 95 monthly, 80 weekly or more)*	368	F(3,364)=8.15, ***p=0.000****	277	χ^2(3)=3.48, *p=0.324*	277	χ^2(3)=3.49, *p=0.322*
Illicit drug use status						
Drug use status *(80 former, 181 never, 147 current users)*	408	F(2,405)=18.72, ***p=0.000****	315	χ^2(2)=0.06, *p=0.969*	315	χ^2(2)=1.13, *p=0.568*
ASSIST-Count *(73 one/two drugs, 74 three or more)*	147	t(145)=3.28, ***p=0.001****	121	*U*=1817.0, *p=0.949*	121	*U*=1699.5, *p=0.490*
ASSIST-Freq *(92 less than six, 55 six or more)*	147	t(145)=2.32, ***p=0.022***	121	*U*=1504.5, *p=0.338*	121	*U*=1656.5, *p=0.909*
ASSIST-Prob *(56 problem users, 91 non-problem users)*	147	t(145)=2.09, ***p=0.038***	121	*U*=1660.0, *p=0.851*	121	*U*=1526.0, *p=0.352*

	IGT Net Score		AST-Accuracy		AST-Interference		DDT Discounting Rate	
Alcohol use	*n*		*n*		*n*		*n*	
Alcohol use status *(368 users, 40 non-users)*	274	t(272)=-1.51, *p=0.132*	125	t(21.2)=-0.81, *p=0.425*	125	t(123)=-0.07, *p=0.942*	160	t(158)=1.81,, *p=0.072*
AUDIT-Total	244	*r*=0.15, *p=0.023‡*	106	*r*=-0.21, ***p=0.029***	106	*r*=-0.18, *p=0.062*	137	*r*=-0.04,, *p=0.669*
AUDIT-Binge *(75 never, 118 less than monthly, 95 monthly, 80 weekly or more)*	244	F(3,240)=1.17, *p=0.321*	106	F(3,102)=1.68, *p=0.174*	106	F(3,102)=2.53, *p=0.062*	137	F(3,133)=1.04,, *p=0.379*
Illicit drug use status								
Drug use status *(80 former, 181 never, 147 current users)*	274	F(2,271)=2.35, *p=0.097*	125	F(2,122)=0.81, *p=0.446*	125	F(2,122)=1.05, *p=0.354*	160	F(2,157)=3.76,, *p=0.025‡*
ASSIST-Count *(73 one/two drugs, 74 three or more)*	104	t(102)=2.17, ***p=0.032***	51	t(49)=1.23, *p=0.225*	51	t(49)=1.92, *p=0.062*	60	t(58)=-1.36,, *p=0.179*
ASSIST-Freq *(92 less than six, 55 six or more)*	104	t(102)=0.29, *p=0.771*	51	t(49)=0.46, *p=0.651*	51	t(49)=2.57, ***p=0.013****	60	t(58)=-0.52,, *p=0.605*
ASSIST-Prob *(56 problem users, 91 non-problem users)*	104	t(102)=-1.44, *p=0.154*	51	t(49)=-1.70, *p=0.095*	51	t(49)=1.55, *p=0.127*	60	t(58)=-1.03,, *p=0.303*

*Test is significant at *p<0.014*†; Missing cases: GNG task 93; IGT 134; AST 283; DDT 248; ‡Result is in the opposite direction to 1-tailed hypothesis

† Bonferroni-correction: *p*<0.10 divided by 7 analyses gives *p*<0.014 (one-tailed)

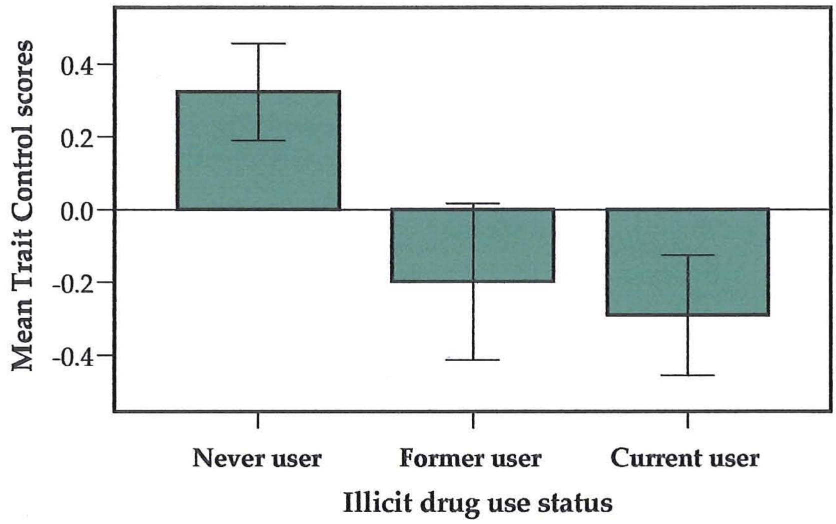

Figure 3.31: Trait-Control scores by illicit drug use status (n=408)

In current drug users, lower Trait-Control scores were significantly associated with more frequent drug use, and there were pronounced trends towards associations with the use of more illicit drugs and the extent of drug-related problems. Overall, Trait-Control was significantly, or near-significantly associated with all seven substance use indices in the directions hypothesised.

There were no significant associations between GNG Reversal indices and any of the substance use measures. There were, however, some associations between substance use and laboratory task indices of control. Thus, within current drug users, less frequent users showed significantly smaller increases in reaction times in antisaccade trials compared to prosaccade trials; this finding is consistent with the hypothesis that higher control will be associated with lower substance use. A small negative association between AST-Accuracy and AUDIT-Total scores failed to reach significance after Bonferroni adjustment. A pronounced trend for IGT Net Score to be higher among less frequent drug users was also consistent with hypotheses. It should be noted, however, that these associations are likely to be spurious.

Combined predictors of substance use

On the following page, Table 3.23 summarises results across the eight hypotheses tested thus far, identifying which predictors were individually associated with substance use. In the following sections, the additive effects of those variables in predicting alcohol and illicit substance use/abuse are assessed. Because the remaining analyses are concerned with variables from all levels of the IIC framework, only data from the London sample with complete data (*n*=165) are analysed.

Regression analyses

The seven continuous and categorical substance use dependent variables were analysed using sequential linear and multinomial logistic regressions.

As shown in Table 3.23, attitudinal factors and Life Stress were moderately and significantly associated with many indices of substance use, as specified at Levels 1 and 2 of the Intentions, Impulse, and Control (IIC) framework. However, the primary focus of this thesis is on relationships between substance use and impulse control, as articulated in Levels 3 and 4 of the framework. There are of course likely to be correlations between variables at different levels; for instance, participants with intrinsically high Trait-Avoidance may be more likely to express negative attitudes towards drug use and/or to experience higher life stress. Thus, in order to maximise the sensitivity of these analyses to possible combined effects of factors at the higher levels of the framework, variables are entered into sequential regressions in the reverse order to their sequence in the framework: individually significant predictors from Level 4 only are entered in the first model; the second also includes predictors from Level 3 alongside those from Level 4; the third also enters Life Stress at Level 2; and the final model enters predictors from all levels, including attitudinal factors at Level 1.

Intentions are not included in these analyses: while there were strong, consistent associations between intentions to use drugs and all substance use measures except ASSIST-Prob, it is arguably unsurprising that current drug or alcohol users report stronger intentions to engage in future drug and alcohol use, and this variable was excluded to enable a better exploration of other, more theoretically interesting, predictor variables.

Table 3.23: Results of planned analyses for the hypotheses tested

		Alcohol use Dependent Variables			Illicit drug use Dependent Variables			
		Alcohol Use Status	*AUDIT-Total*	*AUDIT-Binge*	*Illicit Drug Use Status*	*ASSIST-Count*	*ASSIST-Freq*	*ASSIST-Prob*
General Hypothesis:	***Predictor Variables***	*Alcohol users vs. Non-users*		*Never, Less than monthly, Monthly, Weekly or more*	*Never vs. Former vs. Current users*	*1/2 vs. 3 or more drugs*	*5 or less vs. 6 or more*	*Problem users vs. No problem users*
I. Positive associations between substance use and Attitudes	*Attitudes*	✓	✓	✓	✓	✓	✓	*Trend*
II. Negative associations between substance use and Riskiness	*Riskiness-Alcohol/Illicit*	✓	×	*Trend*	✓	✓	✓	×
III. Positive associations between substance use and Intentions	*Alcohol/ Illicit-Intentions*	✓	✓	✓	✓	✓	✓	×
IV. Lower scores for participants reporting religious affiliations	*Religious Restrictions*	✓	×	×	✓	not tested		
V. Positive associations between substance use and Life Stress	*Life Stress*	×	✓	×	✓	×	×	×
VI. Positive associations of approach indices with all substance use/abuse measures	*Trait-Approach*	×	×	×	×	×	×	×
	GNG Reward expectancies	×	×	×	×	×	×	×
	GNG Reward responses	×	×	×	×	×	×	×
VII. a) Negative associations between avoidance indices with substance use; b) Positive associations with problem substance use measures	*Trait-Avoidance*	×	×	×	×	×	×	×
	GNG Punish. responses	×	×	×	×	×	×	×
	GNG Punish. expectancies	×	×	×	×	×	×	×
VIII. Negative associations of control indices with all substance use/abuse measures	*Trait-Control*	✓	✓	✓	✓	✓	*Trend*	*Trend*
	GNG Reversal expectancies	×	×	×	×	×	×	×
	GNG Reversal responses	×	×	×	×	×	×	×
	IGT Net score	×	×	×	×	*Trend*	×	×
	AST-Accuracy	×	*Trend*	×	×	×	×	×
	AST-Interference	×	×	×	×	×	✓	×
	DDT Discounting Rate	×	×	×	×	×	×	×

✓= significant association; ×= no significant association; *Trend* = association not significant after correction

Where sequential logistic regressions are used, steps are taken to reduce the number of subpopulations and minimise missing cell frequencies: specifically, all continuous variables are replaced by ranked quartiles, and variables that do not significantly contribute to each successive model after Bonferroni correction are excluded from subsequent regressions. Thus, sample sizes can fluctuate from one model to the next.

Outcome measures: alcohol use

Alcohol use status

As noted in Table 3.23, alcohol use status was significantly or near-significantly associated with Trait-Control at Level 4 of the IIC framework, and with Attitudes, Riskiness-Alcohol, and Religious Restrictions at Level 1. These were included in sequential logistic regressions as predictors of alcohol use status; the results are presented in Table 3.24.

Table 3.24: Sequential regressions examining predictors of alcohol use status

Alcohol use status: Non-users (n=25) vs. users (n=140)					
	n	Model Pseudo R^2	Wald	Odds Ratio	p
Model 1	165	0.03			
Level 4: Trait-Control			3.00	1.43	***0.083****
Model 2	164	0.30			
Level 4: Trait-Control			1.56	0.73	*0.211*
Level 1: Attitudes			0.73	1.25	*0.392*
Level 1: Riskiness-Alcohol			5.86	0.57	***0.015**§
Level 1: Religious-Restrictions			10.89	5.48	***0.001**§
Final Model	164	0.27			
Level 1: Riskiness-Alcohol			7.00	0.55	***0.008**#
Level 1: Religious-Restrictions			13.36	6.20	***0.000**#

Religious-Restrictions missing one case; all continuous variables replaced by ranked quartiles
*Wald test is significant at *p<0.10-one-tailed;* § Wald test is significant at $p<0.025^{\alpha}$;
#Wald test is significant at $p<0.05^{\alpha 2}$

Trait-Control was significantly related to drinking status in model 1, but when included alongside the three attitudinal factors, it became non-significant, and only Riskiness and Religious-Restrictions emerged as significant predictors. In combination the two variables explained roughly 27% of the variance in alcohol use status [$\chi^2(2)$=27.61, p<0.001]. Participants with religious restrictions were six times more likely

[α] Bonferroni-correction: *p<0.10 divided by 4 Wald tests gives p<0.025 – one-tailed*
[α2] Bonferroni-correction: *p<0.10 divided by 2 Wald tests gives p<0.05 – one-tailed*

to be teetotal, while the likelihood of being a current drinker halved across increasing quartiles of Riskiness.

AUDIT-Total

Among current alcohol users (n=140), AUDIT-Total was associated with the Level 4 variables Trait-Control, and AST-Accuracy, Life Stress (Level 2), and Attitudes (Level 1). These variables were entered into linear regressions to predict AUDIT-Total; Table 3.25 presents the results. As previously, predictors which did not emerge as significant predictors in an earlier model were dropped from subsequent models and hence the sample size changes from one model to the next.

Table 3.25: Sequential regressions examining predictors of AUDIT-Total

AUDIT-Total	n	Adjusted R^2	Sr^2	β	p
Model 1	*106*	0.20			
Level 4: Trait-Control			0.18	-0.44	***0.000****
Level 4: AST-Accuracy			0.01	-0.08	*0.361*
Model 2	*117*	0.25			
Level 4: Trait-Control			0.21	-0.47	***0.000***#
Level 2: Life Stress			0.01	0.11	*0.216*
Model 3	*140*	0.31			
Level 4: Trait-Control			0.13	-0.35	***0.000***#
Level 1: Attitudes			0.13	0.34	***0.000***#

Sr^2=squared semi-partial correlations; AUDIT-Total is log-transformed;
*T-test is significant at $p<0.033^{\alpha}$; # T-test is significant at $p<0.05^{\alpha 2}$

In the first model, Trait-Control uniquely explained 18% of the variance in AUDIT-Total scores; AST-Accuracy did not contribute additional explanatory power. In the second model, Life Stress did not account for significant additional variance over that explained by Trait-Control. In a final significant model [F(2,114)=19.93, p<0.001], Attitudes and Trait-Control both significantly contributed to prediction; each uniquely explained 13%, and together they explained 31% of the variance in AUDIT-Total.

AUDIT-Binge

As shown in Table 3.23, Trait-Control (Level 4), and Attitudes and Riskiness (Level 1) were individually associated with AUDIT-Binge responses in current drinkers (n=140), and were therefore entered into multinomial logistic regressions predicting binge drinking frequency. Table 3.26 presents the results of these analyses.

[α] Bonferroni-correction: *p<0.10 divided by 3 t-tests gives p<0.033 – one-tailed*
[α2] Bonferroni-correction: *p<0.10 divided by 2 t-test gives p<0.05 – one-tailed*

Table 3.26: Sequential regressions examining predictors of AUDIT-Binge

AUDIT-Binge: Never (n=41), Less than monthly (n=43), Monthly (n=30), Weekly or more (n=26)

	n	Model Pseudo R^2	χ^2	df	p
Model 1	*165*	0.20			
Level 4: Trait-Control			28.18	3	***0.000****
Model 2	*165*	0.40			
Level 4: Trait-Control			13.14	3	***0.004‡***
Level 1: Attitudes			30.01	3	***0.000‡***
Level 1: Riskiness			6.66	3	*0.083*
Final model	*165*	0.37			
Level 4: Trait-Control			14.10	3	***0.003#***
Level 1: Attitudes			31.40	3	***0.000#***

All continuous variables replaced by quartiles; *Likelihood ratio test is significant at $p<0.10$ *1-tailed;* ‡ Likelihood ratio test is significant at $p<0.033^{\alpha}$; #Likelihood ratio test is significant at $p<0.05^{\alpha 2}$

As expected, Trait-Control was significantly related to AUDIT-Binge responses when entered as the only predictor. In the second model, Attitudes independently accounted for additional significant variance, but Riskiness did not. Thus, the final model included only Trait-Control and Attitudes, which jointly explained around 37% of the variance in responses [$\chi^2(6)=59.58$, $p<0.001$]. Table 3.27 presents parameter estimates for the final model.

Table 3.27: AUDIT-Binge regressed onto Trait-Control and Attitudes

AUDIT-Binge	Less than monthly vs. Never				Monthly vs. Less than monthly				Weekly or more vs. monthly			
	B	Wald	Odds Ratio	p	B	Wald	Odds Ratio	p	B	Wald	Odds Ratio	p
Final model												
Trait-Control	-0.52	5.24	0.59	***0.022***	-0.01	0.00	0.99	*0.978*	-0.54	3.53	0.58	*0.060*
Attitudes	0.53	4.71	1.69	***0.030***	0.83	9.09	2.30	***0.003****	-0.09	0.07	0.92	*0.793*

*Parameter estimate significant at $p<0.017^{\alpha 3}$

Comparing never bingers with 'less than monthly' bingers, high Trait-Control and positive attitudes towards drinking were respectively associated with lower and higher odds of ever bingeing. Positive attitudes to drinking were likewise associated with increased odds of binge drinking at least monthly (but less than weekly) vs. less than monthly; here, Trait-Control had no effect. Neither Trait-Control nor Attitudes discriminated between those bingeing monthly vs. at least weekly. However, it should

[α] Bonferroni-correction: *$p<0.10$ divided by 3 tests gives $p<0.033$ – one-tailed*

[α2] Bonferroni-correction: *$p<0.10$ divided by 2 tests gives $p<0.05$ – one-tailed*

[α3] Bonferroni-correction: *$p<0.10$ divided by 6 Wald-tests gives $p<0.017$ – one-tailed* be noted that with Bonferroni corrections, several of these predictors fall short of formal significance.

Outcome measures: illicit drug use

Illicit drug use status

Independent associations were found between illicit drug use status and Trait-Control, Life Stress, and Attitudes, Riskiness, Religious-Restrictions. Table 3.28 presents the results of multinomial logistic regressions testing these variables as combined predictors of current drug use status; again, as predictors are dropped and added to sequential analyses, sample sizes change correspondingly.

Table 3.28: Sequential regressions examining predictors of illicit drug use status

Drug use status: Never users (n=71), Former users (n=32), Current users (n=62)					
	n	Pseudo R^2	χ^2	df	p
Model 1	*165*	0.18			
Level 4: Trait-Control			27.60	2	***0.000****
Model 2	*159*	0.27			
Level 4: Trait-Control			22.01	2	***0.000‡***
Level 2: Life Stress			9.04	2	***0.011‡***
Model 3	*138*	0.64			
Level 4: Trait-Control			4.40	2	*0.109*
Level 2: Life Stress			2.07	2	*0.356*
Level 1: Attitudes			42.56	2	***0.000§***
Level 1: Riskiness-Illicit			0.37	2	*0.830*
Level 1: Religious-Restrictions			8.38	2	***0.015§***
Final model	*164*	0.59			
Level 1: Attitudes			96.21	2	***0.000‡***
Level 1: Religious-Restrictions			11.86	2	***0.003‡***

Missing cases: R-Restrictions 2; Life stress 24; Continuous variables replaced by quartiles
*Parameter estimate is significant at *p<0.10-one-tailed;* ‡Parameter estimate is significant at $p<0.05^{\alpha}$;
§Parameter estimate is significant at $p<0.02^{\alpha_2}$

The relationship between Trait-Control and illicit drug use status was significant in the first model; when Life Stress was included in the second, both contributed significantly to prediction. After including the three attitudinal factors in the third model, Attitudes, and Religious-Restrictions, but not Trait-Control, Life Stress or Riskiness, made significant independent contributions to prediction. Together, these two variables were included in a final significant model [$\chi^2(4)=120.73$, $p<0.001$] which explained roughly 60% of the variance. Table 3.29 presents parameter estimates for this model.

$^{\alpha}$ Bonferroni-correction: *p<0.10 divided by 2 tests gives p<0.05 – one-tailed*
$^{\alpha_2}$ Bonferroni-correction: *p<0.10 divided by 5 tests gives p<0.02 – one-tailed*

Table 3.29: Drug use status regressed onto Trait-Control, Attitudes, and Religious-Restrictions

Drug use status	Never vs. Former users				Never vs. Current users				Former vs. Current users			
	B	Wald	Odds Ratio	*p*	B	Wald	Odds Ratio	*p*	B	Wald	Odds Ratio	*p*
Final model												
Attitudes	-1.53	25.88	0.22	***0.000****	-2.40	45.42	0.09	***0.000****	-0.87	9.06	0.42	***0.003****
R-Restrictions#	-0.43	0.61	0.65	*0.436*	-2.28	8.83	0.10	***0.003****	-1.85	6.41	0.16	***0.011****

*Parameter estimate significant at $p<0.017^{\alpha}$; #No religious restrictions vs. Religious restrictions

Positive attitudes towards drugs and having no Religious-Restrictions were both positively associated with increased odds of being current vs. former drug users and both were associated with increased odds of currently using drugs, compared to never having used drugs. Attitudes towards drugs was the only predictor to differentiate between never and former users.

ASSIST-Count

Earlier analyses found that participants who had used only one or two illicit drugs differed from those who used at least three illicit substances on the Level 4 variables Trait-Control and IGT Net Score, and the Level 1 variables Riskiness-Illicit and Attitudes. The combined predictive power of these variables was analysed using binary logistic regressions. The results are presented in Table 3.30.

Table 3.30: Sequential regressions examining predictors of ASSIST-Count

ASSIST-Count: One/Two drug (n=28), Three or more (n=34)					
	n	Model Pseudo R^2	Wald	Odds Ratio	p
Model 1	61	0.31			
Level 4: Trait-Control			11.42	0.33	***0.001‡***
Level 4: IGT Net Score			0.65	0.79	*0.419*
Model 2	61	0.69			
Level 4: Trait-Control			6.34	0.32	***0.012§***
Level 1: Riskiness-Illicit			7.04	0.21	***0.008§***
Level 1: Attitudes			4.29	4.50	***0.038***

Missing cases: IGT 3, Riskiness 1; All continuous variables replaced by ranked quartiles
‡ Parameter estimate is significant at $p<0.05^{\alpha 2}$; § Wald test is significant at $p<0.033^{\alpha 3}$;

IGT Net Score was not a significant predictor after controlling for Trait-Control; in the second model, Trait-Control, Riskiness, and Attitudes each made significant unique contributions, and together they significantly explained around 70% of the variance

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$^{\alpha}$ Bonferroni-correction: *p<0.10 divided by 6 Wald-tests gives p<0.017 – one-tailed*
$^{\alpha 2}$ Bonferroni-correction: *p<0.10 divided by 2 tests gives p<0.05 – one-tailed*
$^{\alpha 3}$ Bonferroni-correction: *p<0.10 divided by 3 Wald tests gives p<0.033 – one-tailed*

[$\chi^2(6)=44.12$, $p<0.001$]. The odds of having used more illicit drugs decreased with higher Trait-Control and higher perceived riskiness of drug use, and increased with more positive attitudes to drugs. However, these findings should be interpreted with caution given the small number of participants in these analyses.

ASSIST-Freq

Frequency of drug use by current users was categorised as approximately fortnightly or more (scores above 5), versus less than fortnightly. Individually significant predictors were Trait-Control and AST-Interference at Level 4, and Attitudes and Riskiness at Level 1. Table 3.31 presents the results of logistic regressions exploring the combined predictive power of these variables.

When Trait-Control and AST-Interference were entered together, only the latter made a significant unique contribution to the model. However, together the two variables accounted for around a fifth of the variance in drug use frequency. In the second model, AST-Interference was entered alongside Riskiness-Illicit and Attitudes; here, only Attitudes accounted for significant variance. When entered alone, Attitudes explained roughly 30% of the variance in ASSIST-Freq [$\chi^2(1)=16.01$, $p<0.001$]; thus, as predicted, users endorsing more positive attitudes to drugs reported using more frequently.

Table 3.31: Sequential regressions examining predictors of ASSIST-Freq

ASSIST-Freq: Five or less (n=33), Six or more (n=29)					
	n	Pseudo R^2	Wald	Odds Ratio	p
Model 1	*51*	0.21			
Level 4: Trait-Control			3.40	1.75	*0.065*
Level 4: AST-Interference			4.40	1.85	***0.036***#
Model 2	*51*	0.40			
Level 4: AST-Interference			2.10	1.65	*0.148*
Level 1: Riskiness-Illicit			1.05	1.66	*0.305*
Level 1: Attitudes			4.64	0.24	***0.031***‡
Final model	*62*	0.30			
Level 1: Attitudes			10.85	0.18	***0.001******

Missing cases: AST 11 Riskiness 1; All continuous variables replaced by ranked quartiles
#Wald test is significant at $p<0.05^{\alpha}$; ‡ Wald test is significant at $p<0.033^{\alpha 2}$
*Wald test is significant at *p<0.10-one-tailed*

$^{\alpha}$ Bonferroni-correction: *p<0.10 divided by 2 Wald tests gives p<0.05 – one-tailed*
$^{\alpha 2}$ Bonferroni-correction: *p<0.10 divided by 3 Wald tests gives p<0.033 – one-tailed*

ASSIST-Prob

Of the 62 current drug users, 23 reported problems related to drug use (health, social, legal, or financial problems, failure to cut down/quit, and/or failure to perform expected tasks). In previous analyses, only Trait-Control (Level 4) and Attitudes (Level 1) differed between participants who did or did not report drug-related problems. Table 3.32 presents regressions analysing their combined effect.

Table 3.32: Sequential regressions examining predictors of ASSIST-Prob

ASSIST-Prob: No prob. drug use (n=39), Prob. use (n=23)					
	n	Model Pseudo R^2	Wald	Odds Ratio	p
Model 1	62	0.09			
Level 4: Trait-Control			3.58	1.71	***0.058****
Model 2#	62	0.14			
Level 4: Trait-Control			2.52	1.59	*0.112*
Level 1: Attitudes			2.25	0.53	*0.133*

All continuous variables replaced by ranked quartiles
*Wald test is significant at *p<0.10-one-tailed;* #No Wald test is significant at $p<0.05^{\alpha}$

When entered alone in model 1, Trait-Control significantly predicted drug-related problems among current users, but accounted for only around 9% of the variance in ASSIST-Prob; this model was significant [$\chi^2(1)=3.99$, $p<0.05$]. When entered together in model 2, the overall model was significant [$\chi^2(1)=6.53$, $p<0.05$] and accounted for around 14% of the variance in ASSIST-Prob, but neither Trait-Control nor Attitudes made significant unique contributions to prediction.

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Discussion

The goals of this study were two-fold. Initially, it aimed to empirically test a series of hypotheses concerning individual associations between substance use and risk factors implicated in past research, and included in the Intention, Impulse, and Control (IIC) framework, in a combined sample of over 400 university students in the UK and Australia. A second objective was to explore the combined influence of these factors in predicting various measures of alcohol and illicit substance use and abuse in the smaller UK sample.

Seven different substance use indices were employed. The Alcohol Use & Disorders Identification Test (AUDIT: Babor et al., 1992) was used to identify whether students were current drinkers or not (alcohol use status); it also yielded a total AUDIT score reflecting both alcohol use and abuse (AUDIT-Total), and an index of the frequency of binge-drinking (AUDIT-Binge). The Alcohol, Smoking, and Substance Involvement Screening Test (WHO ASSIST Working Group, 2002) was used to identify current, former, and never drug users (illicit drug use status), and to derive three further indices that were subsequently collapsed into three categorical variables. Thus, current drug users who had used only one or two illicit drugs in their life were compared with those who had used three or more (ASSIST-Count); participants who had used drugs more than five times over the preceding three months (equating to an average of at least fortnightly use) were compared with less frequent drug users (ASSIST-Freq); and drug users who reported problems resulting from their illicit substance use during the previous three months were compared with users who reported none (ASSIST-Prob).

Individual risk factors

Level 1: Attitudinal factors

Under the assumptions of the IIC framework, it is argued that pre-existing attitudinal factors are highly relevant to the likelihood that an individual will engage in substance use/abuse; some may hold positive or negative attitudes that influence their response if/when they are presented with the chance to drink or take drugs, while others may intentionally seek out opportunities to do so.

In line with current hypotheses and past research (e.g. Azaiza et al., 2008), more positive attitudes to substance use were associated here with significantly higher scores on all alcohol and illicit drug use indices, though associations with problematic substance use fell short of significance following Bonferroni corrections for multiple comparisons. Thus, when compared with other alcohol and drug users, participants with more positive attitudes towards drugs were likely to consume more alcohol (n=140), engage in more frequent binge drinking (n=140), experiment with more illicit drugs (n=62), and use drugs more frequently (n=62). Perhaps unsurprisingly given their higher levels of substance use, they were also somewhat more likely to experience drug-related problems (n=62). Overall, these findings are as expected, and add to a growing literature linking attitudes towards drugs with substance use.

There are many reasons why individuals might develop positive attitudes towards drugs. They may have been raised in an environment where drugs were considered less dangerous or immoral, or by parents who themselves held relaxed attitudes towards drug use and its legal status; personal experiences and/or the experiences of peers may have directly informed their beliefs; young students may be particularly willing to 'defy the system' and be more open-minded to questioning society's rules. Some of these examples refer to factors that in themselves increase the likelihood of encountering opportunities to engage in substance use (e.g. exposure to drug-using peers, student lifestyle), and which could partially or wholly mediate the observed relationships between attitudes and behaviours. However, it was not possible to test these potential explanations within the present dataset. Participants who had used illicit drugs in the past but were not current users on average had less positive attitudes towards drug use than current users, and more positive attitudes than never users (n=165); it is possible that negative experiences with drug use dampened previously more positive attitudes, but it is also plausible that their attitudes preceded their behaviour and limited the extent and duration of their substance use. Boys et al. (2007) found that the intention to use drugs was predicted by past drug use, providing evidence that attitudinal factors can be influenced by behaviour. From the cross-sectional findings reported here, however, it is not possible to determine whether past drug use contributed to the formation of attitudes, or vice versa, or indeed whether the association is non-causal but rather an artefact of some third variable to which they both relate (e.g. personality).

There were also significant negative associations between the perceived riskiness of substance use and actual alcohol and illicit drug use. It is generally assumed that the more risky an activity is perceived to be, the more aversive it is and the less likely an individual is to actively pursue the activity, or to engage in the activity if presented with an opportunity to do so; however, danger may be attractive to people with risk- or sensation-seeking personalities (e.g. Ryb et al., 2006). While for the most part findings here were consistent with the hypothesis that greater perceived riskiness would be associated with less substance use, the results were not as consistent as for attitudes. Thus, the perceived riskiness of alcohol consumption was significantly higher in teetotallers than drinkers (*n*=163), and was lower in participants who more frequently binged (*n*=140), but in alcohol users there was no association with overall consumption level as indexed by AUDIT-Total (*n*=140). The AUDIT questionnaire taps frequency and quantity of alcohol consumption and indicators of problem drinking (e.g. "Have you or someone else been injured as a result of your drinking?") and dependency (e.g. How often during the last year have you needed a drink in the morning to get yourself going after a heavy session the night before?"). In the present sample of 163 students, AUDIT scores indicated risky consumption for 20 per cent, and six participants (3%) were in the range signifying likely alcohol dependence. The lack of association between AUDIT scores and perceived riskiness indicates that more risky/dependent drinkers perceive just as many potential risks to alcohol use as do lighter drinkers; thus, other factors must underlie their higher levels of consumption and problem drinking. The fact that risk perception predicts binge drinking, but not total consumption or problematic drinking, adds to other findings suggesting that binge drinking patterns are driven by cognitive and motivational factors different from those which underlie physiological and psychological dependence (Borsari et al., 2007).

There was a similar pattern of findings for illicit drug use: perceived riskiness was significantly lower in current drug users than former or never users (*n*=163), and was significantly associated with higher and more frequent drug consumption (*n*=61) but not with problem drug use (*n*=61). It had been predicted that both problem alcohol use and problem drug use would be related to lower perceived risks, but the present findings do not support this hypothesis. Instead, they suggest that higher perceived riskiness may deter some individuals from drug and alcohol use, but that it does not reduce susceptibility to problem use or dependency in those who have begun to use.

As discussed at the start of this chapter, binge drinking is widely recognised to be a problem among young people. In the present study, students who binged the most frequently (i.e. drinking six or more drinks on at least one occasion per week) perceived alcohol to be significantly less risky than did all other alcohol users; occasional bingers did not differ from 'never-bingeing' alcohol users. This finding is important since it suggests that the students who are at the most risk are the least likely to perceive their actions to be harmful. Similarly, Hampson et al. (2001) identified risk perception to be a strong predictor of alcohol use by 13-16 year old adolescents. This might imply that very early interventions should seek to modify risk perception. However, as noted in relation to attitudes towards drug use, the nature of the causal link between risk perception and alcohol use is not clear: it is possible for instance, that less negative attitudes result from personal experiences of heavy drinking that did not lead to harmful consequences of significance to the individual.

According to Ajzen's Theory of Planned Behaviour (TPB), intentions are formed from social norms and attitudes, and are direct antecedents to behaviour. In the present study, participants were asked to rate how strongly they intended to use alcohol and ten illicit drugs during the following year; consistent with the TPB, those who reported stronger intentions to engage in future substance use also reported higher current alcohol and drug use (n=165). It is perhaps unsurprising that intentions did not however correlate with current problem drug use (n=62) since those who report experiencing problems are likely to want to reduce or quit their consumption. As for other attitudinal factors, this pattern of findings may again reflect a distinction between some factors implicated in substance use initiation and in susceptibility to problem use and dependence.

It may be that some attitudinal factors are so intrinsically linked with actual use that their inclusion in the present analysis adds little to our understanding of substance use. As noted, it is self-evident that individuals who currently engage in alcohol use also report intentions to continue drinking, and that individuals who do not drink are less likely to report intentions to engage in future alcohol use. There may be some circularity in the relationship between intentions towards substance use and actual drug and alcohol use and Chapter 5 will report longitudinal associations between these variables that may cast some light on this issue.

Responses to the question "Does your religion limit/prohibit the use of alcohol or drugs?" were used to determine religious restrictions over substance use. In the present study, religious restrictions were associated with a reduced likelihood of being a current drinker or current drug user (n=165), but not with level of alcohol consumption (n=140) or frequency of binge drinking (n=140). This finding is consistent with those of Patock-Peckham, Hutchinson, Cheong, and Nagoshi (1998), who found religious affiliations to be associated with alcohol *use*, but not with problem drinking. They argue, as proposed here for other attitudinal variables, for a separation between factors predicting alcohol use and those predicting abuse. Heath et al. (1997) did find associations between religiosity and problem drinking in a sample of over 3000 adult twins; however, the younger sample in the present study and lower prevalence of problem drinking may explain why these effects were not detected here. Galen and Rogers (2004) reported associations between drinking frequency and religiosity in a comparable student sample; however, they specifically measured the strength of religious commitment, which other studies have identified to be a more important predictor of substance use than nominal affiliation only (e.g. Sanchez et al., 2008). The absence of a direct measure of personal commitment in this study may also explain the lack of significant associations with alcohol consumption or binge drinking. Moreover, only three participants who reported religious-restrictions were current drug users (n=62); thus, associations between religious restrictions and other illicit drug use/abuse indices could not be analysed. This could be interpreted as further evidence of religiosity's protective influence, but a larger sample or one including a larger proportion of participants with religious affiliations would be needed to fully test these associations.

Overall, the samples included in analyses of attitudinal factors were modest in size. Of the total participants, predictors of alcohol consumption were explored within a smaller subgroup of 140 current drinkers, and predictors of drug use were explored within a smaller still subgroup of 62 current drug users. Thus, it is possible that a larger sample would detect associations that were identified as trends or could not be tested in the current sample. It is also important to note that Islamic students comprised a third of the participants reporting religious restrictions and, given their strict prohibitions against alcohol use, this may have influenced analyses of differences between never and current drinkers.

Level 2: Situational factors (Life Stress)

Life Stress was the only situational factor considered in the present study. The Revised Life Changes Questionnaire (RLCQ; Miller & Rahe, 1997) was used to quantify the magnitude of stressful life events experienced during the previous 12 months. Significant associations were found with just two substance use indices: alcohol consumption by current drinkers (*n*=140) and whether or not participants use illicit drugs (*n*=165). Past research has found a robust association of life stress with problem drinking, but not with alcohol use (e.g. Camatta & Nagoshi, 1995; Ham & Hope, 2005), and Zimmerman et al. (2007) suggest that the stress-dampening effect of alcohol may underlie the development of problematic drinking. The small significant positive association found here between life stress and AUDIT scores is difficult to interpret, since this measure taps both non-problematic and problem drinking. However, the lack of association with either binge drinking or whether or not participants are current drinkers may suggest that, in the present student sample, life stress is related specifically to problem drinking.

Interestingly, the reverse was true for illicit drug use: within the 62 current users, life stress did not predict problem use, but it did discriminate between the 62 users and the 103 non-users. These results are consistent with other research reporting positive associations between illicit substance use and exposure to life stressors (e.g. Arellanez-Hernandez et al., 2004). There are many possible explanations for this relationship: individuals may turn to drugs to cope with stressful experiences; drug use may contribute to the occurrence of stressful events; stress may increase the likelihood that psychological problems arise which subsequently impair an individual's ability to refrain from drug use; moreover, psychophysiological evidence has identified overlapping brain neurocircuits that respond to both stress and drugs (Piazza & LeMoal, 1996), suggesting that exposure to stressors may directly influence the subsequent effects of, and proneness to, drug use.

Stress-reduction models implicate emotional distress caused by stressful life events in the transition from controlled to problematic substance use (Marsh & Dale, 2005). There is no evidence in this sample that life stress leads to problem drug use; however, given the very small number of current drug users (*n*=62), it is likely that there was insufficient power to detect any such effects. It should also be noted that all participants were first year undergraduate students at the time of testing and life stress scores will have been elevated by their having recently started at a new college, and in most cases moved home; however, given the relative homogeneity of the sample, this effect should be spread across the sample and is not likely to have greatly influenced the findings.

Level 3: The approach system

It was hypothesised here, based on both theory and some empirical literature, that substance use/abuse would be positively associated with indices of the approach system, since it is expected that stronger approach tendencies increase the likelihood that an individual will pursue the expected rewards associated with drug or alcohol use. However, these data provided no support for these predictions. Trait-Approach (n=408) - derived in chapter 2 from self-report measures of reward sensitivity – was not significantly associated with any of the substance use indices. This is somewhat surprising, given that Trait-Approach comprised subscales from Carver and White's (1994) BIS/BAS scale and Torrubia et al.'s (2001) Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ), both of which have previously been related to alcohol use (e.g. Franken & Muris, 2006a; Pardo et al., 2007) and illicit drug use (e.g. Genovese & Wallace, 2007; Simons & Arens, 2007) in young non-clinical samples.

The speed of reward learning on a Go-No Go (GNG) task was indexed by self-reported expectancies (GNG Reward Expectancies) and task performance (GNG Reward Responses). These were taken as indices of individual variation in approach tendencies, in line with Zinbarg and Mohlman's (1998) argument that speed of reward learning reflects the activation of approach-like systems. However, contrary to expectation, GNG Reward Expectancies failed to correlate with alcohol use (n=277) or drug use (n=121). This suggests either that the measure taps factors other than individual differences in approach, or that the role of the approach tendencies assessed by the task are more complex than assumed here. These measures will be further tested in chapters 4 and 5, and general issues will be revisited in the Final Discussion.

Level 3: The avoidance system

A curvilinear relationship was postulated to exist between anxiety/avoidance and substance use, such that low avoidance tendencies increase the likelihood of substance use because the individual is not attuned to potential risks, whilst high avoidance tendencies may elevate the risk of substance use in attempts to reduce anxiety. In the present sample, negative associations were hypothesised between indices of avoidance and non-problematic substance use, whilst positive associations were hypothesised with problematic substance use. Avoidance indices included measures of the speed of punishment learning on the GNG task (n=315) and a measure of Trait-Avoidance (n=408) derived from self-report measures of punishment sensitivity. A clinical index of self-report Anxiety was also assessed (n=163).

There were no significant associations of any index of avoidance *or* anxiety with any of the substance use indices; scatter plots revealed no hint of the hypothesised curvilinearity in these relationships. Thus, overall, these findings are not consistent with the many studies that report associations between measures of sensitivity to reward or punishment and substance use (e.g. Magid et al. 2007; Franken & Muris, 2006a; Genovese & Wallace, 2007) or abuse (e.g. Jackson & Sher, 2003), or that note associations between anxiety and substance use (e.g. Kushner & Sher, 1993; Gilles, Turk, & Fresco, 2006).

Anxiety was moderately correlated with Trait-Avoidance (n=163), providing some evidence of construct validity for the derived measure. A normative study of Zigmond and Snaith's (1983) Hospital Anxiety and Depression Scale (HADS) identified 12.6% of the adult sample with anxiety scores in the range indicative of a clinically significant mood disturbance (J. R. Crawford, Henry, Crombie, & Taylor, 2001); in the present study, 16% scored in this range, suggesting that, despite the relatively small sample, there was sufficient variability in anxiety for analyses to detect the expected associations.

Even if an insufficient sample size offers some explanation for the lack of association with anxiety, over 400 students were analysed for associations between Trait-Avoidance and substance use, which should be a sizeable enough sample to detect even modest associations. For example, although Franken and Muris (2006) also failed to find associations between BIS and overall frequency of alcohol use, they did detect weak negative associations between a BIS measure and frequency of binge drinking in a sample of 276 students. Given the comparatively large sample here, and the significant associations previously found in similar student samples using trait measures that correlate very closely with Trait-Avoidance, the lack of any association between avoidance indices and substance use is surprising.

Level 4: The control system

The IIC framework assumes that low control increases the risk of problematic and non-problematic substance use by a reducing the ability to refrain from use. Thus, it was hypothesised that control would be negatively associated with all measures of substance use. As predicted, after Bonferroni corrections, modest significant (negative) associations were found between Trait-Control - derived in chapter 2 from broad self-report measures of impulsivity and novelty seeking – and all alcohol use indices (n=368); some similar associations with illicit drug use fell just short of significance after conservative Bonferroni corrections were applied (n=140).

In the second part of the GNG task, participants had to unlearn previous associations between stimuli and to use reward and punishment cues to learn the task anew; the speed with which they learned punishment cues in this phase was proposed to measure inhibitory control. However, there were no associations between substance use and this index (n=121). Keilp, Sackeim and Mann (2005) found performance on Go-No Go tasks to correlate with self-reported impulsivity, and other researchers have linked aspects of Go-No Go task performance with alcohol use (e.g. Colder & O'Connor, 2002; G. Dom et al., 2006) and smoking (Spinella, 2005). However, these studies used simpler tasks involving only the suppression of a previously learnt or automatic response. The GNG task used here has not previously been tested among substance users; in Chapter 2 it was noted that around a third of participants showed no learning on the task, and learning slopes were less steep than those reported by Zinbarg and Mohlman (1998). It is possible that the probabilistic reinforcement schedule that was included here, but not by Zinbarg and Mohlman in their original task, may have made the task too difficult, or changed its nature such that the derived indices no longer correspond to the proposed systems. In any event, the implications of the present data are either that the GNG indices are insensitive to facets of the control system which may influence substance use, or that other factors obscure any real but subtle relationships that may exist.

There were however some associations between another laboratory task index of control and substance use. On an oculomotor antisaccade task (AST), an individual's ability to refrain from looking towards a visual stimulus and to instead look in the opposite direction (anti-saccade) was proposed to index inhibitory control. The amount by which participants' reaction times were slowed in antisaccade vs. prosaccade trials was significantly shorter in the less frequent drug users within the sample of 51 drug users on which AST data were collected. As predicted, those substance users with stronger control processes engaged in less substance use. Several other associations fell short of significance but showed trends in the hypothesised direction, and while these are likely to be spurious, a larger sample may have enabled the detection of these effects. While previous studies have explored this task in relation to smoking (e.g. Powell, Dawkins and Davis, 2002; Spinella, 2002), this is the first study to demonstrate associations with substance use in a non-clinical sample.

Successful performance on the Iowa Gambling Task (high IGT Net scores) is achieved by resisting the temptation to make potentially high-reward but risky choices. There was only one trend for less frequent drug users (n=104) to score higher on the IGT, and this result fell short of significant after Bonferroni corrections. The overall lack of support for the hypothesised relationship between IGT performance and substance use runs counter to previous studies that have demonstrated risky decision-making by binge-drinkers (Goudriaan et al., 2007) and illicit substance users (e.g. Verdejo-Garcia, Benbrook et al., 2007). Goudriaan et al. also found the expected effects in a student sample, but they randomly selected 200 binge drinkers from a sample of over two thousand students and therefore had a far higher concentration of heavy users than would a representative sample. This task has not been widely used in non-clinical populations and one reason for the absence of associations in the present sample may be a low concentration of heavy users.

There was also no evidence to support the predicted association between illicit drug use and the strength of an individual's preference for immediate over delayed rewards on the delay discounting task (DDT; n=160). This lack of an association conflicts with the many studies that have demonstrated higher discounting rates in substance users and abusers, including subclinical illicit substance users (Kollins, 2003); alcoholics (Mitchell, Fields, D'Esposito, & Boettiger, 2005); and opiate addicts (Kirby & Petry, 2004). Kollins' (2003) study was the first to explore the DDT in relation to substance use in a non-clinical sample. Significant correlations were found between DDT performance and multiple indices of alcohol and illicit drug use in a sample of only 47 students of a similar age to those comprising the current sample, where no significant associations were found amongst 137 alcohol users, or among 60 illicit drug users. There were two notable methodological differences between Kollins study and the present study: first, Kollins used a computerised version of the task, while the card sorting task used here has been widely and successfully used elsewhere, but only in clinical groups (e.g. Bickel et al., 1999); second, Kollins did not separate users and non-users in his analyses, while in the present study qualitative differences were assumed to exist between the two groups. However, given that no differences were found here between the discounting rates of users and non-users, this is unlikely to contribute to the different results obtained.

Overall, then, although there was some evidence that Trait-Control and antisaccade indices showed the hypothesised relationships with substance use, other indices of control did not. It will be interesting to note whether associations involving the DDT and IGT will be found in later chapters, where associations between these measures, smoking, and change in substance use over time will be assessed.

Combining predictors of substance use

In the review at the start of this chapter, it was noted that while many risk factors and protective factors have been implicated in substance use, no single variable or cluster of variables was identified as critical or sufficient to account for the variance in any aspect of substance use or abuse. One of the aims of this study was therefore to test the combined influence of a range of variables found individually to be predictive, and to explore whether differing combinations of factors might predict different measures of alcohol and illicit substance use/abuse. To this end, sequential regressions were conducted. Factors tapping each level of the IIC framework were added to consecutive models in reverse order: thus, the effects of 'higher level' variables were explored initially without, and subsequently alongside, the effects of 'lower level' factors (such as attitudes and beliefs) which may themselves to some extent reflect (and therefore mask the effects of) 'higher level' variables.

The results of these regressions are briefly summarised here, and will be considered in greater detail in chapter 6 alongside related findings from all of the empirical studies.

Alcohol use

When combinations of risk factors were considered, alcohol use/non-use was best predicted by a combination of religious-restrictions and the perceived riskiness of alcohol. Together, these explained around a quarter of the variance in alcohol use status (140 alcohol users and 25 teetotallers). The importance of religiosity and perceived riskiness as protective factors against drinking has been discussed and is not surprising.

Trait-Control and attitudes towards substance use were the best predictors of AUDIT-Total scores in the 140 current drinkers; they together explained 31% of the variance in scores, with each uniquely contributing 13%. These two variables also emerged in combination as the best predictors of binge drinking frequency, explaining roughly 37% of the variance. While around two-thirds of the variance in both alcohol use measures remains unexplained, these finding provides important support for one of the primary assumptions of the IIC framework, that combining factors from multiple levels will provide a more sophisticated understanding of the underlying influences on substance use than any single level can alone. It is interesting also that neither variable emerged as a significant predictor of whether or not people drink, but that within current drinkers both predict the level of use. There is a clear separation therefore between factors that predict whether students choose to drink – i.e. religiosity and perceived riskiness - and those predicting level of alcohol use in those who do - i.e. control processes and attitudes to drug use.

Illicit substance use

Religious-restrictions and attitudes jointly accounted for around 59% of the variance in drug use status, where 164 participants were classified as either current, former, or never users. When included with Trait-Control, these same variables accounted for 69% of the variance in whether 61 current drug users had used only one or two versus three or more illicit drugs at any time in the past.

It is notable that it was possible to explain a much larger proportion of the variance in drug use than did in alcohol use. However, distributional issues meant that continuous measures of illicit drug use were replaced by categorical variables. The resulting loss of sensitivity to variation in aspects of drug use, especially given the small number of current illicit drug users (n=62), requires that these findings are interpreted very cautiously.

The best predictors of frequency of drug use by current users differed between regression models. Trait-Control and accuracy on the oculomotor antisaccade task together significantly explained around a fifth of the variance, with only antisaccadic accuracy making a significant unique contribution. Attitudes towards drug use alone provided the most parsimonious model, single-handedly explaining around 30% of the variance; however, with all three variables included, the amount of variance explained increased to 40%. The frequency of drug use is an important indicator of the potential harm that illicit drug use may cause, and might help to identify participants at risk of becoming problem users; thus, replication of this analysis is needed in a larger sample, ideally using continuous indices of substance use, to establish which variable or combination of variables best predicts variability in drug use frequency.

With respect to problematic drug use, Trait-Control and Attitudes jointly accounted for around 14% of the variance; however, neither made a significant unique contribution. It is noteworthy that these variables explained far less of the variance in problem substance use than in any of the other substance use indices. Thus, although the risk factors assessed in this study did not prove to be strong predictors of the problematic aspects of drug use, they did combine to explain substantial variance in non-problematic drug use. Again, however, it would be interesting to see if these findings replicate in a large sample.

Conclusions

This chapter has examined a wide range of variables that a literature review identified as important risk factors for alcohol and illicit substance use and abuse. When considered individually, attitudinal and situational factors, and indices of control, were consistently associated with a range of indices of drug and alcohol use and abuse. When the combined influence of these variables was explored, religiosity and the perceived riskiness were predictors of alcohol status, whereas a trait measure of control and attitudes towards drug use predicted level of alcohol use, and frequency of binge drinking; together they also predicted problem drug use. Religious restrictions over substance use, trait control, and attitudes towards drugs emerged as the best combination of predictors of the number of illicit drugs used and religious restrictions and attitudes towards drugs were the best predictors of whether or not participants used drugs at all. Importantly, there was no support for the hypothesised associations between approach or avoidance and substance use.

The next chapters will consider issues associated with impulse control and smoking. More general implications of the findings in the present study will be addressed in more depth in the Final Discussion.

CHAPTER FOUR

Impulse control and cigarette use

Chapter Summary

Smoking rates in the UK are currently in decline. According to the General Household Survey (Office for National Statistics, 2006), the population prevalence of smoking in the UK in 2006 was 22%, reduced from 24% in 2005, and the proportion of young adults smokers (aged 16-19) reduced from 24% in 2005 to 20% in 2006. Likewise, there has been a reduction in the number of cigarettes smoked, and respondents in all age-groups are now more likely to be light, rather than heavy smokers. Despite declines in smoking prevalence, smoking still represents the greatest cause of preventable illness and death: an estimated 81,900 deaths in England in 2005 were caused by smoking, and in 2005/6 around 1.7 million diagnoses were of diseases potentially caused by smoking – an annual cost to the National Health Service (NHS) of between £1.4 and £1.5 billion. Given the widely advertised harmful effects of cigarette use, it is unsurprising that 68% of smokers in the 2006 General Household Survey said they would like to stop smoking. Indeed, 31% of all smokers questioned in the 2007 National Statistics Omnibus Survey made a quit attempt in the previous year; however, only around 2-3% of smokers successfully stop. In Chapter 1, addiction was described as the discrepancy between "personal will and urge" (Buhringer, 2007, p.1002); this conflict is manifest in these statistics, and in the renowned difficulties associated with stopping smoking.

The overall aim of this thesis is to explore the involvement of self-control and inhibitory control mechanisms in the early stages of drug use and addiction. Chapter 2 focused upon deriving measures of impulse control, and Chapter 3 used these to explore associations between attitudinal factors, situational factors, impulse control, and alcohol and illicit recreational substance use. The present chapter is specifically concerned with cigarette use, providing an opportunity to investigate the involvement of impulse control in nicotine dependency.

Consistent with the focus of the thesis, the questions addressed in this chapter pertain to the role of impulse control in smoking. There is a clear discrepancy between attitudinal factors (i.e. the intention not to smoke) and impulses (i.e. the urge to smoke) in many smokers. Thus, smokers provide a useful population within which to test the assumptions of the Intention, Impulse, and Control (IIC) framework. 'Occasional smokers' - who do not smoke daily or with the frequency of 'regular' smokers - represent a uniquely interesting subset of smokers, because they appear to be able to control their substance use; this suggests that for some smokers, intermittent smoking is not part of an inexorable progression to dependency. Exploring differences between regular and occasional smokers may expand our understanding of the extent to which attitudinal factors, and situational factors and impulse control are differentially implicated in different patterns of cigarette use. These lines of enquiry tap a fundamental issue in addiction research and theory: how is it that some individuals, but not others, move from non-user to controlled user and from controlled user to addict?

This chapter will first review evidence implicating attitudinal factors, situational factors, competing approach and avoidance impulses, and cognitive control in cigarette use; special attention will be paid to research involving occasional smokers. Data from the cross-sectional database described in Chapters 2 and 3 will then be used to test hypotheses derived from this review, and which are relevant to the IIC framework.

Student smoking behaviour

Smoking initiation during late adolescence and early adulthood is associated with more prolonged, stable patterns of smoking than smoking initiation in later life (e.g. Breslau, Fenn, & Peterson, 1993; Breslau & Peterson, 1996). Despite a robust link between *low* educational achievement and smoking (e.g. de Walque, 2007; Gilman et al., 2008), student smoking rates appear to be higher than in the general population (~30% in the US; Centres for Disease Control and Prevention, 1997; in Wetter, Welsch, Smith, et al., 2004). One prospective student study noted that, over a four year period, almost 87% of baseline regular smokers and more than half of baseline occasional smokers were still smoking four years later (Wetter et al., 2004). This is perturbing, given concerns regarding the long-term effects associated with smoking initiation during early adulthood.

Some students' smoking behaviour undergoes considerable change during their period of study. Kenford et al. (2005) reported that the strongest predictor of continued smoking was cumulative nicotine exposure across the four-year assessment period. They interpret this finding to be evidence that nicotine exposure is a powerful determinant of the progression or continuation of regular cigarette use among students, but also note that quitters reported various smoking frequencies at baseline and that consequently tobacco use alone cannot fully account for individual differences in smoking progression.

Interestingly, both student smoking rates and successful quit-rates (e.g. Wetter et al., 2004; Kenford et al., 2005) are far higher than in the general population. Given the higher levels of change in their smoking behaviour, students are an interesting population in which to explore factors that influence individual differences in susceptibility to dependency and relapse. The analyses reported later in this chapter address these issues using data from the cross-sectional study of undergraduate students' substance use. From past studies (e.g. Kenford et al., 2005), it is likely that occasional smokers will be highly represented in this sample.

Occasional smokers

Occasional smokers are not a consistently conceptualised or well-defined group. Some researchers refer to non-daily smokers as 'chippers' (Davies, Willner, & Morgan, 2000; Wortley, Husten, Trosclair, Chrismon, & Pederson, 2003); others apply the term 'occasional' to those smokers who may smoke daily but at lower rates than dependent smokers (e.g. Owen, Kent, Wakefield, & Roberts, 1995; Shiffman, 1989).

Reflecting this lack of precision in definition, the literature is also imprecise as to the size and stability of this group in the wider population. Several studies report that around 16-20% of smokers use cigarettes less than daily (N. J. Evans et al., 1992; Gilpin, Cavin, & Pierce, 1997; Hennrikus, Jeffery, & Lando, 1996; Wortley et al., 2003), while Owen et al. (1995) found only 8% to be low-rate smokers. Data from the 1998/9 Tobacco

Use Supplement of the US Current Population Survey (in Hassmiller, Warner, Mendez, Levy, & Romano, 2003) gathered responses from over 38,000 smokers. Of these, 19.2% were non-daily smokers; around a third of these were in transition to regular smoking or cessation but nearly half reported stable patterns for over a year. This is therefore evidence that occasional smoking can be maintained for stable periods of at least 1-2 years (see also Hennrikus et al., 1996). Similarly, Zhu et al. (2003) found that 37% of low-rate smokers maintained this rate of smoking over 20 months. McCarthy, Zhou, and Hser (2001) found in 254 polydrug users that over a three year interval 55% of intermittent smokers became regular smokers, while 29% quit. The higher levels of transition in smoking status reported in this study suggest that smokers who use other drugs digger from those who do not.

Many theories of smoking dependence highlight nicotine as arguably the principal addictive component of cigarette smoke (e.g. deBry & Tiffany, 2008). Brauer, Hatsukami, Hanson, and Shiffman (1996) found no difference in smoking topography (i.e. duration of smoking, puff number, pre and post salivary cotinine levels) between occasional and regular smokers, suggesting that both groups expose themselves to similar levels of nicotine during smoking. How then is it that these occasional cigarette users continue to smoke, but fail to become addicted? Within the Intentions, Impulse and Control (IIC) framework there are several possible explanations: Are they simply less sensitive to reward? Are they higher in sensitivity to harm, and smoke less regularly so as to avoid the detrimental effects of cigarette use? Perhaps they have stronger control processes, and can resist the drive to pursue or increase smoking. While there is evidence of non-addicted use for other substances of abuse (e.g. opiates; Harding, 1983), the legal status of cigarette use and highly addictive nature of smoking makes occasional smokers an accessible and interesting group in which to examine issues of impaired impulse control, and explore risk factors that differentiate between smoking patterns. These questions, among others, will be addressed in the study described later in this chapter.

The following sections will discuss risk factors at each level of the IIC framework in turn. Particular attention will be paid to research that has investigated chippers, occasional, non-daily and light smokers, since each of these groups ostensibly includes non-dependent smokers, and a better understanding of these groups may contribute to our understanding of the association between impaired control and smoking.

Level 1: Attitudinal risk factors

Many studies have reported that religiosity reduces the likelihood of smoking (e.g. Marsiglia, Kulis, Nieri, & Parsai, 2005; Merrill, Folsom, & Christopherson, 2005; Sinha, Cnaan, & Gelles, 2007). Andrews et al. (2008) also found that self-reported willingness and intentions to smoke in very young children predicted cigarette use in adolescence. A large-scale study of four thousand adolescent never-smokers across six European countries examined predictors of smoking status after one year (Hoving, Reubsaet, & de Vries, 2007): smoking among girls was associated with having more spending money, parental smoking, and higher intentions to smoke; for boys, smoking was predicted by fewer perceived negative consequences of smoking, and higher alcohol consumption. Smith et al. (2007) found that attitudes towards smoking, peer group expectations, and perceived behavioural control were all related to higher intentions to smoke among non-smokers. Likewise, Carvajal and Granillo (2006) found that, across a period of 10 months, 13% of 1137 adolescent never-smokers had started smoking; smoking initiation was predicted by higher intentions to smoke, fewer perceived risks associated with smoking, more favourable peer attitudes to smoking, fewer environmental impediments to smoking, and lower self-efficacy at baseline. Taken together, these findings highlight the importance of attitudinal factors to smoking initiation.

Interestingly, de Leeuw, Engels, Vermulst, and Scholte (2008) tested the causal direction of the association between attitudinal factors and smoking in over 400 families, and found that adolescents' attitudes towards smoking were not consistent predictors of smoking, but rather that past smoking influenced later attitudes; that is, adolescents who began smoking subsequently demonstrated more favourable attitudes towards smoking. This complements other prospective research and theories – such as Ajzen's Theory of Planned Behaviour (Ajzen, 2002) – which argue that attitudes influence intentions, which in turn causally lead to behaviour. This finding emphasises the potentially complex association between attitudes and smoking, and reminds that a cautious approach should be taken to interpreting these causal associations.

Risk factors for occasional smokers

Few studies have investigated attitudinal factors in occasional smokers. Hines, Fretz, and Nollen (1998) asked regular smokers and occasional smokers to rate self-attributes associated with smoking. Both groups agreed that smoking was not healthy, was associated with being less attractive as a potential date, and that smokers were less attractive whilst smoking; occasional smokers felt more strongly than regular smokers that smoking made them feel daring and adventurous, and did not make them feel like an outcast. Owen, Kent, Wakefield, and Roberts (1995) also found that low-rate smokers perceived quitting smoking to be easier than did regular smokers. Thus, there is some evidence that attitudinal factors vary between regular and occasional smokers, though whether these factors predispose some individuals to a specific smoking pattern, or rather reflect their experiences of smoking is again not clear.

Predictor variables in the present study

Three attitudinal factors are examined in the present study: perceived riskiness of smoking ('**Riskiness-smoking**'), intentions regarding future substance use ('**Smoking-intentions**'), and religious restrictions on substance use ('**Religiosity**'). Consistent with past findings (Hoving et al. 2007), perceived riskiness of cigarette use is expected to be negatively associated with smoking, religiosity is expected to be associated with reduced smoking (e.g. Sinha et al., 2007), and stronger intentions to smoke are expected to be positively associated with cigarette use (e.g. Andrews et al. 2008).

Since the research described in this chapter is cross-sectional, prospective causal associations between attitudinal factors and smoking cannot be tested. Instead, it will explore attitudinal factors in relation to current smoking, and also - given the strong associations previously noted between intentions to smoke and actual smoking (e.g. Carvajal & Granillo, 2006) - between smoking intentions and the approach, avoidance and control processes implicated at Levels 3 and 4 of the framework.

Level 2: Situational risk factors (Life stress)

The socio-demographic factors associated with smoking are numerous. One large-scale study of Turkish high-school students (Ozge, Toros, Bayramkaya, Camdeviren, & Sasmaz, 2006), listed the most important risk factors for smoking as household size, late birth rank, school type, low academic performance, high second hand smoking, and stress. The report "Statistics on Smoking: England, 2007" describes considerable variation in smoking rates between socio-economic groups: 17% of managers and professionals smoked, compared to 31% of manual workers, and almost half of unemployed respondents. There were wide variations related to ethnicity and, via interactions, gender: for example, while there is little overall variation between genders in the UK (both ~23%), Bangladeshi men have the highest smoking rate for males in any ethnic group (40%), while Bangladeshi women have the lowest smoking rates for females in any ethnic group (2%). This example demonstrates clear cultural, ethnic, and gender-related influences on smoking prevalence.

In a review, Feldner, Babson, and Zvolensky (2007) found consistent reports of elevated smoking rates and lower quit rates in individuals with a history of traumatic event exposure or post-traumatic stress disorder (PTSD). Their examination of temporal associations suggested an increase in cigarette consumption in response to trauma, or trauma cues. Booker et al. (2004) identified stress as an important predictor of intentions to smoke and of smoking; in a later study, Booker et al. (2008) followed 716 adolescents from the age of 11 and reported a positive association between stressful life events and both lifetime smoking and intentions to smoke. Likewise, in adolescents, Roberts, Fuemmeler, McClemon, and Beckham (2008) found a robust prospective relationship between exposure to stressful/traumatic life events and regular smoking across a seven-year period; nicotine dependence and the number of cigarettes smoked daily were both predicted by past experiences of abuse.

Risk factors for occasional smokers

Few studies have explored situational risk factors for occasional smokers. However, three studies found that compared to regular smokers, non-daily smokers were better educated, earned more, were younger, and were more likely to be from an ethnic minority (particularly Hispanic) (Hassmiller et al., 2003; Husten, McCarty, Giovino, Chrismon, & Zhu, 1998; Wortley et al., 2003). Shiffman (1989) examined individuals who smoked less than six cigarettes per day, at least four days per week; this group reported less family smoking, less stress, better coping, and better social support networks than daily smokers. However, Kassel et al. (1994) found no differences between non-smokers, chippers, and regular smokers in perceived stress, coping or social support. Thus, overall, it is unclear whether life stress is a factor that differentiates between occasional and regular smokers.

Predictor variables in the present study

Participants in this study are a subset of those described in Chapters 2 and 3 are all aged between 18 and 25, and are all first-year undergraduate students; they are thus relatively similar in terms of educational achievement. Whilst it would be interesting to explore all of the situational factors identified above (e.g. SES, ethnicity), it is beyond the scope of this thesis to do so and only a measure of **'Life Stress'** experienced in the preceding 12 months is included in this study. As in previous studies (e.g. Booker et al. 2008), it is expected that recent life stress will be positively associated with smoking dependence among smokers, and will be higher in smokers than non-smokers. There are conflicting findings as to whether past life stress differs between occasional and regular smokers (Shiffman, 1989; Kassel et al., 1994), but since stress is typically found to be positively associated with smoking, it is hypothesised that regular smokers will report higher life stress than occasional smokers.

Levels 3 & 4: Competing impulses and cognitive control

According to the IIC framework, when presented with an opportunity to smoke, an individual may anticipate both appetitive and aversive effects to varying degrees, thus simultaneously triggering activity in both approach and avoidance systems (Level 3). These internal motivational drives compete, resulting in an overall dominant action tendency either towards or against smoking. If the resulting action tendency is congruent with his/her attitude towards smoking, there is no conflict; however, if conflict arises between the net motivational drive and attitudinal factors (Level 1), higher-order cognitive reflective control processes come into play (Level 4). Studies employing trait and behavioural measures that tap all three systems have reported associations with smoking as described in the following paragraphs.

Trait impulsivity and smoking

Many studies report elevated impulsivity in smokers compared to non-smokers: Mitchell (1999) found smokers to be significantly more impulsive than non-smokers on 19 out of 28 personality scales; Skinner, Aubin, and Berlin (2004) found heavy smoking abstinent alcoholics to be more impulsive on a non-planning measure of impulsivity than non-smokers or ex-smokers; and Doran, McChargue, and Cohen (2007) found associations between self-reported impulsivity and both positive and negative reinforcement expectancies in 202 student smokers. Doran et al. suggest a two-fold role for impulsivity: on the one hand, impulsive smokers may smoke to pursue expected rewarding effects; on the other hand, impulsive smokers may continue to smoke because they tend not to take account of long-term consequences of protracted smoking. This is consistent with the IIC framework's assumptions regarding the roles of approach and avoidance sensitivity.

Identifying a possible mechanism by which impulsivity may be implicated in smoking initiation, Perkins et al. (2008) hypothesised that nicotine has greater positive and negative reinforcing effects in more impulsive individuals. In an earlier study, Perkins et al. (2000) reported greater subjective responses to acute nicotine administration in higher sensation-seekers. Perkins et al. (2008) assessed 131 non-smokers on a range of impulsivity-related questionnaires and laboratory task measures. Using factor analysis, five factors were extracted: 'novelty seeking', 'response disinhibition', 'extraversion', 'inhibition', and 'delay discounting'. Nicotine sensitivity was assessed using ratings of nasal sprays: higher novelty seeking was positively associated with subjective ratings of pleasurable effects in men but negatively associated with ratings in women. Overall, the authors concluded that impulsivity did modulate the reinforcing effects of nicotine, and that gender modulated the strength of this relationship.

The relevance of impulsivity to smoking maintenance has also been studied. Rukstalis, Jepson, Patterson, and Lerman (2005) followed 454 smokers through the early stages of a quit attempt and found that, irrespective of nicotine-replacement therapies, increased inattention and hyperactive-impulsive symptoms during the first week following cessation predicted relapse. While Vanderveen, Cohen, Trotter, and Collins (2008) found that higher trait-impulsivity was associated with greater increases in positive smoking expectancies in a group of smokers after 48 hours of abstinence. This suggests that abstinence may differentially influence positive smoking expectancies among more impulsive smokers, providing a mechanism by which impulsivity could increase relapse proneness. The same research group demonstrated that impulsivity was positively associated with cravings and anxiety during abstinence in dependent smokers (VanderVeen, Cohen, Cukrowicz, & Trotter, 2008). Impulsivity has also been found to predict faster relapse (Doran, Spring, McChargue, Pergadia, & Richmond, 2004), whilst Doran et al. (2006) found that higher impulsivity was associated with stronger negative affect relief after consumption of a nicotinised but not a non-nicotinised cigarette. More impulsive smokers also demonstrated stronger preferences for immediate smoking following exposure to smoking-related cues (Doran, Spring, & McChargue, 2007). Thus, nicotine may provide stronger negative reinforcement for very impulsive individuals, making them more susceptible to the effects of withdrawal and cravings, and thereby increasing relapse proneness.

While many of these studies used broad questionnaire scales to assess impulsivity, some have attempted to examine differential associations between specific aspects of impulsivity and smoking. Etter, Pelissolo, Pomerleau, and De Saint-Hilaire (2003) assessed participants on Cloninger's (1987) Tri-dimensional Personality Questionnaire. As in previous research, novelty seeking (NS) was lower in never-smokers than current smokers. However, Pomerleau et al. (1992) found positive associations between smoking and harm avoidance (HA), while Etter et al. reported lower HA in never-smokers than smokers. These latter findings contradict the hypothesis that high HA will tend to be associated with avoidance of smoking as an intrinsically risky activity. Etter at al. (2003) suggest that high HA individuals are anxious and therefore pursue the perceived anxiolytic effects of smoking. Consistent with this speculation, when Leventhal et al. (2007) assessed over 200 smokers on the same measures, they found that HA was associated with abstinence-induced increases in negative affect.

Implications of these findings with respect to the IIC framework will be discussed in later sections.

Behavioural measures of impulsivity and smoking

As previously discussed in Chapter 2, Verdejo-Garcia, Lawrence, and Clark (2008) identified three main types of tests used to measure impulsivity: those that tap 'response inhibition' via the individual's ability to suppress automatic responses; those tapping temporal or 'delay discounting', by assessing preference for immediate over delayed reward; and those that tap 'cognitive impulsivity' in the form of risky vs. conservative decision-making. Few studies have explored impulsivity and smoking using tests of response inhibition: however, Dinn, Aycicegi, and Harris (2004) found no differences between smokers and non-smokers on a Go-No Go task, while by contrast Spinella (2002) reported positive correlations between the number of cigarettes smoked per day and inhibition errors on both a Go-No Go task and an antisaccade eye movement task. Participants in Dinn et al.'s study were relatively light smokers and Mitchell (1999) has suggested that inconsistencies in these findings may be due to differences between heavy and light smoking groups.

Testing abstinent smokers prior to a quit attempt, Powell et al. (2004) found that nicotine administration more strongly enhanced antisaccadic eye movements in participants who subsequently relapsed, than in those who went on to successfully maintain abstinent for one week. Relatedly, Pettiford et al. (2007) found that smokers made significantly more antisaccade (but not prosaccade) errors on an antisaccade task when abstinent than when they had recently smoked; they concluded that smoking abstinence decreases inhibitory control. Together, these findings lend support to self-medication theories of smoking, which suggest that smokers may rely on nicotine to enhance upon cognitive function and inhibitory control processes. Relatedly, Gehricke et al. (2007) present evidence that smoking can regulate attentional deficiencies, and a review by Evans & Drobes (2009) suggests that there may be individual differences in the effects of nicotine on attentional inhibition. Since inhibitory control is an important aspect of impulsivity (as argued in Chapter 1), the self-medication of inhibitory control deficits provides another mechanism by which impulsivity may underlie smoking initiation and maintenance.

Many studies have demonstrated elevated impulsivity in smokers using the delay discounting task (DDT) (e.g. Bickel et al., 1999; Bickel, Yi, Kowal, & Gatchalian, 2008; S. Mitchell, 1999; B. Reynolds et al., 2007). There are contradictory findings with respect to the causal direction of this association. For instance, Reynolds, Karraker, Horn, and Richards (2003) found no difference between adolescent never-smokers and smokers, but adolescents who had experimented with smoking were significantly more impulsive than both other groups on a probability discounting task; Reynolds et al. suggest that impulsivity is associated with experimenting with smoking, rather than becoming a regular smoker. Conversely, Reynolds et al. (2004) found that adolescent smokers demonstrated lower impulsivity on the DDT and lower self-reported impulsivity than did adult smokers, suggesting that cigarette consumption may lead to higher impulsivity. Bickel et al. (1999) noted that while smokers' performance was indicative of elevated impulsivity, never-smokers and ex-smokers did not differ, suggesting either that smoking produces a reversible increase in discounting, or – as indicated in other research findings - that more impulsive smokers are less likely to succeed in quitting. Skinner et al. (2004) likewise found that current smokers were higher on self-reported impulsivity than ex-smokers. Thus, while smokers are consistently found to be more impulsive on the DDT, existing data do not clarify whether the association is causal, or which mechanisms underlie this connection.

Risk factors for occasional smokers

Very few studies have examined occasional smokers on measures of impulse control. Kassel et al. (1994) compared regular smoker, chippers, and non-smokers on personality measurers. Non-smokers were more socially inhibited and lower in sensation seeking than the other two groups; smokers were more impulsive than either chippers or non-smokers. Heyman and Gibb (2006) reported that regular smokers were more impulsive on a delay discounting task and scored lower on self-reported self-control than both chippers and non-smokers.

Wellman, DiFranzam and Wood (2006) noted that chippers reported lower nicotine dependency, and that their perceived level of autonomy over smoking was higher than for regular smokers. Early studies of chippers revealed them to be less sensitive to nicotine, and to report fewer negative experiences when first exposed to nicotine than regular smokers (Shiffman, 1989; Shiffman, Kassel, Paty, Gnys, & Zettler-Segal, 1994). Various studies have shown that chippers are more likely to emphasise appetitive motives and social motives than regular smokers (Shiffman et al., 1994) – implicating the involvement of approach-like behaviour – and that they appear not to experience withdrawal symptoms (Shiffman, 1989) or the changes in cognitive performance, mood, or arousal typically observed in smokers during abstinence (Shiffman, Paty, Gnys, Elash, & Kassel, 1995). There is also evidence that relatives of chippers are less likely to be nicotine-dependent, more likely to also be chippers, and more likely to be successful at quitting, suggesting that there may be a genetic component to being non-dependent cigarette use (O. F. Pomerleau, 1995).

Predictor variables in the present study

This study includes the three self-report indices derived in Chapter 2 to index approach, avoidance, and control - '**Trait-Approach**', '**Trait-Avoidance**', and '**Trait-Control**' – and measures from four laboratory task measures described in Chapters 2 and 3. Spinella (2002) found that the number of inhibition errors on a **Go-No Go task** (GNG) was positively correlated with the number of cigarettes smoked. Pettiford et al. (2007) found that abstinence-induced performance deficits on an **antisaccade task** (AST) in smokers correlated with trait impulsivity measures. A series of studies have demonstrated elevated impulsivity in smokers using a **delay discounting task** (DDT) (e.g. Bickel et al., 1999; Bickel et al., 2008; S. Mitchell, 1999; B. Reynolds et al., 2007). Finally, Xiao et al. (2008) found that performance on the **Iowa Gambling Task** (IGT) was predicted by past smoking behaviour. All four of these measures have therefore been linked with smoking in past research.

As the previous sections demonstrate, there is consistent evidence for the involvement of approach and control processes in the link between impulsivity and smoking; however, there is less consistent evidence regarding the role of avoidance. On the one hand, Pomerleau et al. (1992) found positive associations between smoking and harm avoidance (HA), while Etter et al. (2003) reported lower HA in never-smokers than smokers. As was discussed in Chapter 3, highly anxious individuals may seek the perceived anxiolytic effects of substance use, which may explain the inconsistency in findings. Despite associations between anxiety and indices of the avoidance system, analyses in Chapter 3 found no evidence for a curvilinear relationship between avoidance and substance use in the same sample that is included in the analyses in this chapter. While it is acknowledged that a curvilinear relationship between smoking and anxiety may exist in the wider population, it is hypothesised here that an underactive, rather than overactive avoidance system will serve as the stronger risk factor for smoking.

Occasional smokers appear to be less impulsive than smokers. Some studies have suggested that this may be due to lower sensation seeking, implicating the approach system; others note higher self-control and less impulsivity on tasks argued in this thesis to tap control processes (i.e. the DDT), implicating the control system; still others suggest that occasional smokers are less sensitive to nicotine, and specifically to its initial aversive effects, which implies that factors unrelated to impulse control may differentiate between dependent smokers, and non-daily or low-rate cigarette users. There is a paucity of research considering specific aspects of impulsivity among occasional smokers and no studies were found that were concerned with avoidance amongst occasional smokers. However, given that occasional smokers are typically found to be less impulsive, it is hypothesised here that occasional smokers will be lower in approach and higher in control and avoidance than regular smokers.

Purposes of the current study

The objectives of this study are twofold: firstly, data from the student sample will be used to test hypothesised associations between various smoking indices and individual measures of attitudinal variables, life stress, and the various facets of impulse control. Secondly, regression analyses will assess the combined influence of predictors found to be individually associated with smoking.

Smoking measures

A variety of smoking indices are employed. Responses concerning cigarette use from the Alcohol, Smoking and Substance Involvement Screening Test (WHO ASSIST Working Group, 2002) yielded three indices: 1) '**ASSIST-Use**', indicating whether the individual has ever smoked; 2) '**ASSIST-Freq**', reflecting current smoking frequency; and 3) '**ASSIST-Prob**', a measure of the level of harm/ problems associated with smoking. Additionally, participants who reported ever smoking completed the Fagerstrom Test of Nicotine Dependence ('**FTND**'; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991).

Study hypotheses

The predictor and outcome variables previously described will be used to test the following hypotheses:

Level 1: Attitudinal factors

I. The perceived riskiness of smoking (Riskiness-Smoking) will be negatively associated with smoking indices.

II. Higher future smoking intentions (Smoking-Intentions) will be positively associated with smoking indices.

III. Higher future Smoking-Intentions will be positively associated with approach, and negatively associated with avoidance and control.

IV. Students reporting religious affiliations that prohibit or restrict substance use (Religious Restrictions) will, on average, score lower on all smoking indices.

Level 2: Life Stress

V. Smoking indices will be positively associated with higher Life Stress.

Levels 3 & 4: Competing impulses & Control

VI. Smoking indices will be positively associated with higher approach, lower avoidance, and lower control.

Method

Participants

This study analyses smoking data from the 408 undergraduate students previously described in Chapter 3. Attitudinal and Life stress data are available for London participants only.

Design and Analyses

This is a cross-sectional study, exploring interrelationships between self-reported smoking, three attitudinal measures, a measure of life stress, and three self-report and ten laboratory task indices of the approach, avoidance, and control systems.

As argued with respect to alcohol and illicit drug use in Chapter 3, it is likely that participants who completely refrain from smoking differ qualitatively from individuals who have ever smoked. Consequently, while analyses of differences between ever and never smokers will be addressed within the whole sample, tests of associations with smoking status and smoking frequency (ASSIST-Freq) will only be assessed among ever-users. Analyses exploring associations with indices of problem use or dependency (ASSIST-Prob and FTND) will include only current smokers.

A variety of analytic techniques will be used to test individual associations between predictor variables and smoking indices. These are summarised in Table 4.35 on page 177. Where directional hypotheses are made, one-tailed tests ($p<0.10$) are used; two-tailed tests ($p<0.05$) are used for all other analyses. Conservative Bonferroni corrections are used to correct the p-value to account for multiple comparisons; the corrected significance levels are presented in footnotes throughout the text. Emboldened text is used in tables to highlight all results that reach conventional significance levels ($p<0.05$). SPSS Version 14 is used in all analyses.

Measures

a) Cigarette use measures

Alcohol, Smoking and Substance Involvement Screening Test (WHO ASSIST Working Group, 2002) - page 101

The ASSIST is a structured interview, in which lifetime use of a range of substances is assessed. Only selected responses related to cigarette use are used here: Firstly, yes/no responses to Q1 ("In your life, which of the following substances have you ever used?") are used to identify all participants who have ever used cigarettes ('ASSIST-Use'). Secondly, responses to Q2 ("In the past three months, how often have you used cigarettes?") indicate the frequency of current cigarette use ('ASSIST-Freq'). Thirdly, responses to Q4 ("During the past three months, how often has your use of cigarettes led to health, social, legal or financial problems?") reflect the frequency of problem cigarette use ('ASSIST-Prob'). Responses for ASSIST-Freq and ASSIST-Prob are scored as follows: 0=never, 1=once/twice, 2=monthly, 3=weekly and 4=daily/almost daily.

Fagerstrom Test of Nicotine Dependence (FTND)(Heatherton et al., 1991)

The FTND is a six-item standard questionnaire widely used to assess nicotine dependency. Responses are scored and summed: conventionally, from a maximum score of ten, scores above six indicate high dependency, a score of five indicates moderate dependency, scores of three or four indicate low dependency, and scores of two or less indicate very low [or no] dependency (Storr, Reboussin, & Anthony, 2005). Only participants who had ever smoked were asked to complete the FTND.

b) Attitudinal indices

Perceptions of riskiness associated with substance use ('Riskiness': EIB, 2008) – page 106

Participants reported the amount of risk (no risk=0, small risk=1, moderate risk=2, or great risk=3) associated with the a) occasional or b) frequent use of 12 substances. The two responses were moderately correlated [Spearman's Rho=0.59, $p<0.001$] and, for simplicity, in the present study riskiness ratings for occasional and frequent cigarette use are combined to produce a single 'Riskiness-smoking' score (max. score 6).

Intentions to engage in substance use ('Intentions': EIB, 2008) – page 107

Responses regarding intentions to smoke ranged from "No, I definitely do not intend to try this substance" (scored 0) to "Yes, I definitely intend to try this substance" (scored 4).

Religious-Restrictions – page 107

The dichotomous variable 'Religious-Restrictions' (restricted vs. unrestricted) indicates whether participants report religious prohibitions over substance use or not.

c) Life stress

The Revised Life Changes Questionnaire (RLCQ; Miller & Rahe, 1997) (page 108) quantified the cumulative magnitude of stressful life events occurring in the 12 months prior to assessment.

d) Trait and laboratory indices of approach, avoidance, and control

As described in Chapter 2, factor analysis was earlier used to extract self-report indices of approach, avoidance, and control systems, here referred to as Trait-Approach, Trait-Avoidance, and Trait-Control. Additionally, ten indices were obtained from four laboratory tasks: a Go-No Go (GNG) task, an oculomotor antisaccade task (AST), the Iowa Gambling Task (IGT), and a delay discounting task (DDT) - see pages 64-69 for full descriptions of the tasks and their derived indices.

GNG Reward expectancy and GNG Reward responses are proposed indices of the approach system; GNG Punishment expectancy and GNG Punishment responses are proposed indices of the avoidance system; and GNG Reversal expectancy, GNG Reversal responses, IGT-Net Score, DDT-Discounting Rate, AST-accuracy, and AST-Interference are all proposed indices of the control system.

e) Demographics

Age, gender, and ethnicity data for these participants are detailed in Chapter 3.

Procedure

The full testing procedure is described in Chapter 2. Participants were asked to abstain from alcohol and drug use for 12 hours prior to testing, and from smoking cigarettes or consuming caffeine for 90 minutes prior to testing. The latter precaution was taken to minimise any effect that recent stimulant exposure might have on performance in the cognitive tasks. For logistical/cost reasons, compliance with these requests was not verified via any objective measurement.

....

Results

Data screening

Prior to analysis, all variables were screened for missing data and assumptions of univariate and multivariate normality. Chapter 2 describes data screening for indices of approach, avoidance, and control, after which 408 of the original 496 cases were retained. All had complete data for Trait-Approach, Trait-Avoidance, and Trait-Control; 315 had GNG task data, 124 AST data, 160 DDT data, and 274 IGT data.

Attitudinal and life stress data are available only for London participants. Of the 165 London cases, two participants were missing more than 5% of items on Riskiness-Smoking, one participant did not provide information on religious restrictions, and, due to experimenter error, 24 participants did not provide data on Life Stress. All of these cases were retained, but were excluded from analyses that involved measures for which they were missing data.

One Brisbane case was identified as a multivariate outlier and another Brisbane participant did not provide any data on cigarette use; these latter two cases were excluded, leaving 243 Brisbane participants and 408 cases in total.

Descriptive Statistics

The 165 London participants comprised 40 male (24.2%) and 125 female (75.8%) students, aged 18 to 22 (mean 19.0 years; s.d. 1.0); the 243 Brisbane participants comprised 68 male (28.0%) and 175 (72.0%) female student, aged 17 to 25 (mean 19.5 years, s.d. 2.0). The combined sample comprised 108 men (26.5%) and 300 women (73.5%), aged between 17 and 25 (mean 19.30 years, s.d. 1.7). Chapter 3 provides descriptive statistics for ethnicity and socio-economic status (Tables 3.6 & 3.7).

Attitudinal indices and Life Stress

Riskiness-Smoking scores ranged from zero to six (*n*=165) and the mean score was 3.84 (s.d.=1.4), which corresponds to a moderate-to-high level of perceived risk. Life Stress scores ranged from zero to 1171 (*n*=141) and the mean score was 459.74 (s.d.=217.0). Thirty-nine participants of the 164 on whom data were available reported religious restrictions. Figure 4.32 presents Smoking-Intentions data, which as can be seen were not normally distributed. They are analysed non-parametrically.

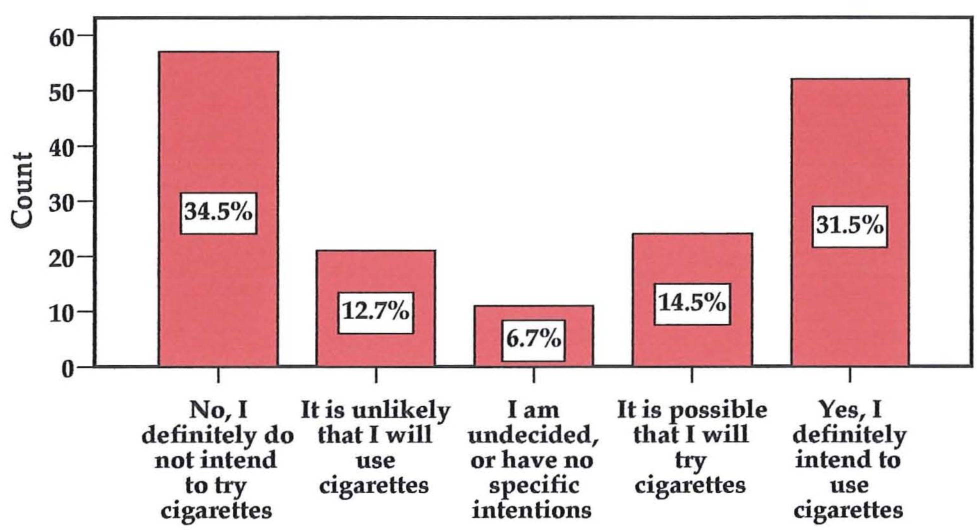


Figure 4.32: Smoking-Intentions data (n=165)

Impulse control

Descriptive statistics for all indices of impulse control are presented in Table 4.33. Only the GNG task indices were not normally distributed and are thus analysed non-parametrically.

Table 4.33: Descriptive statistics for indices of the approach, avoidance, and control systems.

	Range	*n*	mean	s.d.
Indices of the approach system				
Trait-Approach	-2.4 – 2.5	408	0.03	0.84
GNG Reward expectancy	0.0 – 0.7	315	0.12	0.16
GNG Reward responses	0.0 – 0.7	315	0.09	0.13
Indices of the avoidance system				
Trait-Avoidance	-2.0 – 2.4	408	0.02	0.93
GNG Punishment expectancy	0.0 – 0.7	315	0.13	0.15
GNG Punishment responses	0.0 – 1.0	315	0.20	0.22
Indices of the control system				
Trait-Control	-2.3 – 2.3	408	0.00	1.00
GNG Reversal expectancy	0.0 – 0.6	315	0.08	0.11
GNG Reversal responses	0.0 – 0.7	315	0.12	0.16
IGT Net Score	-68.0 – 82.0	274	11.98	28.93
AST Accuracy	0.0 – 102.5	125	47.35	19.75
AST Interference	-0.1 – 0.25	125	0.10	0.06
DDT Discounting Rate	-2.7 – 0.7	160	-1.30	0.68

GNG=Go-No Go; IGT=Iowa Gambling Task; AST=Antisaccade Task; DDT=Delay discounting Task

Smoking measures

ASSIST-Use

Overall, 280 participants (68.6%) reported ever using cigarettes, while 128 (31.4%) reported never smoking even a single cigarette. Analyses of all other smoking indices are restricted to 'ever' smokers (*n*=120 in the London sample and *n*=160 in the Brisbane sample).

ASSIST-Freq

Figure 4.33 presents smoking frequency data among the 280 ever smokers, 120 from London and 160 from Brisbane.

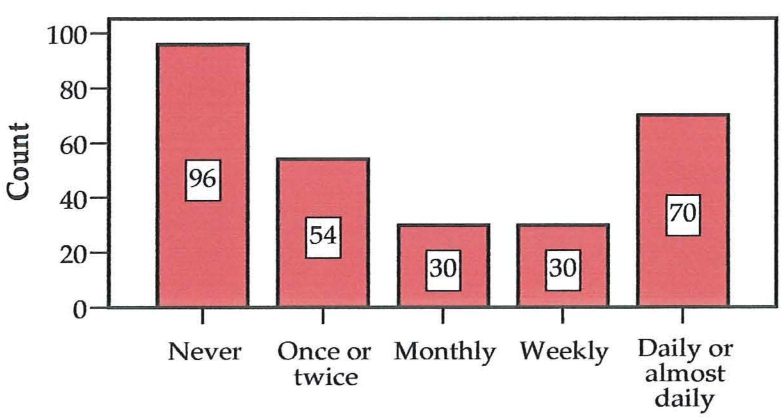


Figure 4.33: Current smoking frequency (n=280)

A third did not currently smoke, while 184 reported some cigarette use in the previous three months and 70 reported smoking daily or almost daily. ASSIST-Freq data were not normally distributed and non-parametric analyses are used.

ASSIST-Prob

ASSIST-Prob data are analysed only within the 184 current smokers (i.e. ASSIST-Freq>0); of these, 43 reported some problems (i.e. failure to do something that is expected of his/her, failure to stop/cut down smoking) as a result of smoking: six reported experiencing problems daily/almost daily, 15 weekly, and 22 occasionally. Given these low response frequencies, participants were dichotomised into 'problem smokers' (n=43) with any frequency of problem use, or 'no-problem smokers' (n=141).

FTND

Among ever smokers, FTND scores ranged from zero (91.8%) to seven. Only two smokers scored in the 'high dependency' range; one participant's score indicated 'moderate dependency' and six scored in the 'low dependency' range. The remaining participants' scores reflect very low, or no dependency. Specifically, only 15 participants reported smoking more than 10 cigarettes per day. Overall, these scores suggest very few highly or moderately dependent smokers in the present sample. Given the small amount of variability in FTND scores, predictors of these data were not investigated.

London and Brisbane site-differences

There was no significant difference in the proportion of participants who had ever smoked [72.7% vs. 65.9%; $\chi^2(1)=2.16$, *ns*]. Table 4.34 summarises ASSIST-Freq data among ever-smokers for the two sites.

Table 4.34: ASSIST-Freq for London and Brisbane sites

	London		Brisbane	
ASSIST-Freq				
Never	33	27.5%	63	39.4%
Once or twice	17	14.2%	37	23.1%
Monthly	11	9.2%	19	11.9%
Weekly	18	15.0%	12	7.5%
Daily or almost daily	41	34.2%	29	18.1%
Total	*120*		*160*	

London participants smoked more frequently than Brisbane participants [Mann-Whitney U=16374.5, p=0.001], but there were no significant differences in ASSIST-Prob scores [Mann-Whitney U=19463.5, *ns*].

Planned analyses

Table 4.35 summarises all planned analyses in the order in which they will be reported. For Hypothesis III, associations between intentions to smoke and indices of approach, avoidance, and control are assessed using Spearman correlations.

Table 4.35: Planned analyses for tests of Hypotheses I to VI (excluding Hypothesis III)

Hypotheses	ASSIST-Use *Ever vs. Never*	ASSIST-Freq *Never (0) to Daily/almost daily (5)*	ASSIST-Prob *No problem vs. Problem*
I. Riskiness-smoking will be negatively associated with smoking	T-Test	Correlation	T-Test
II. Smoking-intentions will be positively associated with smoking	M-W *U* test	Correlation	M-W *U* test
IV. Students reporting Religious Restrictions will score lower on all smoking measures	χ^2 test	M-W *U* test	χ^2 test
V. Smoking measures will be positively associated with higher Life Stress.	T-Test	Correlation	T-Test
VI. Smoking measures will be positively associated with indices of approach.			
Trait-Approach	T-Test	Correlation	T-Test
GNG Reward indices	M-W *U* test	Correlation	M-W *U* test
VI. Smoking measures will be positively associated with lower indices of avoidance.			
Trait-Avoidance	T-Test	Correlation	T-Test
GNG Punishment indices	M-W *U* test	Correlation	M-W *U* test
VI. Smoking measures will be positively associated with lower indices of control.			
Trait-Control	T-Test	Correlation	T-Test
GNG Reversal indices	M-W *U* test	Correlation	M-W *U* test
IGT Net Score	T-Test	Correlation	T-Test
AST indices	T-Test	Correlation	T-Test
DDT Discounting Rate	T-Test	Correlation	T-Test

MW *U* test = Mann-Whitney *U* test; KW test= Kruskall Wallace test; ANOVA=analysis of variance.

Levels 1: Attitudinal factors

Hypothesis I: Perceived risks for smoking (Riskiness-smoking) will be negatively associated with smoking (London sample, *n*=165).

Table 4.36 presents analyses testing associations for Riskiness-smoking with ASSIST-Use in the whole London sample, with ASSIST-Freq among ever smokers, and with ASSIST-Prob among current smokers.

Table 4.36: Analyses of associations between perceived riskiness and smoking indices

	n	Riskiness-Smoking	
ASSIST-Use *(120 ever vs.45 never smokers)*	165	t(163)=1.36	*p=0.179*
ASSIST-Freq	120	Rho=-0.13	*p=0.164*
ASSIST-Prob *(69 non-problem vs. 18 problem smokers)*	87	t(85)=-0.26	*p=0.795*

*Correlation is significant at $p<0.025$ [†]

There were no significant associations between the perceived riskiness of smoking and any of the smoking indices; these data thus provide no support for the hypothesis.

Hypothesis II: Higher future smoking intentions (Smoking-intentions) will be positively associated with smoking (London sample, *n*=165).

Table 4.37 presents analyses of associations between smoking and Smoking-Intentions.

Table 4.37: Analyses of associations between smoking intentions and smoking indices

	n	Smoking-Intentions	
ASSIST-Use *(120 ever vs.45 never smokers)*	165	*U*=996.0	***p=0.000****
ASSIST-Freq	120	Rho=0.64	***p=0.000****
ASSIST-Prob *(69 non-problem vs. 18 problem smokers)*	87	*U*=430.5	***p=0.026****

*Correlation is significant at $p<0.025$ [†]

As expected, ever-smokers reported significantly stronger smoking intentions than never-smokers; there was a moderately strong positive significant correlation between intentions and smoking frequency among ever smokers; and current smokers with problems reported significantly stronger smoking intentions than current smokers without problems.

[†] Bonferroni-correction: $p<0.10$ divided by 4 analyses given $p<0.025$ (one-tailed)

Hypothesis III: Higher future smoking-intentions will be positively associated with approach, and negatively associated with avoidance and control (London sample, *n*=165).

It was hypothesised that more impulsive individuals would report stronger intentions to smoke. Table 4.38 presents the Spearman correlations between approach, avoidance and control indices and smoking intentions in the 120 London ever-smokers.

Table 4.38: Spearman correlations between Smoking-Intentions and indices of impulse control.

	n	*Rho*	p^{α}
Indices of approach			
Trait-Approach	**120**	**0.19**	***0.035***
GNG Reward expectancy	120	-0.16	*0.082*
GNG Reward responses	120	-0.07	*0.475*
Indices of avoidance			
Trait-Avoidance	120	0.13	*0.147*
GNG Punishment expectancy	120	0.12	*0.206*
GNG Punishment responses	120	0.18	*0.052*
Indices of control			
Trait-Control	120	-0.14	*0.131*
AST Accuracy	95	-0.10	*0.325*
AST Interference	95	-0.08	*0.462*
DDT Discounting Rate	118	0.11	*0.233*
IGT Net Score	117	0.09	*0.324*
GNG Reversal expectancy	120	0.02	*0.814*
GNG Reversal responses	120	0.00	*0.968*

After conservative Bonferroni corrections were applied, there were no significant correlations. Consistent with hypotheses, there was a slight trend for participants with stronger smoking intentions to score higher on Trait-Approach; however, there were no associations with Trait-Avoidance or Trait-Control. Overall, there was very little support for the hypothesis that impulsivity would be associated with more positive intentions to engage in future smoking.

Hypothesis IV: Students reporting religious affiliations that restrict substance use (Religious Restrictions) will, on average, score lower on all smoking measures.

Participants in the London sample were categorised as either 'religion-restricted' (*n*=39) or 'no religion-restriction' (*n*=125). Table 4.39 presents the results of analyses testing

[α] Bonferroni-correction: *$p<0.10$ divided by 13 analyses gives $p<0.0077$- one-tailed* differences between these two groups on ASSIST-Use among all London participants, on ASSIST-Freq among ever smokers, and on ASSIST-Prob among current cigarette users.

Table 4.39: Analyses of associations between religious restrictions and smoking indices

	Religious-Restrictions (restricted vs. not restricted)	
ASSIST-Use *(120 ever,.44 never smokers)*	17.5% of ever vs. 40.9% of never smokers	$\chi^2(1)$=9.34 ***p=0.002****
ASSIST-Freq	Mean ranks: 63.5 vs. 59.9	*U*=976.5 *p=0.652*
ASSIST-Prob *(69 non-problem, 18 problem smokers)*	82.6% of non-prob. vs. 77.8% of prob. smokers	$\chi^2(1)$=0.22 *p=0.638*

*Correlation is significant at *p<0.025* †; Religious-Restrictions is missing 1 case

Contrary to the hypothesis, restricted and unrestricted ever-smokers did not significantly differ on smoking frequency, nor was there any effect of religious-restrictions on whether current smokers experienced problems. However, consistent with the hypothesis, unrestricted students were 3.27 times more likely to have ever smoked than restricted students.

Hypothesis V: All smoking measures will be positively associated with higher Life Stress.

Table 4.40 presents analyses of associations between Life Stress and smoking indices.

Table 4.40: Analyses of associations between life stress and smoking indices

	Life Stress		
ASSIST-Use *(99 ever, 42 never smokers)*	Ever: mean=493.55, s.d.=196.5 Never: mean=380.05, s.d.=243.3	t(139)=-2.91	***p=0.004****
ASSIST-Freq		*Rho*=0.19	*p=0.060*
ASSIST-Prob *(58 non-problem,13 problem smokers)*	Non-Prob: mean=502.43, s.d.=193.3 Prob: mean=565.69, s.d.=216.7	t(69)=-1.04	*p=0.300*

*Correlation is significant at *p<0.025*†; Life stress is missing for 24 cases

While reported life stress in the previous 12 months was significantly higher among ever smokers compared to never smokers (see Figure 4.34 below), there was no significant association with any of the other smoking indices.

† Bonferroni-correction: *p*<0.10 divided by 4 analyses given *p*<0.025 (one-tailed)

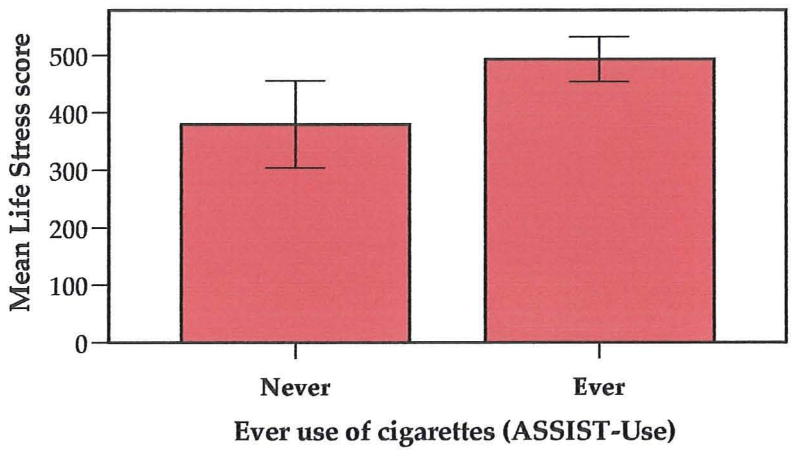


Figure 4.34: Life stress by ASSIST-Use (n=141)

Overall, there was support for the hypothesis that life stress would be associated with ever having used cigarettes, but no support for hypothesised associations with level of current use or problem use.

Levels 3 & 4: Approach, avoidance, and control systems

Hypothesis VI: Smoking will be positively associated with higher approach, lower avoidance, and lower control.

Table 4.41 presents analyses of associations between ASSIST-Use and indices of approach, avoidance, and control in the combined London and Brisbane samples (*n*=408), smoking status and ASSIST-Freq among ever-users (*n*=280), and ASSIST-Prob among current cigarette users (*n*=184).

After Bonferroni corrections were applied, ever smokers differed significantly from never smokers on Trait-Control. These data are shown in Figure 4.35 and, consistent with hypotheses, never smokers were significantly higher in Trait-Control than ever smokers.

Table 4.41: Tests of associations between indices of impulse control and smoking indices

	ASSIST-Use Ever smokers (*n*=280) vs. Never smokers (*n*=128)			**Smoking Status** Smokers (*n*=38) vs. ex-smokers (*n*=19) vs. occasional (*n*=64) vs. non-smokers (*n*=108)			**ASSIST-Freq** (*n*=280)			**ASSIST-Prob** No prob. smokers (*n*=141) vs. Prob. smokers (*n*=43)		
	n			*n*			*n*			*n*		
Indices of approach												
Trait-Approach	408	t(406)=-1.09	*p=0.278*	225	F(3,225)=1.33	*p=0.264*	280	*Rho*=0.05	*p=0.280*	184	t(182)=0.63	*p=0.529*
GNG Reward expectancy	315	***U*=8837.0**	***p=0.025***	180	$\chi^2(3)$=3.87	*p=0.276*	220	*Rho*=-0.18	*p=0.009‡*	145	*U*=1710.5	*p=0.622*
GNG Reward responses	315	*U*=9606.5	*p=0.216*	180	$\chi^2(3)$=1.58	*p=0.664*	220	*Rho*=-0.07	*p=0.317*	145	*U*=1619.0	*p=0.313*
Indices of avoidance												
Trait-Avoidance	408	t(406)=1.54	*p=0.124*	225	F(3,225)=0.33	*p=0.807*	280	*Rho*=-0.06	*p=0.311*	184	t(182)=-1.23	*p=0.221*
GNG Punishment expectancy	315	*U*=10329.5	*p=0.867*	180	$\chi^2(3)$=7.35	*p=0.062*	220	*Rho*=0.06	*p=0.360*	145	*U*=1719.5	*p=0.666*
GNG Punishment responses	315	*U*=10177.5	*p=0.704*	180	$\chi^2(3)$=2.22	*p=0.527*	220	*Rho*=-0.02	*p=0.751*	145	*U*=1507.0	*p=0.136*
Indices of control												
Trait-Control	408	**t(406)=-4.95**	***p=0.000****	225	F(3,225)=0.67	*p=0.572*	280	***Rho*=-0.15**	***p=0.012***	184	**t(182)=-2.57**	***p=0.011***
GNG Reversal expectancy	315	*U*=9739.0	*p=0.323*	180	$\chi^2(3)$=2.65	*p=0.448*	220	*Rho*=-0.04	*p=0.360*	145	*U*=1547.5	*p=0.203*
GNG Reversal responses	315	*U*=10444.5	*p=0.994*	180	$\chi^2(3)$=2.21	*p=0.531*	220	*Rho*=-0.06	*p=0.419*	145	*U*=1772.5	*p=0.862*
IGT Net Score	274	t(272)=-1.38	*p=0.169*	171	F(3,171)=0.81	*p=0.489*	197	*Rho*=-0.02	*p=0.760*	135	t(133)=0.60	*p=0.552*
AST Accuracy	125	t(123)=-1.12	*p=0.246*	91	F(3 91)=0.26	*p=0.854*	95	*Rho*=-0.11	*p=0.312*	71	t(69)=0.69	*p=0.495*
AST Interference	125	t(123)=1.02	*p=0.308*	91	F(3 91)=1.07	*p=0.366*	95	*Rho*=0.01	*p=0.962*	71	t(69)=0.21	*p=0.838*
DDT Discounting Rate	160	t(158)=-3.18	*p=0.002‡*	114	F(3 114)=2.32	*p=0.079*	118	*Rho*=0.01	*p=0.901*	85	**t(83)=-2.96**	***p=0.004****

*Test is significant at p<0.0077[α]; ‡ Result is in opposite direction to the 1-tailed hypothesis; *U* = Mann-Whitney *U* test; Rho=Spearman Rho correlation

[α] Bonferroni-correction: *p<0.10 divided by 13 analyses gives p<0.0077 (one-tailed)*

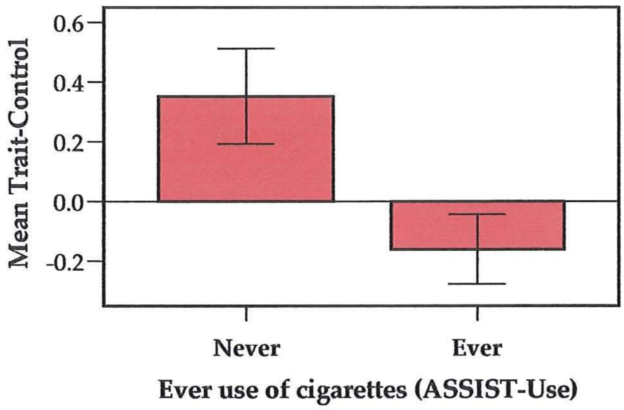
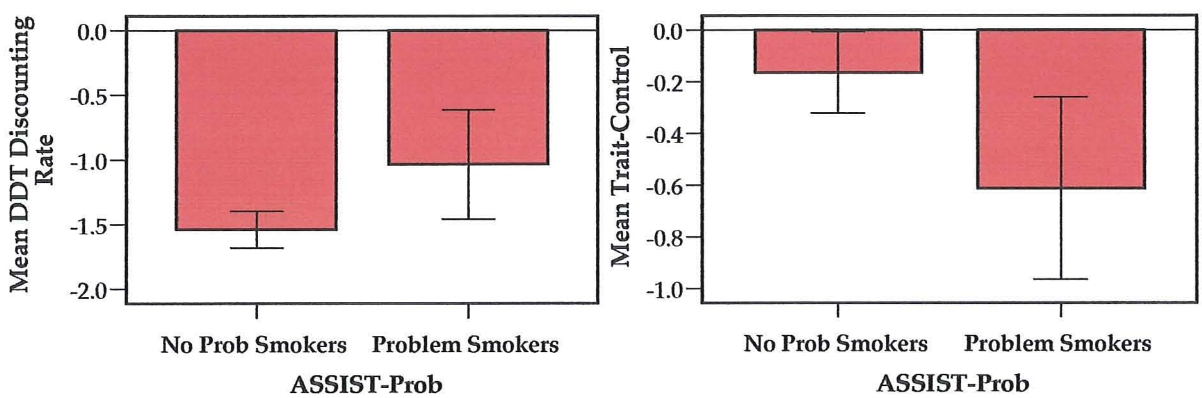


Figure 4.35: Trait-Control by ASSIST-Use (error bars = 95%)

There was also a slight trend for ever smokers to report stronger reward expectancies on the Go-No Go task than never-smokers, and trends for smoking frequency to correlate inversely with Trait-Control which are consistent with the hypothesis; however after Bonferroni corrections were applied, these associations fell short of significance, and both are therefore likely to be spurious.

As shown in Figures 4.36 and 4.37, problem smokers scored significantly higher on DDT Discounting Rate than non-problem smokers and showed a trend towards lower Trait-Control; both of these findings are consistent with hypotheses, though the latter should be treated tentatively.



Figures 4.36 & 4.37: Trait-Control and DDT Discounting Rates by ASSIST-Prob (error bars = 95%)

Combined predictors of smoking

Table 4.42 summarises the results of analyses just described of individual associations between measures of attitudinal factors, life stress, and indices of approach, avoidance, and control.

Table 4.42: Results of tests of Hypotheses I to VI (excluding Hypothesis III)

Hypothesis	ASSIST-Use	ASSIST-Freq	ASSIST-Prob
I. Perceived riskiness of smoking will be negatively associated with smoking.	×	×	×
II. Smoking intentions will be positively associated with smoking.	✓	✓	✓
IV. Students reporting Religious Restrictions will, on average, score lower on all smoking measures.	✓	×	×
V. All smoking measures will be positively associated with higher Life Stress.	✓	×	×
VI. Smoking will be positively associated with indices of approach.			
Trait-Approach	×	×	×
GNG Reward expectancy	*Trend*	×	×
GNG Reward responses	×	×	×
VI. Smoking will be positively associated with lower indices of avoidance.			
Trait-Avoidance	×	×	×
GNG Punishment expectancy	×	×	×
GNG Punishment responses	×	×	×
VI. Smoking will be positively associated with lower indices of control.			
Trait-Control	✓	*Trend*	*Trend*
GNG Reversal expectancy	×	×	×
GNG Reversal responses	×	×	×
IGT Net Score	×	×	×
AST Accuracy	×	×	×
AST Interference	×	×	×
DDT Discounting Rate	×	×	✓

✓= significant association; ×= no significant association; *Trend* = association not significant after Bonferroni correction

In this section, the combined influence of predictors previously found to be independently associated with individual smoking indices are tested in the London sample. Smoking-Intentions are not included in these analyses. As noted in Chapter 3, intentions to use drugs are likely to be intrinsic to current drug use. Thus, it is not theoretically interesting to include this variable as a predictor and indeed its inclusion may obscure associations with other variables.

Multinomial logistic regressions are used to test the combined predictors of ASSIST-Use and ASSIST-Prob, since all are ordinal and either dichotomous or non-normally distributed (only Trait-Control was associated with ASSIST-Freq and consequently this outcome measure was not analysed). A sequential approach was taken in each case: since relationships between smoking and indices of approach, avoidance and control are of most theoretical interest here, those predictors (from Levels 3 and 4 of the IIC framework) are entered first, followed by Life Stress (Level 2) and finally attitudinal factors (Level 1).

Steps have been taken to reduce the number of subpopulations and minimise missing cell frequencies: all continuous predictor variables have been re-scored into ranked quartiles, and variables that do not significantly contribute to each consecutive model after Bonferroni correction are excluded from subsequent analyses. Thus, sample sizes fluctuate between consecutive models for each dependent variable.

ASSIST-Use

As was shown in Table 4.42, ASSIST-Use was associated with Trait-Control (Level 4 of the IIC framework), GNG Reward Expectancies (Level 3), Life Stress (Level 2), and Religious Restrictions (Level 1). These were included sequentially as described above; the results are presented in Table 4.43.

Table 4.43: Sequential regressions examining predictors of ASSIST-Use

ASSIST-Use: Never smokers (n=45) vs. Ever smokers (n=120)					
	n	Model Pseudo R^2	Wald	Odds Ratio	p
Model 1	*160*	0.11			
Level 4: Trait-Control			11.95	1.82	***0.001****
Model 2	*164*	0.12			
Level 4: Trait-Control			10.45	1.79	***0.001*†**
Level 3: GNG Reward Expectancies			2.14	0.80	*0.144*
Model 3	*141*	0.17			
Level 4: Trait-Control			8.03	1.69	***0.005*†**
Level 2: Life Stress			5.43	0.65	***0.020*†**
Model 4:	*140*	0.23			
Level 4: Trait-Control			8.30	1.77	***0.004*‡**
Level 2: Life Stress			3.12	0.71	*0.077*
Level 1: Religious-Restrictions			6.00	0.35	***0.014*‡**
Final model:	*164*	0.19			
Level 4: Trait-Control			12.33	1.92	***0.000*†**
Level 1: Religious-Restrictions			7.94	3.17	***0.005*†**

Missing cases: GNG 1; Life Stress 25; Religious-Restrictions 1; R^2=Nagelkerke;
*Significant at *p<0.10 (1 tailed)*; †Significant at $p<0.05^{\alpha}$; ‡Significant at $p<0.025^{\alpha 2}$

[α] Bonferroni-correction: $p<0.10$ *divided by 2 analyses gives* $p<0.05$ *– one-tailed*
[α2] Bonferroni-correction: *p<0.10 divided by 3 analyses gives p<0.033 – one-tailed*

In the first model, Trait-Control significantly contributed to predicting ASSIST-Use. In the second, GNG Reward Expectancies did not explain significant additional variance, and so only Trait-Control was entered into the third model alongside Life Stress; here, both made significant independent contributions to prediction and were entered into a fourth model which additionally included Religious Restrictions. While this model was significant [$\chi^2(4)=29.49$, $p<0.001$] and explained approximately 28% of the variance in ASSIST-Use, only Trait-Control and Religious-Restrictions made significant unique contributions to prediction. A more parsimonious model was tested, including only these two variables; the model was significant [$\chi^2(2)=23.04$, $p<0.001$] and accounted for around 19% of the variance in ASSIST-Use, to which both variables made significant unique contributions. The likelihood of ever smoking roughly halved between increasing quartiles of Trait-Control scores and was three times higher among participants who reported no religious restrictions over their substance use.

ASSIST-Prob

As shown in Table 4.42, ASSIST-Prob was associated with Trait-Control and DDT Discounting Rate (Level 4). Table 4.44 presents sequential binary logistic regressions testing these variables as predictors of ASSIST-Prob in current smokers (i.e. participants reporting some cigarette use during the previous three months).

Table 4.44: Sequential regressions examining predictors of ASSIST-Prob

ASSIST-Prob: No Problem smokers (n=69) vs. Problem smoker (n=18)					
	n	Model Pseudo R^2	Wald	Odds Ratio	p
Model 1	*85*	0.21			
Level 4: Trait-Control			3.14	1.68	*0.076*
Level 4: DDT Discounting Rate			5.91	0.53	***0.015****
Model 2	*85*	0.15			
Level 4: DDT Discounting Rate			7.80	0.49	***0.005***'

Missing cases: DDT 2; R^2=Nagelkerke; * Significant at *$p<0.05^{\alpha}$*; Significant at *$p<0.010$- 1 tailed*

In the first model, DDT Discounting Rates and Trait-Control together significantly predicted ASSIST-Prob [$\chi^2(2)=12.16$, $p<0.005$], accounting for around 21% of the variance. However, only DDT Discounting Rates made a significant unique contribution to prediction; alone, this variable significantly predicted ASSIST-Prob

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[α] Bonferroni-correction: $p<0.10$ *divided by 2 analyses gives $p<0.05$ – one-tailed*

[$\chi^2(1)=8.73$, $p<0.005$], explaining around 15% of the variance. The likelihood that a smoker experienced problems related to their cigarette use doubled between increasing quartiles of DDT Discounting, suggesting that smokers in this sample who were more impulsive – i.e. exhibited a stronger preference for immediate, rather than delayed rewards – were more likely to report problems caused by their smoking.

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Discussion

The purpose of this study was to investigate the relationship between cigarette use and attitudinal factors, life stress, and impulse control by exploring the following research questions: Which risk factors are associated with whether an individual ever experiments with smoking? Which risk factors predict smoking frequency among current smokers? And which predict whether current smokers experience problems as a result of their cigarette use?

A sample of 408 young undergraduate students in London and Brisbane were assessed on a range of factors implicated at various levels of the Impulse, Intention, and Control (IIC) framework: perceived riskiness of smoking, intentions towards future smoking, and religious-restrictions against substance use (Level 1); the magnitude of recent life stress (Level 2); and trait measures and laboratory task indices of approach and avoidance (Level 3), and control (Level 4). Smoking measures were derived from responses to the Alcohol, Smoking, and Substance Involvement Screening Test (WHO ASSIST Working Group, 2002). Three smoking indices were employed within specific subgroups: ever-use of cigarettes (ASSIST-Use) was assessed in the whole sample (n=408); smoking frequency (ASSIST-Freq) was assessed among ever smokers (n=280); and problems associated with cigarette use (ASSIST-Prob) was assessed among current smokers (n=183). Associations between attitudinal, life stress, and impulse control predictors and smoking were first assessed individually, and subsequently the combined influence of individually significant predictors was assessed. The results of these analyses are summarised below.

Level 1: Attitudinal risk factors

To measure risk perception, individuals were simply asked to rate how risky (no risk=0 to great risk=3) they believed occasional and frequent smoking to be. Indices of smoking were expected to be positively associated with lower perceived riskiness of smoking, but there were no significant associations in the present sample between the perceived riskiness of cigarettes and whether they had ever smoked (n=165), the frequency of smoking among ever smokers (n=120), or whether current smokers experienced problems resulting from cigarette use (n=87). This lack of association is surprising, especially given the significant associations noted in Chapter 3 between risk perceptions of alcohol/illicit drugs and actual alcohol/illicit drug use in the same student group. The adverse health consequences and highly addictive nature of smoking are widely publicised and acknowledged - unlike alcohol, which may not be considered risky in small, socially acceptable quantities, or illicit drugs such as cannabis, for which there is wide debate as to the true harmful effects – so one explanation for the lack of association could be that the risks of smoking are less controvertible than the risks of alcohol/illicit drug use and that those individuals who smoke do so *despite* the strong risks associated with cigarette use, rather than as a result of their lower pre-existing risk perceptions. However, perceived riskiness scores were normally distributed around a mean of 3.84 - out of a maximum of 6 – with 60.6 per cent of participants scoring 4 or less, which undermines the assumption that participants unanimously perceived smoking to be very high-risk.

The findings indicate that whether an individual in this sample perceived smoking to be very risky or not at all risky had no bearing on their smoking behaviour, which directly contradicts studies reporting associations between smoking and its perceived riskiness (e.g. Hoving et al., 2007). Another explanation for this finding is that past experiences have differentially influenced risk perceptions in this group. Scores on the Fagerstrom Test of Nicotine Dependence (FTND)(Heatherton et al., 1991) indicate very low levels of smoking dependency, and since comparatively few smokers report problems resulting from their cigarette use (15.3% of ever smokers), smokers in this sample may perceive smoking to be low-risk *because* they have not been adversely affected by their own cigarette use; that is, perceptions may be more closely reflective of perceived experience than predictive of current behaviour. However, this does not explain why smokers who report problem cigarette use do not perceive smoking to be more risky than those who do not.

It was hypothesised that intentions to smoke would be positively associated with all smoking measures. There was strong evidence for this: stronger intentions to smoke were significantly associated with ever having smoked a cigarette (n=165), being a current vs. occasional and occasional vs. non-smoker (n=113), smoking more frequently (n=120), and experiencing problems associated with smoking (n=87). In Chapter 3, it was noted that intentions might be so closely related to current recreational substance use that close associations between them are inevitable and theoretically meaningless. While this is probably true for recreational illicit substance use, the vast majority of smokers want to quit (e.g. UK General Household Survey, 2006) and some dependent smokers would presumably therefore be expected to report intentions that conflict with their current behaviour. However, FTND scores indicated that very few smokers in this sample were dependent; thus there may have been few in such a state of conflict.

Interestingly, whereas no association was found in Chapter 3 between problematic illicit drug use and intentions to use drugs, a small positive association was noted here between smoking intentions and problem cigarette use. Although it may seem counterintuitive that smokers who have experienced the harmful effects of cigarettes report stronger intentions to smoke that those who haven't, it may reflect the onset of dependency with the desire to smoke outweighing any desire to avoid adverse repercussions. de Leeuw, Engels, Vermulst, and Scholte (2008) provided evidence that smoking can influence subsequent attitudes towards smoking; it is thus possible that smoking intentions here reflect higher smoking frequency, which is more likely to be associated with problems. Conflict between intentions and behaviour are at the heart of the IIC framework, and more fine-grained longitudinal research – perhaps in an adolescent sample that includes larger numbers of people who start smoking during the course of the study - is needed to disentangle the temporal associations between them.

It was also hypothesised that having religious affiliations which restricted substance use would be negatively associated with smoking measures. There was some evidence for this, since students reporting restrictive religious affiliations were significantly less likely to report ever having smoked a cigarette. However, religious restrictions were not associated with smoking frequency in 120 ever-users, or problem use in 87 current smokers. These findings suggest that religiosity may be protective against smoking initiation or experimentation, but that it does not protect against high levels of use, or problem use, once smoking is initiated. This finding parallels Patock-Peckham, Hutchinson, Cheong, and Nagoshi's (1998) finding that religiosity was associated with less alcohol *use*, but did not affect the incidence of *abuse*. Elsewhere it has been noted that religiosity is most strongly associated with reduced drinking only when accompanied by a personal religious commitment (e.g. Galen & Rogers, 2004), and it seems logical to presume that individuals whose religious commitment did not successfully deter them from substance use initiation or experimentation may also be less likely to be deterred from increasing their substance use to levels that lead to adverse consequences. However, it should be noted that only 21 of 39 participants (53.8%) with religious-restrictions reported ever smoking (vs. 99 out of 125 [79.2%] without), so it may be that this subgroup was too small to enable the detection of more subtle associations.

Level 2: Life Stress

Life Stress was expected to be positively associated with all smoking indices, and the magnitude of stressful life events in the previous 12 months was indeed significantly higher among those who reported ever smoking than never smoking (n=141), but was not significantly associated with smoking frequency in 99 current smokers, or problem cigarette use. Thus, the pattern of results was similar to that for religiosity: there were associations with smoking initiation or experimentation, but not with level of use or problem use. There were however tentative signs of a small association (r=0.19, p=0.06) with smoking frequency.

Prospective research suggests that life stressors are temporal precursors of smoking initiation (Booker et al., 2008; Roberts et al., 2008) and there are several explanations for this association. At a situational level, stressful life events may be related to socio-demographic factors that themselves are associated with an increased risk of smoking: for example almost half of unemployed respondents were smokers in the report "Statistics on Smoking: England, 2007". At a cognitive/behavioural level, stress reduction theories suggest that some individuals turn to cigarette use in the belief that smoking will reduce stress (Feldner et al., 2007), and at the neurochemical level, animal studies have demonstrated that repeated exposure to stressors affects hypothalamic-pituitary-adrenal (HPA) axis functioning in a way that directly influences physiological responses to nicotine (Lutfy et al., 2006). Given findings such as this, it is interesting that associations were not found here between life stress and smoking frequency/problem use in the subgroup of current smokers. However, these results should be interpreted with caution, given the small number of probable dependent smokers in the sample.

Levels 3 & 4: The approach, avoidance, and control systems

The IIC framework articulates clear hypotheses regarding associations between smoking and indices of approach, avoidance and control.

Higher approach is expected to be linked with higher smoking; however, after Bonferroni corrections were applied, there were no significant associations between any of the smoking indices and the derived trait measure of approach (n=408) or the behavioural measures (the two GNG indices).

With respect to avoidance, it was hypothesised that a negative association would be found on the basis that an under-active avoidance system should reduce the likelihood of being deterred from smoking by the harm associated with it. However, there were no associations between either trait (n=408) or GNG punishment task indices (n=315) and smoking. As noted in the introduction, there have been inconsistent findings regarding associations between harm avoidance and smoking in previous research (e.g. Etter et al., 2003; C. S. Pomerleau et al., 1992). There were significant positive associations between smoking and intentions to smoke in the present sample, but no associations with the perceived riskiness of smoking; one might have therefore expected there to be little association with avoidance, given that these students' smoking behaviour appears to be more closely associated with their intentions than with concerns about the detrimental effects of their behavior. Perhaps stronger associations would be obtained in a sample that includes more dependent – and therefore presumably less controlled – smokers.

Higher Trait-Control was significantly – or near-significantly - associated with a reduced likelihood of ever smoking, less frequent smoking in the 280 current smokers, and a lower likelihood of experiencing problem use. These significant associations are all consistent with the hypothesis that individuals with higher control will be better able to refrain from smoking, be more likely to control their cigarette use, and thus be less likely to experience smoking-related problems.

Associations with laboratory tasks which tap behavioural control were less consistent with hypotheses. There were no associations between smoking and performance on the Iowa Gambling Task (IGT; n=274) which is purported to index cognitive impulsivity, on the oculomotor antisaccadic task (AST; n=125), a purported index of inhibitory control, or on the reversal indices from the GNG task (n=315). There were, however, associations with performance on the delay discounting task (DDT), which is argued to tap an individual's ability to delay gratification. Discounting rates were significantly higher for 18 problem smokers than 67 non-problem smokers. This finding is in keeping with hypotheses, in that participants who were more responsive to short term rewards were more likely to report problem smoking. This makes sense, given that one of the features of nicotine dependence according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 2000) is continued smoking despite problems caused or exacerbated by smoking; thus, the smoker pursues the immediate reward of smoking, rather than the longer term health and financial benefits of abstinence or quitting.

Additionally, associations were explored for indices of approach, avoidance, and control, with intentions to smoke. After Bonferroni corrections were applied, there were no significant associations; however, there was a trend ($p<0.05$) towards a positive association between smoking intentions and Trait-Approach. This trend is consistent with the hypothesis that higher approach drives will increase the likelihood that an individual will be attracted to the idea of smoking, although the lack of any association between approach and actual smoking may suggest that other factors become more relevant to the behavioural decisions.

The combined influence of individual risk factors

Sequential regressions were used to explore the combined influence of individually significant predictors. When applied to individual predictors of ever-use of cigarettes, the most powerful model included the trait measure of control, life stress, and religious-restrictions. Together these variables accounted for around 23% of the variance in whether the 140 individuals on whom complete data were available had ever used cigarettes. However, life stress did not make an independent contribution and a more parsimonious model (explaining around 19% of the variance in ever use) included only Trait-Control and religious restrictions. While the amount of variance explained by these variables is relatively modest, the findings do demonstrate the value of considering factors from multiple levels of analysis. Clearly, further research is needed to identify factors accounting for the remaining variance in cigarette use.

Trait-Control and DDT discounting rates were both individually associated with whether or not participants had problems due to smoking. When entered together into regression analyses, they significantly accounted for around 21% of the variance in 85 current smokers; however, Trait-Control did not make a significant unique contribution to this model and, alone, discounting rates accounted for around 15% of the variance. Thus, of all the predictors included in this study, a smoker's ability to delay hypothetical monetary gratification was the single strongest predictor of whether he or she experienced problems resulting from their cigarette use; as previously noted, the inability to focus on long-term consequences of one's behaviour closely mirrors central features of nicotine dependency. Trait-Control is likely to tap more general control processes than those tapped by the DDT, and together these measures emphasise the importance of control processes in problem smoking. Clearly, the causal nature of this association needs further exploration, but this finding points to key psychological processes that might be pinpointed by future research and therapeutic or policy-based interventions.

Risk factors for occasional smokers

One aim of this study was to explore risk factors for occasional smoking, to understand which factors may differentiate between individuals who do and do not become dependent cigarette users. However, scores on the Fagerstrom test for nicotine dependence (FTND) indicated very low levels of nicotine dependency in cigarette users. Trends towards individual associations were only found between smoking frequency and Trait-Control. Given the range of variables initially implicated in differences between occasional and regular smokers, it is surprising that only one variable was found to be very modestly associated with frequency of smoking. It is highly likely that the low numbers of dependent smokers in this sample has strongly influenced these results, and replication of this study in a sample that includes a representative proportion of smokers would be needed to more fully explore predictors of occasional vs. regular smoking.

Study Limitations

Given that one of the aims of this study was to identify factors associated with occasional vs. dependent smoking, a major limitation of this research is the small number of dependent smokers in the sample. The age range and education level of the sample was deliberately restricted; while the homogeneous nature of the group is a strength, this does mean that the findings reported here cannot be extrapolated to the population as a whole.

Another concern is the presence of poly-drug users in this sample; in Chapter 3 – which included the same 408 participants – it was found that 147 students were currently using one or more illicit drug; moreover, 75 reported some binge-drinking. Associations with smoking reported in this chapter did not take into account the influence of alcohol/illicit drug use because the study was not adequately powered to do so. However, given the prevalence of poly-drug use, it could be argued that this does provide a more representative sample, since the analysis of only non-drug users or non-bingers would provide findings of limited real world significance. The Spearman correlation between overall alcohol use (AUDIT-Total) and smoking frequency in the present sample (n=408) was 0.37, suggesting around 13% shared variance, and the Spearman correlation between smoking frequency and the frequency of illicit substances use (ASSIST-Freq) was 0.54, suggesting nearly 30% shared variance. Given these associations, polydrug use may have somewhat inflated the correlations reported in the present study, since smoking is mildly associated with greater alcohol consumption and modestly associated with illicit drug use in this sample.

Conclusions

This study has examined a range of variables that have been previously implicated or would be expected under the assumptions of the IIC framework to be associated with smoking. Surprisingly, the perceived riskiness of smoking was not associated with smoking behaviour, while smoking intentions were significantly associated with all aspects of smoking. Both religious-restrictions and life stress were associated with ever-use of cigarettes but neither was associated with smoking frequency or whether problems resulted from smoking, suggesting that these factors are related to smoking initiation/experimentation but not to continuation/dependency. There were no meaningful associations between indices of approach or avoidance and smoking. A trait measure of control was significantly associated with ever smoking, smoking frequency, and problem use, suggesting that control processes are implicated in both smoking initiation and the progression to dependency. The ability to delay gratification was inversely associated in current smokers with experiencing smoking-related problems.

When predictors were combined, the trait control measure and religiosity emerged as the strongest, most parsimonious predictors of whether an individual had ever used cigarettes, while trait control and the ability to delay gratification emerged as the strongest predictors of whether a smoker experienced problems as a result of their cigarette use. The low numbers of dependent smokers in this study make it difficult to generalise from these results to the wider population and the causal direction of each of these associations needs to be clarified; however, this study contributes to the existing literature by identifying variables that in this population are relatively strong and therefore potentially useful predictors of substance use initiation and of progression from recreational to problematic levels of smoking.

CHAPTER FIVE

Impulse control and substance use: A longitudinal study

Chapter Summary

Thus far, this thesis has examined cross-sectional relationships between recreational substance use and risk factors implicated within the IIC framework, specifically focusing upon the role of impaired impulse control. Evidence has been cited to support the association between impulsivity and recreational substance use, substance abuse, and addiction. The question addressed in this chapter is simple – why? Why should substance users or abusers demonstrate more impaired impulse control, relative to non-users?

While some authors assume impulsivity to be a relatively stable trait that predates substance use (e.g. G. Dom et al., 2006), the vast majority of studies investigating associations between impulsivity and substance use are cross-sectional, and both the retrospective nature of data collection and potentially confounding effects of past substance use cast doubt on such conclusions. Longitudinal studies are needed to clarify the causal relationship between substance use and impaired impulse control and the processes by which individuals become addicted (Bickel & Yi, 2006). Bickel and Yi (2006) comment,

> *"clarifying the pathways and the processes by which individuals become both addicted and impulsive will inform neuro- and behavioural science, our efforts regarding prevention, and treatment, and will lead to more nuanced, interactive understanding of behavior, biology and environment as they play out in addictive disorders" (p.291).*

In 1949, Max Born (in Sowa, 2000) identified three conditions for demonstrating causality: the occurrence of entity B must depend upon the occurrence of entity A; entity A must occur prior to, or at least simultaneously to, entity B; and entities A and B must be in direct contact, or connected by a chain of processes. These conditions will guide the following discussion of possible causal links between impaired control and

substance use. Thus, the existing evidence will be considered in relation to three questions: 1) Does the initiation of substance use depend upon impaired impulse control, or vice versa? 2) Does impaired impulse control predate substance use initiation, and/or vice-versa? 3) By what processes and mechanisms might impaired impulse control and substance use be linked? Data from a longitudinal study of recreational substance use will then be reported, testing hypotheses derived from this review. To further assess assumptions of the Intention, Impulse, and Control (IIC) framework, the study will also include an assessment of attitudinal factors and life stress as predictors of change in substance use.

Impaired impulse control as a predictor of substance use

1. Does the initiation of substance use depend upon impaired impulse control?

As stated at the start of this thesis, drug addiction is a considered by many to be a clear example of diminished self-control; its DSM-IV diagnosis (APA, 2000) requires the presence of impaired inhibitory control as manifest in an inability to reduce or desist from drug taking. Moeller et al. (2001) suggest that the perceived association between impulse control and substance use disorders (SUDs) reflects the importance placed upon behavioural inhibition in the definition and conceptualisation of SUDs. Thus, impaired impulse control appears to be a centre feature of addiction – but does it play a fundamental role in substance use initiation?

Chapters 3 and 4 have cited numerous studies reporting associations between recreational substance use and impaired impulse control – as indexed by elevated novelty seeking, impulsivity, or lower harm avoidance (e.g. Genovese & Wallace, 2007; Kollins, 2003; Pardo et al., 2007; D. Patton, Barnes, & Murray, 1993; Sher et al., 2000; von Diemen et al., 2008). Although an unknown quantity of null or contradictory findings are not published, those which are tend to rationalise their results with methodological difficulties, rather than concluding that there is an underlying lack of association (e.g. Franken et al., 2006). However, in some cases substance use initiation may be a planned rather than impulsive act; for example, in response to peer pressure, in order to 'fit in' with others, or as a form of self-medication – e.g. to alleviate social anxiety (Kambouropoulos & Staiger, 2007). The prevalence of such motives in initiation, and the extent to which instances of planned substance use initiation also involve weak impulse control are unknown. Thus, while there often appears to be a general consensus that initiation of substance use depends upon impaired impulse control, this may not always be the case. Indeed, as will become more evident in the following section, there is considerable evidence that in at least some individuals, impulsivity is exacerbated by drug use; that is, there is evidence for the reverse causal association.

2. Does impaired impulse control predate substance use?

Prospective studies of childhood developmental disorders characterised by impaired impulse control - such as Conduct Disorder (CD), Oppositional Defiant disorder (ODD), and Attention Deficit/Hyperactivity Disorder (ADHD) - provide strong evidence that in many cases impulsivity predates substance abuse. Large-scale longitudinal studies have shown that adolescent ADHD is associated with smoking in adulthood (McClernon, Fuemmeler, Kollins, Kail, & Ashley-Koch, 2008), and both Pardini, White, and Stouthamer-Loeber (2007), and Caspi, Moffi, Newman and Silva (2008) found adolescent CD and ADHD symptoms to be consistent predictors of alcohol use disorders and dependence in adulthood. Indeed, Pardini et al. (2007) found that impulsive behaviour in infants as young as three predicted alcohol problems at age 21.

Ivanov et al. (2008) suggest that the evidence is strongest for the link between ADHD and smoking, and that impulsivity, as a key feature of ADHD and CD, may account for associations between ADHD, CD, and SUDs. Inhibitory control deficits have been reported in ADHD- and CD-diagnosed participants (e.g. Rubia, Taylor, Taylor, & Sergeant, 1999; Young, Bramham, Tyson, & Morris, 2006) and impulsivity has been found to account for some of the association between ADHD, CD, and recreational substance use in a sample of young adolescents (Molina, Smith, & Pelham, 1999). Together these findings lend support to the notion that impaired impulse control is causally linked to susceptibility for substance abuse.

Longitudinal studies have also explored predictors of substance use in representative samples. Supporting the argument that impulsivity is a predictor of substance use, one

New Zealand group assessed the personality correlates of problem gambling and substance use in 939 participants (Slutske, Caspi, Moffitt, & Poulton, 2005); lower constraint, higher risk-taking, and higher impulsivity at age 18 were all associated with substance use at age 21. Elkins, McGue, and Iacono (2007) reported that hyperactivity/impulsivity in 1500 Minnesota twins at age 11 predicted the initiation of all types of substance use, smoking, and cannabis abuse by age 18.

On the other hand, Goudriaan, Grekin, and Sher, (2007) assessed the binge drinking patterns of 200 students in Columbia twice across a two-year interval, and also recorded baseline measures of self-reported impulsivity and performance on the Iowa Gambling task (IGT). Students whose binge drinking was stable across the two occasions performed worse on the IGT than those who did not binge-drink frequently at either occasion, but baseline measures of self-reported impulsivity did not differ between the groups. The authors interpret these results as an indication that prolonged binge drinking is associated with worse decision making, but acknowledge that this study does not directly address the question of cause and effect. Barnes, Welte, Hoffman, and Dintcheff (2005) looked at gambling and substance use in 699 participants at yearly intervals between the ages of 13 and 22. After accounting for socio-demographic factors, impulsivity was only a very weak predictor of alcohol misuse in females, and did not predict alcohol misuse among male participants. Another study by Leff et al. (2003) assessed smoking and a range of cognitive and behavioural risk factors in 59 adolescents across an interval of around 15 months, and found that aggression and hyper-activity, but not impulsivity, were significant predictors of later smoking initiation.

However, the samples included in these studies are older than those assessed in the longitudinal ADHD or CD research, which suggests that at least some participants will already have initiated substance use and that any conclusions regarding the direction of association between impulsivity and substance use could be compromised by the confounding effects of past exposure to drug use. Moreover, while Leff et al's study appears most pertinent since it directly assesses substance use initiation, their findings are less convincing due to the small sample and the short interval between assessments. On the other hand, Elkins et al.'s large-scale longitudinal study provides compelling evidence that impulsivity does often predate and increases the risk for recreational substance use.

3. What mechanisms link impaired impulse control and substance use?

Ivanov et al. suggest that impaired pre-frontal cortex (PFC) regulated cognitive processes, present in neuro-developmental disorders characterised by impulsiveness and hyperactivity, may represent a vulnerability to substance abuse. Functional imaging studies of ADHD-diagnosed children and controls performing a Go-No go task (which indexes inhibitory control) describe differences in activation in the right ventrolateral PFC (Schulz et al., 2005) and striatum (Durston et al., 2003); similar studies comparing substance abusers to controls likewise report differential activation in the PFC (G. Dom, Sabbe, Hulstijn, & Van Den Brink, 2005). However, abnormalities in substance abusers may be accounted for in part by the effects of substance use, making it difficult to make causal inferences from these findings.

Bechara et al. (2001) used the IGT to assess impulsive decision-making in addicts and patients with damage to the ventromedial prefrontal cortex (VM patients); both groups are arguably hypersensitive to reward and appear insensitive to future outcomes of their actions. They found that, while 63% of addicts showed impairments similar in degree to those of VM patients, those who did not were better able to hold and maintain employment. This led Bechara et al. to question whether the IGT performance of addicts resulted from chronic drug use, or predisposed them towards substance abuse. Data on recreational levels of substance use is not provided for the healthy controls, but it is reported that a quarter of these participants also showed similar impairments on the task; since these were not heavy substance users, this suggests that whilst impulsive decision-making may predispose to addiction, clearly it is not a sufficient factor.

Volkow et al. (1999) found that baseline measures of dopamine (DA) receptor density predicted the extent of subjective experiences of drug-induced pleasure in healthy controls who were given the stimulant drug methylphenidate. This suggests that individual variation in the sensitivity of DA circuitry may mediate the reward obtained from substance use, and therefore – given the supposed role of DA reward circuitry in addiction discussed in Chapter 1 – perhaps confer susceptibility to repetitive substance use and abuse. Moreover, the well-known acute effects of alcohol in increasing impulsiveness and aggression has been found to be greater in adults with antisocial personality disorder (also characterised by impaired inhibitory control) than in healthy controls (Giancola & Zeichner, 1995). More research is needed to test whether Giancola and Zeichner's findings generalise to other substances of abuse, but this provides preliminary evidence that individual variation in aspects of impulse control could modulate the direct effects of substance use.

Thus, findings suggest that constitutional differences in brain function may underlie impaired control, which in turn may represent vulnerability to SUDs. Bechara et al. suggested that poor IGT performance, which has been linked with PFC damage, may index this susceptibility; however, it is notable that 39% of the addicts in their study were not impaired on the IGT. Thus, either or both of the following conclusions must be true: a) the IGT is not a perfect indicator of the relevant underlying control processes; and b) factors other than control processes may be sufficient to predispose to SUDs.

Thus far, this review has focused upon demonstrating whether and how impulsivity might be considered a determinant of substance use. Discussion now turns to considering the opposite causal relationship: what is the evidence that impulsivity arises as a consequence of substance use?

Substance use as a predictor of impaired impulse control

1. Does impaired impulse control depend upon the initiation of substance use?

If impaired control did depend upon substance use, then all impulsive individuals would have previously engaged in substance use. Clearly this is not the case, as is aptly demonstrated by Elkins et al (2007) who found that impulsivity in 11 year olds predicted substance use initiations; or by Pardini et al. (2007) who reported that impulsivity among three-year olds predicted alcohol use at age 21. In both studies, individuals with no past alcohol or drug use exhibited impulsive behaviour.

Moreover, impaired impulse control is a feature of many other psychological disorders in people with no history of substance use: the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 2000) includes a general diagnosis of impulse control disorder, comprising Trichotillomania, Intermittent Explosive Disorder, Pathological Gambling, Kleptomania, and Pyromania. Thus, impaired impulse control is fundamental to many disorders, and is not an exclusive feature of substance use and/or abuse.

2. Does substance use predate impaired impulse control?

There is some evidence from human research that impaired inhibitory control can result from acute doses of cocaine (Bolla, Funderburk, & Cadet, 2000) and MDMA (Kuypers, Wingen, Samyn, Limbert, & Ramaekers, 2007), and the disinhibiting effects of alcohol on behaviour are widely cited (Dougherty, Marsh, Moeller, Chokshi, & Rosen, 2000; Fillmore, 2007; George, Rogers, & Duka, 2005). While many prospective studies have examined the effects of impulsivity on later substance use, little or no longitudinal research to date has assessed the longer-term effects of substance use exposure upon impulse control; evidence must therefore be derived from neuro-imaging research of current drug addicts and the study of abstinent substance abusers.

Neuro-imaging studies of addicts often report abnormalities in dopaminergic (DA) receptor density, and low DA release in multiple brain regions involved in reward, motivation, inhibitory control, and memory (Volkow, Fowler, & Wang, 2003). Volkow et al. (2004) postulate that these disruptions underlie loss of control in drug dependent individuals, and provide evidence that activity in the orbitofrontal cortex (OFC) and anterior cingulate gyrus (CG) is associated with DA receptor density and is lower in drug addicts. However, as the authors themselves acknowledge, it is difficult to determine whether these abnormalities pre-exist or result from substance abuse. Animal research does provide strong, consistent evidence that prolonged exposure to substances of abuse leads to impairments of inhibitory control (Jentsch & Taylor, 1999); however, there is as yet little direct evidence in humans of a causal link between substance use and disruptions to brain function.

The study of abstinent addicts is another potential source of relevant evidence. If impaired impulse control is in part a direct consequence of chronic substance abuse, then the cessation of substance use may be followed by recovery of impulse control. In support of this, studies of abstinent alcoholics have shown recovery of structure and function in a range of brain regions and related processes including hippocampal-related deficits (Bartels et al., 2007), various aspects of cognitive performance (Fein, Torres, Price, & Di Sclafani, 2006; Mann, Gunther, Stetter, & Ackermann, 1999), and whole brain tissue volume over a 12 month interval (Gazdzinski, Durazzo, & Meyerhoff, 2005). Relatedly, reductions in neurological and cognitive impairments were found after a two-year period of abstinence in petrol sniffers (Cairney, Maruff, Burns, Currie, & Currie, 2005); and Fowler et al. (1998) reported significantly depleted levels of monoamine-oxidase (MOA) - which metabolises DA - in smokers but not in ex-smokers relative to non-smokers. Shi et al. (2008) found that DA transporter uptake in the striatum of heroin users, though lower than in healthy controls, was higher in ex-heroin users than methadone-treated heroin-users, which the authors argue is evidence that prolonged withdrawal can allow recovery of impaired DA neurons.

On the other hand, Volkow et al. (1997) found that abnormalities in the OFC of alcoholics persisted 11 weeks after detoxification, and poly-substance users have elsewhere demonstrated elevated impulsivity and impaired performance on measures sensitive to OFC functioning (including the IGT) after four months of abstinence (Verdejo-Garcia, Rivas-Perez, Vilar-Lopez, & Perez-Garcia, 2007). Dawkins et al. (in press) assessed successful quitters and continuing smokers over a three month interval; abstainers did not improve on two measures of inhibitory control (an antisaccade and a continuous performance task). However, the lack of improvement reported in these studies may be explained by the shorter duration of abstinence compared to some of the studies where improvements were observed.

Overall, it remains unclear to what extent the impairments observed in addicts are the consequence of substance abuse or reflect differences that pre-date substance use. On the one hand, many studies that report evidence consistent with recovery are cross-sectional, making it difficult to interpret their findings: significant differences between abstinent and current users could reflect either stable differences that existed prior to substance abuse and which perhaps make it easier for some to quit, or true recovery of function. On the other hand, longitudinal studies are more powerful, but they are also costly, and the shorter durations of abstinence that are assessed may explain their failure to demonstrate recovery. Reciprocal causal influences may of course exist; or alternatively the observed associations could reflect a shared third factor, though it is not clear what this might be.

3. What mechanisms link impaired impulse control and substance use?

As discussed in Chapter 1, Jentsch and Taylor (1999) proposed a two-strand hypothesis that links impaired impulse control and substance use. Long-term exposure to substances of abuse is argued to alter brain function in two important regions: firstly, subcortical limbic and amygdala regions involved in the incentive motivational aspects of substance use; and secondly, PFC and OFC regions, involved in inhibitory control. Goldstein and Volkow's (2002) Impaired Response Inhibition and Salience Attribution model (I-RISA) similarly posits that substance use results in disruptions to the striato-thalamo-orbitofrontal circuit, resulting in the addict's inability to inhibit maladaptive appetitive responses elicited by drugs, related stimuli, or internal drive states.

In support of these theories, imaging studies have shown altered functioning in addicts' subcortical reward pathways (e.g. Garavan et al., 2000), and there is evidence that damage to prefrontal structures leads to inhibitory deficits and impulsive decision-making (Damasio, 1996; Dias et al., 1997). There is also extensive evidence that almost every drug of abuse is (given acutely) capable of increasing DA release in the PFC (Adinoff, 2004), while chronic use is associated with reduced dopaminergic tone (Volkow et al., 2003). Jentsch and Taylor hypothesise that chronic substance use results in DA hypofunction in cortical regions, which manifests in impaired inhibitory control over increasingly potent sub-cortical reward-drives. They describe their theory as a "continuous, feed-forward cycle" (p. 384), whereby repeated consumption leads to further impairments, which in turn worsen the addict's control over substance abuse.
These theories deliver a convincing account of the addictive state. Understandably, methodological and ethical constraints have led to a dearth of longitudinal research that assesses temporal fluctuations of neural function in human substance users. Cross-sectional studies and comparative research compensate for this weakness, and these

theories have become widely accepted. However, these accounts do not on their own explain why individuals initiate substance use, or why impaired control has been observed to predict future recreational drug use. A more comprehensive account of the causal association between impaired control and substance use is therefore needed. Many researchers have noted that impulsivity, both within the normal range and as a characteristic of childhood psychopathologies, appear to predispose to drug and alcohol use, and various explanations have been proposed. This literature will be briefly considered in the following sections.

As many researchers have observed (e.g. Lubman et al., 2004; F. G. Moeller et al., 2001), the association between impulsivity and substance use may be bi-directional. On the one hand, longitudinal studies of childhood developmental disorders and population-based cohorts - while not wholly consistent - do provide persuasive evidence that impaired impulse control is an important risk factor for substance use initiation. On the other hand, as previously described, there is compelling evidence that substance use can induce neuro-adaptations that result in impaired inhibitory control.

It is notable that explanations for both directions of causal influence often implicate similar PFC-regulated cognitive processes and subcortically-mediated reward pathways: damage to PFC circuitry is thought to be responsible for reduced inhibitory control over drug seeking in addicts (Goldstein & Volkow, 2002), and abnormal PFC-activation in ADHD-diagnosed children suggests that their susceptibility for substance abuse may be related to impulsiveness (Schulz et al., 2005); DA reward circuitry is thought to be important to addicts' reward seeking behaviours (Jentsch & Taylor, 1999), and variation in DA receptor density has been shown to predict subjective experiences of pleasure in response to the stimulant methylphenidate (Volkow et al., 1999). It is, of course, entirely possible and plausible that pre-existing deficiencies in these brain regions underlie impaired impulse control, increasing susceptibility for substance use initiation, and that these same impairments subsequently become further exacerbated by drug use exposure, leading to loss of control over substance use.

This literature review has identified important questions yet to be answered regarding the extent to which impaired control is a predisposing risk factor for substance use and/or abuse, or of successful abstinence in addicts, or is a trait that remains stable across the lifetime. Longitudinal research is needed to unpack this association and the research described in this chapter will test a series of hypotheses that directly explore these issues.

Attitudinal factors and life stress as predictors of change in substance use

While this discussion has focused upon the causal relationship between impulse control and substance use, the IIC framework also implicates attitudinal and situational factors as important predictors of substance use. The cross-sectional study described in Chapter 3 found significant associations between aspects of substance use/abuse and attitudes towards and risk perceptions about alcohol/drug use, intentions towards future alcohol/drug use, religious restrictions that prohibit substance use, and stressful life events during the previous 12 months. The present longitudinal study provides an opportunity to explore the utility of these factors as predictors of change in substance use over time. The following sections will briefly outline why and how these variables would be expected to affect drug and alcohol use.

Attitudinal factors

A large body of research reports associations between attitudinal factors and substance use. This includes prospective studies which have shown that more positive attitudes towards substance use predict subsequent drug use (van Hulten et al., 2003), and cross-sectional studies which link lower perceived riskiness of drinking or taking drugs with drug use initiation and heavier drug/alcohol use (e.g. Chabrol et al., 2008; Hampson et al., 2001; Ryb et al., 2006). Religiosity has also been identified in many studies as a protective factor against drug and alcohol use and/or abuse (e.g. Chu, 2007; Francis, 1997; Galen & Rogers, 2004; T. J. Johnson et al., 2008) and there is also strong evidence that intentions to engage in future drug/alcohol use are associated with actual substance use (Huchting et al., 2008).

Taken together, these findings provide convincing evidence that an individual's overall attitudes towards substance use directly influence the likelihood that drug use will take place. Interestingly, some recent findings have suggested that the reverse causal relation may partly explain the strength of these associations, with past drug use influencing later intentions to use (Boys et al., 1999). This is a credible explanation, since our personal experiences and those of our peers will logically influence the formation of our attitudes. In Chapter 3, religious-restrictions predicted whether participants currently used alcohol or illicit drugs, while attitudes towards drug use contributed to predicting level of alcohol use, frequency of binge-drinking, the number of illicit drugs used, frequency of drug use, and whether problem drug-use occurred. However, the cross-sectional nature of this study meant that it could not disentangle whether past substance use had influenced current attitudes, or vice versa. In the present longitudinal study, baseline attitudinal factors will be assessed as predictors of subsequent change in substance use, covarying out baseline substance use; this constitutes a more powerful test than cross-sectional analyses of whether an individual's attitudes influence their subsequent substance use.

Life Stress

In Chapter 3, a measure of the magnitude of stressful life events during the previous 12 months was associated with level of alcohol use among current drinkers and whether students engaged in illicit drug use. This is consistent with the many past findings showing that exposure to stressors is positively correlated with alcohol and drug use/abuse (Arellanez-Hernandez et al., 2004; Camatta & Nagoshi, 1995; Rutledge & Sher, 2001; Schilling et al., 2008).

There are many explanations for the stress-substance use link. Drug or alcohol use may be perceived as a welcome escape from negative experiences, and therefore used as a coping mechanism by some individuals. At a neurochemical level, chronic stress has wide-ranging effects upon many physiological systems, including the hypothalamic-pituitary-adrenal (HPA) axis and dopamine system. Animal studies have shown that stressful experiences can increase dopaminergic responses, leading to an overly-sensitised behavioural response to the effects of cocaine (Meaney, Brake, & Gratton, 2002), an enhanced cocaine-induced increase in dopamine levels in the ventral striatum (Kosten, Zhang, & Kehoe, 2003), and increased cocaine and alcohol consumption (Miczek, Yap, & Covington, 2008). Human neuro-imaging studies have also demonstrated interrelationships between elevated HPA-axis function, greater brain dopamine release and higher subjective responses to acute drug administration (Oswald et al., 2005). Thus, there is evidence that stress could directly modify responses to drug exposure, and thereby influence the likelihood of subsequent substance use/abuse.

The mechanisms through which stressors are purported to exert an influence over substance use involve processes (i.e. dopamine function) that are also argued to be relevant to impaired inhibitory control and impulsivity (Jentsch & Taylor, 1999); thus, it is also possible that life stress may influence the likelihood that substance use/abuse takes place via its effect upon the impulsivity-substance use relationship. The present longitudinal study will provide an opportunity to explore whether stressful life experiences predict change in substance use over time; the parallel assessment of indices of impulsivity will enable the further exploration of the combined predictive power of these risk factors.

Study Hypotheses

Testing the causal link between impulse control and substance use

The primary objective of this study is to use longitudinal data to test a series of hypotheses about the causal links between impulsivity and substance use. To that end, measures of alcohol and illicit substance use, and the trait and laboratory task indices of approach, avoidance, and control (and all related facets of impulsivity) introduced in Chapters 2 and 3 were assessed twice across an interval of one to two years. These data are analysed here to test three broad hypotheses:

I. If impulse control is assumed to be a relatively stable trait-like construct, and if it is indeed a causal risk factor for substance use, baseline (T1) measures of impulse control should predict changes in substance use across the interval between T1 and T2. Specifically, more impulsive participants should be more likely to increase their substance use between T1 and T2, whereas less impulsive participants should be more likely to report unchanged or decreased substance use at T2.

II. Change in impulsivity between T1 and T2 should correlate positively with/parallel change in substance use between T1 and T2.

Testing attitudinal factors and Life stress as predictors of change in substance use

A secondary aim of this study is to test whether attitudinal factors and life stress, which were earlier introduced in Chapters 3 and 4, predict change in substance use. Thus, attitudes towards drug use, perceived riskiness of alcohol/illicit drug use, intentions towards future drug/alcohol use, religious restrictions on substance use, and stressful life experiences over the preceding 12 months were all assessed at both T1 and T2. However, since the primary focus of this thesis is substance use and impulse control, only T1 attitudinal factors will be analysed in relation to substance use. Stressful life events that have occurred during the interval between assessments could be related to changes in substance use; thus, both T2 and T1 measures of life stress will be included as predictors in analyses. These data will be used to test the following hypotheses:

III. More positive attitudes towards substance use (Attitudes) at T1 will predict greater increases in substance use between T1 and T2.

IV. The greater the perceived risks of alcohol use (Riskiness-Alcohol) at T1, the less drinking will increase from T1 to T2, and the greater the perceived risks for substance use (Riskiness-Illicit) at T1, the less substance use will increase between T1 and T2.

V. Greater future intended use of alcohol at T1 (Alcohol-Intentions) will be associated with greater increases in drinking from T1 to T2, and greater future intended illicit drug use (Illicit-intentions) at T1 will be associated with greater increases in illicit drug use between T1 and T2.

VI. The presence of Religious-Restrictions at T1 will be associated with a lower likelihood of increases in alcohol and illicit drug use between T1 and T2.

VII. T1 and T2 measures of Life Stress during the previous 12 months will be positively associated with change in substance use/abuse between T1 and T2.

Combined predictors of change in substance use

A third aim of the present study is to explore the combined influence of predictors tapping different levels of the IIC framework in predicting change in substance use over time. Regressions will be used to test the combined explanatory power of attitudinal factors, indices of approach, avoidance, and control, and measures of Life Stress that are found to be individually associated with change in substance use between T1 and T2.

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Method

Design & Participants

Chapter 3 described data from 165 London students. Of these, 128 were originally recruited and tested during the 2005/6 and 2006/7 academic years and were re-contacted in two follow-up waves. Eighty-seven (68%) agreed to participate in the follow-up. The interval between T1 and T2 ranged from 12 to 27 months (mean=20.2, s.d.=4.3). Informed consent was obtained from each participant at T1 and T2, and Goldsmiths' Psychology Department Ethics Committee, approved the study.

Within this repeated-measures design, T1 and T2 data were gathered on multiple substance use/abuse indices, nine self-report and ten laboratory task indices of impulsivity, six attitudinal factors and Life Stress.

The study focused on changes in use of alcohol and illicit substances. Although changes in smoking were also of theoretical interest, in practice there was insufficient variance in these change sores and smoking is therefore not considered further.

Analyses

Chapter 2 described the factor analysis of nine self-report questionnaire subscales to derive trait indices of approach, avoidance, and control. Given the within-subject (repeated measures) analyses of the present study, it is necessary to compute trait indices which can be directly compared and which are not influenced by statistics from the larger sample in whom the original Exploratory Factor Analyses (EFAs) were run.

(as would be the case using the factor estimation method employed in Chapter 2). EFAs were therefore re-run on questionnaire data from just the present subsample; these yielded factor scores which are virtually identical in structure to those found in the larger sample. The details of these analyses are given in Appendix A.

Correlations, t-tests, and Wilcoxon signed ranks tests are used to compare T1 with T2 scores on all predictor and outcome variables, to explore test-retest reliability for these measures, and to give an indication of whether and by how much each variable changes across the 12-27 month interval.

It was argued in Chapter 3 that participants who abstain completely from alcohol or drug use are likely to be qualitatively different from participants who use drugs or alcohol at least occasionally. For this reason, predictors of change in alcohol use are explored only in participants who report some alcohol use at either T1 or T2, and change in drug use is analysed only in participants who report having used at least one illicit drug at either time-point. For similar reasons, predictors of problem drug use (ASSIST-Prob) are explored only in current illicit drug users.

The assessments of substance use are described in detail on pages 101-105. Briefly, however, indices employed here are broadly the same as those used in Chapter 3: 'AUDIT-Total' reflects both alcohol use and abuse; 'ASSIST-Freq' estimates the frequency of illicit substance use; 'ASSIST-Count' reflects the number of illicit substances ever used; and 'ASSIST-Prob' measures problematic illicit drug use. Additionally, 'ASSIST-Total' is derived from the Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST; WHO ASSIST Working Group, 2002) to provide a single measure reflecting a combination of substance use and abuse.

When exploring change in substance use (Hypotheses I and II), AUDIT-Total and ASSIST-Total change scores are computed and treated as continuous variables. For ASSIST-Freq, ASSIST-Count, and ASSIST-Prob, 'substance change' subgroups are identified: these are small subgroups from the larger sample who are roughly matched in level of drug use at T1, and who subsequently report higher, lower, or similar levels of drug use at T2.

Testing the causal link between impulse control and substance use

To test Hypothesis I, correlations are used to explore associations between T1 indices of approach, avoidance, control, and change scores for AUDIT-Total and ASSIST-Total. T-tests and Mann-Whitney U tests are then used to test differences on T1 indices of impulse control between substance change groups defined in terms of changes in ASSIST-Count, ASSIST-Freq, and ASSIST-Prob scores.

To test Hypothesis II, correlations are used to assess associations between changes in AUDIT-Total and ASSIST-Total on the one hand, and changes in indices of impulse control on the other. Subsequently, T-test and Mann-Whitney U tests are used to compare participants grouped by their change scores on ASSIST-Count, ASSIST-Freq, and ASSIST-Prob (increase, no change, decrease) in terms of their change scores on indices of impulse control.

Attitudinal factors and Life Stress as predictors of change in substance use

To explore whether attitudinal factors or Life Stress are independently associated with change in substance use, T1 measures of Attitudes, Riskiness, Intentions, Religious-Restrictions, and Life Stress are correlated with changes in AUDIT-Total and ASSIST-Total scores, controlling for T1 substance use. T-tests and Mann-Whitney U tests then compare subgroups of participants whose use increased, decreased, or stayed the same, as assessed in terms of ASSIST-Count, ASSIST-Freq, and ASSIST-Prob scores.

Combined predictors of change in substance use

The general approach taken was to assess the impact of the theoretically interesting predictors of substance use at T2 after controlling for T1 substance use. This was operationalised within the separate regressions for each index of T2 substance use (the dependent variable) by entering the corresponding T1 score at step 1, and subsequently entering the variables which had previously emerged as individually predictive of *change* in the substance use index. Continuous and categorical substance use dependent variables were analysed using sequential linear and multinomial logistic regressions respectively.

Conservative Bonferroni corrections are, as throughout this thesis, applied to reduce the risk of Type I errors resulting from multiple comparisons; the corrected significance levels are presented in footnotes throughout the text. Emboldened text is used in tables to highlight trends that reach conventional uncorrected significance levels ($p<0.05$) but which fall short of corrected significant levels. SPSS Version 14 is used in all analyses.

Measures

These have previously been described in detail in pp 98 to 106. Briefly, however:

a) Substance use measures

Alcohol Use & Disorders Identification Test (AUDIT: Babor et al., 1992) *– page 101*

'AUDIT-Total' indexes overall alcohol use and dependency (max. score 40).

Alcohol, Smoking and Substance Involvement Screening Test (WHO ASSIST Working Group, 2002) *– page 102*

'ASSIST-Freq' reflects the frequency of all illicit drug use over the previous three months (max. score 315) and 'ASSIST-Prob' indexes problematic drug use across the seven substance groups (max. score 21). 'ASSIST-Count' represents the number of drugs ever used. To tap experimentation with novel substances, a broader drug classification system is used here than in chapter 3. Instead of 7 substance groups, 12 substances are listed: crack cocaine is separated from other cocaine use; MDMA or ecstasy use is separated from other amphetamine use; amyl nitrates are separated from other inhalants; and magic mushrooms and LSD from other hallucinogens.

'ASSIST-Total' is a new measure that was additionally derived for the purposes of the current study, to give a global index of current (last 3 months) illicit drug use severity. Responses to Q2 to Q7 of the original ASSIST questionnaire (shown in full on page 103) were summed across seven substance classes. Responses to Q2-Q5 were scored exactly as in the original questionnaire. For Q6-Q7, responses indicating problem use during the previous 3 months were given a score of 6 (as indicated in Figure 3.2), and participants reporting problem use that did not occur in the previous 3 months were given a score of zero. Thus, ASSIST-Total is a composite index reflecting the frequency of drug use, the frequency of urges to use drugs *and* whether specific drug-related problems have occurred during the previous three months. The maximum score for each substance class is 39 and the maximum score across the 7 classes is 273. This measure is thus not sensitive to variation in the number of drugs used or level of drug use for one particular substance; for example, scores of 18 could be achieved by a participant using three substances on a monthly basis, or using one substance daily, craving the substance weekly and experiencing occasional financial problems as a result. However, this measure does capture overall involvement with substance use, and it is important for the purposes of this study to establish an index of substance use which includes sufficient variability to enable the analysis of change in substance use over time. Complementing this index of overall substance use, separate analyses of differences between subgroups of participants whose ASSIST-Count, ASSIST-Freq or ASSIST-Prob scores change or remain the same between T1 and T2 will enable the detailed exploration of specific aspects of drug use.

b) Attitudinal indices – page 105

'Attitudes' indexes the favourability of attitudes towards drug use. 'Riskiness-alcohol' measures the perceived riskiness of alcohol, and 'Riskiness-illicit' the perceived riskiness of illicit drug use. 'Alcohol-intentions' indicates the strength of future intentions to drink, and 'Illicit-intentions' reflects the strength of future intentions to use illicit drugs. The dichotomous variable 'Religious-Restrictions' (restricted vs. unrestricted) indicates whether participants report religious prohibitions over substance use or not.

c) Life stress – page 108

The Revised Life Changes Questionnaire (RLCQ; Miller & Rahe, 1997), was completed at T1 and T2, quantifying the magnitude of stressful life events occurring in the preceding 12 months.

d) Trait and laboratory task indices of approach, avoidance, and control

The following self-report scales are used to derive trait measures of impulse control: Novelty-seeking (TPQ-NS) and Harm Avoidance (TPQ-HA) from the Tri-Dimensional Personality Questionnaire (TPQ; Cloninger, 1987); Eysenck's Impulsiveness scale (IVE-Imp; S.B. Eysenck & Eysenck, 1978); BIS, BAS-Reward, BAS-Drive, and BAS-Fun Seeking from Carver and White's (1994) BIS/BAS scale; and Sensitivity to Reward (SPSRQ-SR) and Sensitivity to Punishment (SPSRQ-SP) from the shortened version of

Torrubia et al.'s (2001) Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ).

Go-No Go (GNG) Task – page 64

'GNG Reward expectancy' and 'GNG Reward responses' reflect the speed of learning of reward and are putative indices of approach; 'GNG Punishment expectancy' and 'GNG Punishment responses' reflect speed of learning of punishment and are putative indices of avoidance; and 'GNG Reversal expectancy' and 'GNG Reversal responses' reflect the inhibition of previous learning, and speed of learning of punishment and are putative indices of control.

Oculomotor antisaccade task (AST) - page 66

The difference in the percentage of correct eye-movements in prosaccade vs. antisaccade trials ('AST-Accuracy') and the amount by which reaction times were slowed in antisaccade vs. prosaccade trials ('AST-Interference') are both putative indices of control, with higher scores on both indicating better control.

Iowa Gambling Task (IGT) –page 68

Two parallel versions of the IGT were used: at T1, as described in chapter 2, choosing a card from decks A' and B' is followed by high monetary gains and losses, while selections from decks C' and D' result in smaller monetary gains and losses; at T2, the decks are labelled K',L', M', and N', with selections from L' and N' resulting in higher gains/losses, and selections from K' and M' resulting in smaller gains/losses. 'IGT-Net Score' reflects advantageous decision-making and is a putative index of control.

Delay Discounting Task (DDT) – page 67

'DDT Discounting Rate' represents the extent to which reward loses its perceived value as the delay to its delivery increases, and is also used an index of control.

e) Demographics

All participants provide details regarding their age, gender, ethnicity and socio-economic status (page 109) at T1 and T2.

Procedure

The full testing procedure was identical at T1 and T2 and is described in Chapter 2.

Results

Data Screening

T1-T2 Attrition

T1 data were analysed for differences between the 87 participants tested at T2 and the 77 participants who were contacted, but who did not attend T2 testing sessions. Table 5.45 presents these results.

Table 5.45: Differences in T1 measures between re-tested participants and non-respondents

T1 Measure	*t*	*Mann Whitney U*	χ^2	*p*
Attitudes	-0.86			*0.392*
Alcohol-intentions		2997.0		*0.188*
Illicit-intentions		2753.0		***0.064***
Riskiness-alcohol		3231.0		*0.812*
Riskiness-illicit		2944.0		*0.350*
Religious-Restrictions			1.98	*0.159*
Life Stress	-0.07			*0.941*
TPQ-Novelty Seeking	-0.43			*0.977*
TPQ-Harm Avoidance	0.18			*0.860*
BIS	-0.34			*0.734*
BAS-Reward Responsiveness	0.50			*0.617*
BAS-Drive	0.10			*0.919*
BAS-Fun Seeking	0.31			*0.761*
IVE-Impulsiveness	-0.69			*0.494*
SPSRQ-Sensitivity to Reward	0.55			*0.582*
SPSRQ-Sensitivity to Punishment	0.45			*0.657*
GNG Reward expectancy		3054.0		*0.497*
GNG Punishment expectancy		3256.0		*1.000*
GNG Reversal expectancy		2881.5		*0.208*
GNG Reward responses		3246.0		*0.973*
GNG Punishment responses		3145.0		*0.709*
GNG Reversal responses		3085.0		*0.566*
IGT Net Score	-1.75			*0.082*
AST Accuracy	-0.54			*0.589*
AST Interference	0.01			*0.993*
DDT Discounting Rate	-0.07			*0.942*
AUDIT-Total	0.30			*0.764*
ASSIST-Total	-1.28			*0.202*
ASSIST-Count		1954.5		*0.684*
ASSIST-Freq		1937.0		*0.600*
ASSIST-Prob		1794.0		***0.073***

AUDIT-Total & ASSIST-Total are square-root transformed; no difference is significant at $p<0.05$

There were no significant differences between re-tested participants and non-respondents; however, there were trends for re-tested participants to report higher intentions to use illicit drugs, and to score higher on ASSIST-Prob. However, given the number of analyses, these effects are likely to be spurious.

Prior to analysis, all variables were screened for univariate and multivariate normality.

T1 data

One student was missing data on Riskiness-Illicit, one did not report Religious-Restrictions and 18 were missing data on Life Stress. Data screening for indices of approach, avoidance and control at T1 were described in Chapter 2; Expectation Maximisation (EM) was used to estimate missing subscale scores for nine participants who did not respond to more than 5% of items on one or two of the nine self-report subscales. Nine further participants omitted two or more whole subscales and were excluded from analyses that include Trait-Approach, Trait-Avoidance, or Trait-Control.

T2 data

One participant did not report Religious-Restrictions. Trait indices were not derived for the nine participants omitting self-report questionnaires at T1.

Descriptive Statistics

Of the 87 cases tested at T2, 18 were male (20.7%), and 69 were female (79.3%); they were aged 18 to 21 at T1 (mean=19.1, s.d.=0.9), and 19 to 23 at T2 (mean=20.8, s.d.=1.0). Tables 5.46 & 5.47 present descriptive statistics for socio-economic status and ethnicity.

Table 5.46: Frequency data for socio-economic status (n=87)

Highest parental ISCO score	T1 frequency	
Managers	14	17.9%
Professionals	32	41.0%
Technicians and associate professionals	10	12.8%
Clerical support workers	8	10.3%
Service and sales workers	6	7.7%
Skilled agricultural forestry and fishery workers	1	1.1%
Craft and related trades workers	3	3.8%
Plant/machine operators and assemblers	6	6.9%
Elementary occupations	2	2.3%
No occupation	5	6.4%
Total	*87*	

Table 5.47: Descriptive statistics for ethnicity (n=87)

Ethnicity	Frequency (%)	
White UK	38	43.7%
White Other	15	17.2%
Black Afro-Caribbean	6	6.9%
Asian	21	24.1%
Mixed or other	7	9.0%
Total	*87*	

Attitudinal indices and Life Stress

Alcohol-Intentions data did were non-normally distributed and were analysed non-parametrically. All other attitudinal indices were normally distributed. Table 5.48 summarises descriptive statistics for attitudinal factors and Life Stress.

Table 5.48: T1 and T2 descriptive statistics for attitudinal factors and Life Stress.

	T1			T2			r	t	Z
	n	mean	s.d.	n	mean	s.d.			
Attitudes	87	2.89	0.7	87	2.88	0.8	0.68*	0.27	
Alcohol-intentions†	87	3.26	1.4	87	3.31	1.4	0.74*		-0.48
Illicit-intentions†	87	8.86	9.4	87	9.48	9.1	0.72*	-0.98	
Riskiness-alcohol†	87	2.39	1.4	87	2.62	1.5	0.61*	-1.65	
Riskiness-illicit†	86	46.53	11.6	87	45.06	9.65	0.53*	1.17	
Life Stress	70	486.11	216.5	87	319.6	207.2	0.45*	6.74*	

Missing cases: T1 Riskiness-illicit 1; T1 Life Stress 18; *significant at $p<0.0083$ [α]

† Non-parametric spearman correlations; Z = non-parametric Wilcoxon signed ranks tests

T1 and T2 attitudinal factors were moderately-to-highly, and significantly, correlated. Interestingly, the amount of shared variance between T1 and T2 scores ranged from only 28% to 55%, meaning that there was substantial variation in participants 'attitudes to and beliefs about alcohol and drug use across the 12-27 month interval.

T1 and T2 Life Stress scores were moderately and significantly correlated. There were no significant differences between T1 and T2 scores on attitudinal factors, but Life Stress scores were significantly higher at baseline than retest. This significant difference is likely to reflect the fact that participants were first tested as first year undergraduate students, when their scores at T1 would have been amplified by their having recently started at a new college, and perhaps moving home or city (two contributory items).

[α] Bonferroni-correction: *$p<0.05$ divided by 6 analyses gives $p<0.0083$ (two-tailed)*

There was a highly significant association between Religious-Restrictions (restricted vs. unrestricted) at T1 and T2 [$\chi^2(1)=72.96$, $p<0.001$]. Overall, 17 participants reported Religious-Restrictions at T1 and 17 at T2; 69 participants reported no religious restrictions at T1 and 69 at T2. Only participant reported restrictions at T2 who had not also reported restrictions at T1; one participant reported restrictions at T1 but not at T2.

Trait indices of approach, avoidance, and control

Table 5.49 summarises T1 and T2 data from the nine self-report measures that were used to derive indices of approach, avoidance, and control. All test-retest correlations were positive and significant, and there were no significant differences between T1 and T2 scores, though there was a trend for TPQ-Novelty Seeking scores to be lower at retest than at baseline [$p=0.007$].

Table 5.49: T1 and T2 descriptive statistics for trait measures of impulse control

	T1		T2		*r*	*t*
	mean	s.d.	mean	s.d.		
TPQ-NS	19.34	5.3	17.92	5.6	0.66 *	-2.79
TPQ-HA	14.22	6.3	14.00	8.2	0.75 *	-0.35
BIS	20.42	3.5	20.87	3.8	0.68 *	1.35
BAS-RR	16.35	1.8	16.71	2.1	0.41 *	1.51
BAS-D	10.54	2.2	10.78	2.3	0.62 *	1.09
BAS-FS	11.71	1.9	11.73	2.3	0.58 *	0.12
IVE-Imp	8.78	4.1	8.10	4.1	0.65 *	-1.74
SPSRQ-SR	7.29	3.7	7.45	3.7	0.73 *	0.50
SPSRQ-SP	7.59	4.1	7.27	4.6	0.75 *	-0.94

N=78; * result is significant at $p<0.0056$ [α]

Appendix A (page 294) describes factor analyses of T1 and T2 data and the estimation of standardised factor scores. Change scores for Trait-Approach, Trait-Avoidance, and Trait-Control were computed by subtracting T2 factor scores from T1 factor scores. Estimated T1 scores were highly and significantly correlated with those estimated in Chapter 2 [Trait-Avoidance: $r=0.99$; Trait-Approach: $r=0.96$; Trait-Control: $r=0.96$], indicating that the two methods have produced almost identical solutions.

Table 5.50 shows descriptive statistics and correlations between estimated factor scores.

[α] Bonferroni-correction: *$p<0.05$ divided by 9 analyses gives $p<0.0014$ (two-tailed)*

Table 5.50: Descriptive statistics and correlations between trait factor scores at T1 & T2 (n=78)

			T1			T2		
			Approach	Avoidance	Control	Approach	Avoidance	Control
Mean (s.d.)			-0.17 (2.2)	-0.01 (2.4)	5.27 (2.4)	0.17 (2.6)	0.01 (2.9)	5.44 (2.6)
T1	Approach	*r*	-	0.10	-0.33*	0.71*	0.10	-0.18
	Avoidance	*r*		-	0.25	-0.06	0.80*	0.29
	Control	*r*			-	-0.28	0.18	0.71*
T2	Approach	*r*				-	0.01	-0.23
	Avoidance	*r*					-	0.29
	Control	*r*						-

* Correlation significant at $p<0.0033$ – two-tailed[α]; 9 missing cases

All T1-T2 correlations for each trait factor were positive and significant, ranging from 0.71 to 0.80. There were no significant differences between scores at T1 and T2 [Approach, t=1.62; Avoidance, t=0.08; Control, t=0.78] in all cases. For each of the three derived factors, T1-T2 correlations were stronger than the T1-T2 correlations for the contributory subscales (Table 5.49).

Laboratory indices of approach, avoidance, and control

Go-No Go (GNG) Task

As described on page 64 for T1 data, positive scores on GNG Reward, and negative scores on GNG Punishment and GNG Reversal indicate that participants successfully learned the task. Scores for between 30 (34.5%) and 41 (47.1%) cases at T1, and between 22 (28.2%) and 37 (47.4%) cases at T2 were in the opposite direction for one or more of the six GNG measures, suggesting that these participants did not learn the task.

Table 5.51 presents descriptive statistics, correlations and t-tests for these data.

Table 5.51: T1 and T2 descriptive statistics for Go-No Go task data (n=78)

	T1		T2		*Rho*	*Z*
	mean	s.d.	mean	s.d.		
GNG Reward expectancy	0.12	0.2	0.10	0.1	0.02	-1.46
GNG Punishment expectancy	0.12	0.2	0.13	0.1	-0.06	-0.49
GNG Reversal expectancy	0.08	0.1	0.05	0.1	-0.03	-1.75
GNG Reward responses	0.09	0.1	0.08	0.1	0.01	-1.24
GNG Punishment responses	0.18	0.2	0.22	0.3	0.08	-0.95
GNG Reversal responses	0.12	0.2	0.12	0.2	0.18	-0.14

No difference/correlation is significant at $p<0.0083$[α]; Spearman/Wilcoxon signed-ranks tests

[α] Bonferroni-correction: *$p<0.05$ divided by 15 analyses gives $p<0.0033$ (two-tailed)*
[α] Bonferroni-correction: *$p<0.05$ divided by 6 analyses gives $p<0.0083$ (two-tailed)*

Strong skews to these data could not be corrected and non-parametric analyses are therefore used. There were no significant associations or differences between scores at T1 and T2.

Oculomotor Antisaccade Task (AST)

At T1, three participants withdrew from the AST because of eye-strain or fatigue, or could not be tested due to visual impairments. Following the procedure described in Chapter 2, seven cases with less than 33% (20 trials) of valid data were excluded. At T2, four participants withdrew or could not be tested, and a further nine cases were excluded because of insufficient data. Overall, 64 participants had complete data at T1 and T2. Table 5.52 summarises descriptive statistics for these data.

Table 5.52: T1 and T2 descriptive statistics for antisaccade task (AST) data (n=64)

	T1		T2		r	t
	mean	s.d.	mean	s.d.		
AST Accuracy	65.21	20.0	77.34	16.5	0.45 *	-5.02 *
AST Interference	19.90	0.1	19.90	0.0	0.64 *	-1.07

* Difference/correlation is significant at $p<0.025$ - 2-tailed[a2]

T1 and T2 AST scores were modestly but significantly correlated. AST-Accuracy was significantly better at T2, indicating that participants improved in their ability to inhibit inaccurate eye-movements in antisaccade trials relative to prosaccade trials. AST-Interference, which reflects the extent of slowing in antisaccadic related to prosaccade trials, showed no change from T1 to T2 and there was a moderate correlation between scores at T1 and T2.

Iowa Gambling Task (IGT)

Technical problems resulted in the loss of IGT data for two cases at T1 and six at T2, leaving complete data from 79. Table 5.53 presents descriptive statistics for these data.

Table 5.53: T1 and T2 descriptive statistics for Iowa Gambling task (IGT) Net Scores (n=79)

	T1		T2		r	t
	mean	s.d.	mean	s.d.		
IGT Net Score	9.47	26.5	8.78	18.0	0.32*	0.23

* Difference/correlation is significant at $p<0.05$ - 2-tailed

[a2] Bonferroni-correction: *$p<0.05$ divided by 2 analyses gives $p<0.025$ (two-tailed)*

T1 and T2 IGT Net Scores were weakly but significantly correlated, and there was no significant change overall across the two occasions.

Delay Discounting Task (DDT)

DDT discounting rate was calculated for all 87 cases, all of whom fulfilled the criteria suggested by Johnson and Bickel (2008) for assessing non-systematic DDT data – i.e. data where an individual's data is poorly explained by the hyperbolic model used to derive discounting rates (see page 67). That is, all perceived reward values to decrease as delay increased, and discounted rewards by at least 10% when the delay was 25 years. DDT Discounting Rates were log-transformed to correct a strong positive skew. Descriptive statistics are shown in Table 5.54.

Table 5.54: T1 and T2 descriptive statistics for delay discounting task (DDT) data (n=87)

	T1		T2		*r*	*t*
	mean	s.d.	mean	s.d.		
DDT Discounting Rate	-1.34	0.69	-1.37	0.70	0.70 *	0.53

* Difference/correlation is significant at p<0.05 - 2-tailed

T1 and T2 scores were significantly correlated, and there was no significant difference between baseline and follow-up scores.

Outcome measures: Alcohol use

Twelve participants reported never drinking at either T1 or T2. Alcohol use characteristics were explored only in the 76 participants reporting some alcohol use on at least one occasion.

AUDIT-Total

AUDIT-Total scores at T1 ranged from zero (4 cases; 5.3%) to 24 and at T2 ranged from 0 (1 case; 1.3%) to 28. Table 5.55 present descriptive statistics for these data.

Table 5.55: T1 and T2 descriptive statistics for AUDIT-Total (n=76)

	T1		T2		*r*	*t*
	mean	s.d.	mean	s.d.		
AUDIT-Total	8.63	5.9	8.59	6.2	0.75*	0.14

* Difference/correlation is significant at p<0.05 - 2-tailed

Scores at T1 and T2 were moderately and positively correlated and did not change significantly in the group as a whole. However, scores increased for 26 participants and decreased for 29 participants. Change scores ranged from -11 to +12, with a mean change of -0.04 (s.d.=4.4). A square-root transformation improved a positive skew to T1 and T2 AUDIT-Total scores.

Outcome measures: Illicit drug use

In total, 22 participants reported never having used any illicit drugs at both T1 and T2. Drug use is therefore explored further in only the remaining 64 participants ('ever-users').

Table 5.56 details the number of participants who had ever used each of 12 illicit substances at T1 and T2, the number of these who used the substance during the previous 3 months, and how many of these used the substance weekly or more.

Cannabis was by far the most widely used illicit substance, with all but four ever-users reporting use at either T1 or T2. It was also the most frequently used drug: 16 cannabis users reported weekly use at T1, though this dropped to only nine participants by T2. Around half of ever-users had tried cocaine, and roughly a third had used ecstasy, amyl nitrates, and/or magic mushrooms; however, almost no participants reported weekly or more frequent use of these substances.

Table 5.56: Frequencies of ever-users (n=64) reporting substance use at T1 and T2

	Number reporting use (ever)		No. reporting use in past 3 months		No. reporting at least weekly use	
	T1	T2	T1	T2	T1	T2
Cannabis	56	60	33	31	16	9
Crack cocaine	1	2	-	-	-	-
Cocaine	18	33	8	19	-	1
Ecstasy	19	23	8	11	1	1
Other Amphetamines	13	17	4	4	-	-
Amyl Nitrates	17	24	1	2	-	-
Other Inhalants	5	7	2	1	-	-
Sedatives	9	9	5	2	2	-
LSD	6	8	3	2	-	-
Magic Mushrooms	17	21	2	0	-	-
Other hallucinogens	7	13	7	5	1	-
Opiates	3	6	-	-	-	-

ASSIST-Total

ASSIST-Total scores ranged from zero (20 cases; 30.8%) to 80 at T1, and from zero (23 cases; 35.4%) to 75 at T2. Table 5.57 presents descriptive statistics for these data.

Table 5.57: T1 and T2 descriptive statistics for ASSIST-Total (n=64)

	T1		T2		r	t
	mean	s.d.	mean	s.d.		
ASSIST-Total	11.85	17.2	13.97	19.1	0.57*	-0.44

* Difference/correlation is significant at $p<0.05$ - 2-tailed

T1 and T2 scores were moderately significantly correlated, and there was no significant change over time in mean scores. However, scores decreased for 23 participants and increased for 29. Change scores ranged from -65 to +58, with a mean change of +2.12 (s.d.=16.2). A log transformation improved a positive skew to scores at both T1 and T2.

ASSIST-Count

Among the 64 ever-users, the number of illicit drugs ever used at T1 ranged from zero (7 cases; 10.9%) to nine; the median number of drugs used was two. At T2, the number ranged from one (18 cases; 28.1%) to 10, and the median score was three.

Figure 5.38 shows that half (*n*=32) tried new illicit drugs between T1 and T2. Scores at T1 and T2 were strongly skewed; these skews could not be corrected and these data are therefore analysed using non-parametric tests.

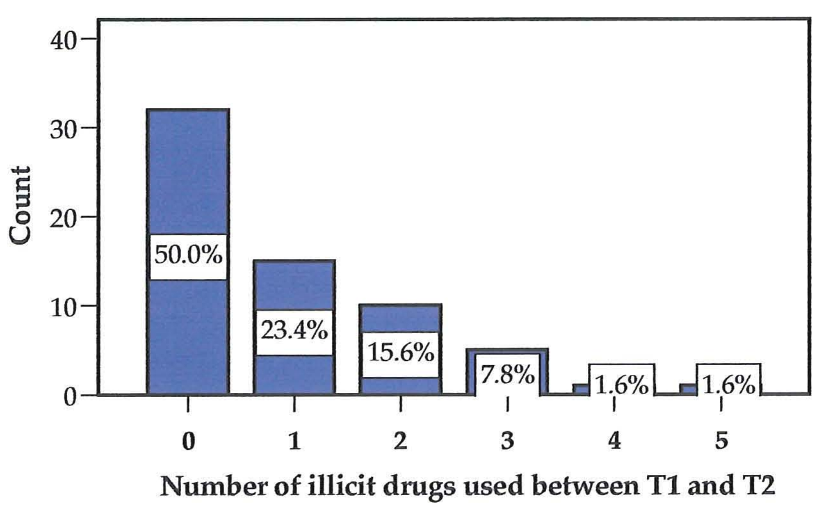

Figure 5.38: Number of new illicit drugs used between T1 and T2.

To assess predictors of change in substance use, 'substance change' groups were formed on the basis of T1 and T2 ASSIST-Count scores. The aim was to find groups who were roughly matched at baseline, but who either did or did not increase their drug use during the subsequent 12-27 months interval. Since ASSIST-Count scores can only increase, two groups were formed: 'stable low-users' and 'increasers'.

- 'Stable low-users' (*n*=19) are participants who had used only one or two illicit drugs at T1 and did not use any new substances before T2.
- 'Increasers' (*n*=22) are participants who had likewise used only one or two illicit drugs at T1, but who used additional illicit drugs between T1 and T2, and participants who had never used illicit drugs at T1, but did use illicit drugs between T1 and T2.

Comparisons between these two groups will enable the exploration of factors that predict which participants are more likely to experiment with new illicit substances. Figure 5.39 presents mean ASSIST-Count scores for the two groups.

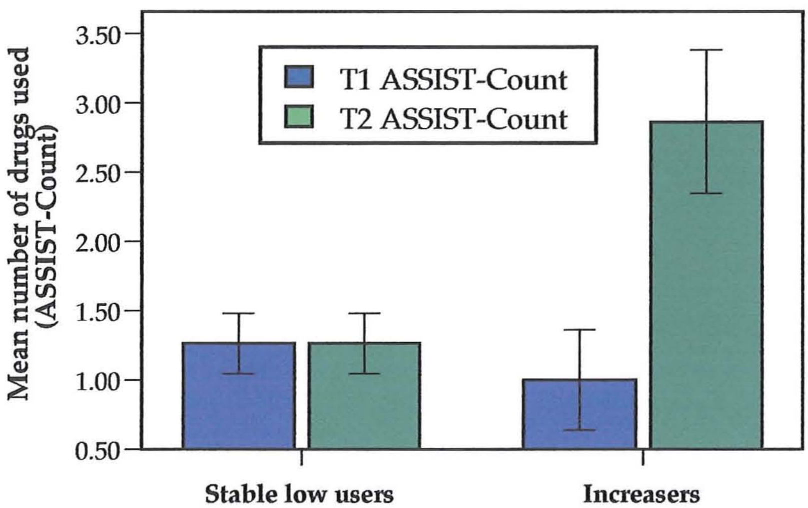

Figure 5.39: T1 and T2 ASSIST-Count scores for 'stable low users' (n=19) and 'increasers' (n-22) (error bars=95%CIs).

ASSIST-Freq

Among the 64 ever users, 42 (65.6%) were using at least one substance at T1, and all were current users at T2. ASSIST-Freq scores ranged from zero to 57 at T1, and at T2 from zero to 49; median scores were one and two respectively. Wilcoxon Signed Ranks test showed no significant differences between T1 and T2 scores [Mean positive rank=17.8, mean negative rank=22.1, Z=-1.93, *ns*], which were significantly correlated

[Rho=0.54, $p<0.001$]. These data were positively skewed and nonparametric analyses are used.

Change scores ranged from -45 to +25 and the mean was -3.20 (s.d.=11.9). Overall, frequency of use increased for 15 (23.4%) and decreased for 24 37.5%). Since there was very limited variance in scores, with about two-thirds of participants using drugs monthly or less on both occasions, only two small 'substance change' groups were extracted on the basis of ASSIST-Freq data. Both groups were moderate users at T1, defined by using drugs between one and four times a fortnight (scale range 6-25).

- 'Stable users' (n=6) showed the same pattern at T2, with a change of less than four points.
- 'Decreasers' (n=8) showed a decrease of five points or more from T1 to T2.

Although these groups are very small, comparisons between them were conducted to explore whether any T1 variables predicted a reduction in drug use.

Figure 5.40 presents ASSIST-Freq scores for the two groups.

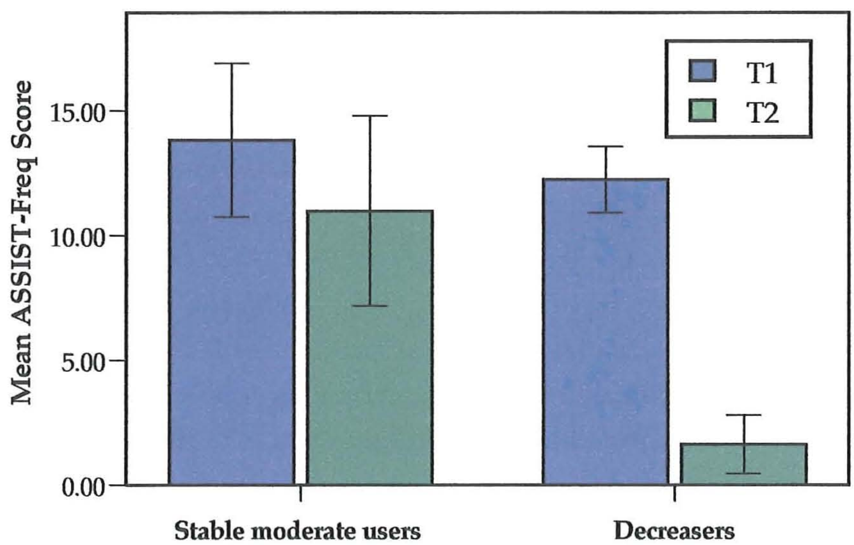

Figure 5.40: T1 and T2 ASSIST-Freq scores for 'stable moderate users' (n=6) and 'decreasers' (n=8) (error bars=95%CIs).

ASSIST-Prob

In order to focus on differences between current drug users who do and do not experience problems, ASSIST-Prob data are analysed only for the 52 participants who report some current illicit drug use (i.e. ASSIST-Freq scores>0) at either T1 or T2.

Among these students, T1 ASSIST-Prob scores ranged from zero (32 cases; 61.5%) to 21, and, at T2, from zero (34 cases; 65.4% students) to 18. Thus, only 20 participants reported any problem drug use at T1 and just 18 at T2. Wilcoxon Signed Ranks test showed no significant difference between T1 and T2 scores [Mean positive rank=8.9, mean negative rank=13.0, Z=-1.81, *ns*], which were significantly correlated [*Rho*=0.54, *p*<0.001]. Transformations could not improve a strong positive skew to T1 and T2 ASSIST-Prob scores, which are therefore analysed nonparametrically.

Change scores ranged from -16 to +9 with a mean of -0.10 (s.d.=4.13). Scores decreased for 14 participants, increased for 8, and remained the same (zero for all but 4 cases) for 30. To identify 'problem change' groups, those 52 participants were dichotomised into 'problem' (any score >0) and 'non-problem' (score of zero) groups at both T1 and T2: 26 reported no problems at either T1 or T2 ('stable non-problem users'), 12 had problems at both T1 and T2 ('stable problem users'), 6 developed problems between T1 and T2 ('increasers'), and 8 reported problems at T1 but had none at T2 ('decreasers'). Figure 5.41 presents ASSIST-Count scores for these four groups at T1 and T2.

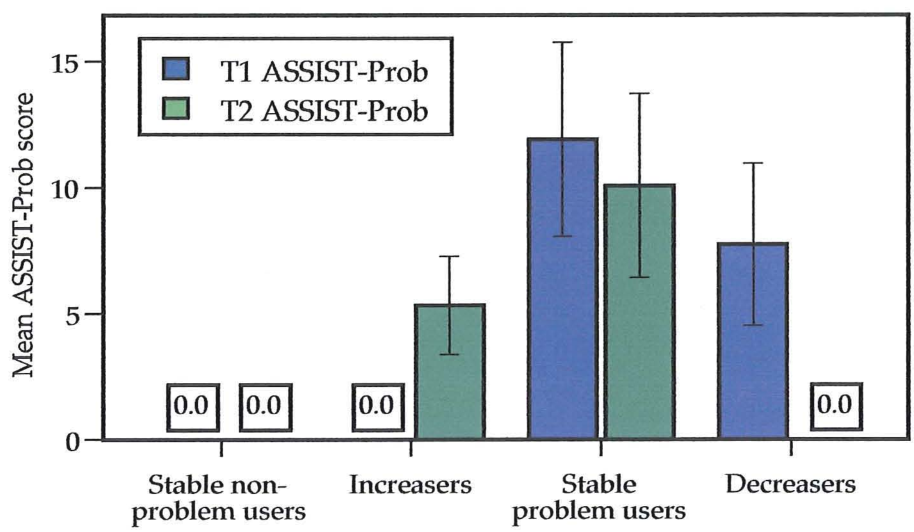

Figure 5.41: T1 and T2 ASSIST-Prob scores for 'stable non-problem users' (n=26), 'increasers' (n=6), 'stable problem users' (n=12) and 'decreasers' (n=8) (error bars=95%CIs).

Contrasts were conducted specifically between:

a. 'Stable non-problem users' (*n*=26) vs. 'increasers' (*n*=6)

b. 'Stable problem users' (*n*=12) vs. 'decreasers' (*n*=8)

Testing the causal link between impulse control and substance use

Hypothesis I – Changes in substance use between T1 and T2 will be positively associated with T1 measures of approach, and negatively correlated with T1 avoidance and control.

Table 5.58 presents the correlations of T1 indices of approach, avoidance, and control with a) AUDIT-Total change scores in the 76 participants reporting some alcohol use at either T1 or T2, and b) ASSIST-Total change scores in the 64 students reporting some past illicit drug use.

Table 5.58: Correlations between change scores for AUDIT-Total and ASSIST-Total with T1 indices of approach, avoidance, and control.

	AUDIT-Total change scores			ASSIST-Total change scores		
T1 measures:	*n*	*r*	*p*	*n*	*r*	*p*
Indices of approach						
Trait-Approach	67	-0.11	0.371	55	0.04	0.752
GNG Reward expectancy‡	76	0.09	0.462	64	-0.09	0.467
GNG Reward responses ‡	76	0.09	0.424	64	-0.00	0.974
Indices of avoidance						
Trait-Avoidance	67	0.07	0.606	55	-0.08	0.566
GNG Punishment expectancy‡	76	-0.14	0.230	64	-0.13	0.301
GNG Punishment responses‡	76	0.18	0.130	64	0.04	0.783
Indices of control						
Trait-Control	67	0.08	0.504	55	-0.10	0.490
GNG Reversal expectancy‡	76	-0.04	0.756	64	0.16	0.209
GNG Reversal responses‡	76	0.12	0.317	64	0.03	0.811
IGT Net Score	70	**-0.31**	**0.008**	59	0.03	0.850
AST Accuracy	55	0.15	0.287	47	**-0.29**	**0.047**
AST Interference	55	-0.10	0.460	47	-0.26	0.080
DDT Discounting Rate	76	**0.26**	**0.026**	64	0.12	0.356

No correlation is significant at $p<0.0077^{\alpha}$; ‡ Spearman correlations, all others are Pearson tests
Missing cases: Trait measures: 9; IGT: 6; AST: 21

There was a pronounced trend ($p<0.01$) for IGT Net Score to predict change in AUDIT-Total, with better task performance at T1 tending to predict a reduction in alcohol use. Since this IGT score purports to index control, this result is consistent with hypotheses. A weak positive association ($p<0.05$) between change in alcohol use and T1 DDT discounting rate is also in the direction expected, with more impulsive individuals increasing their alcohol use over time. A third weak negative association between accuracy on the antisaccade task and change in drug use (ASSIST-Total) is also consistent with the hypothesis that more highly controlled participants will be more likely to decrease their substance use. However, given the number of correlations performed, and relatively small sample sizes, it is quite likely that these trends reflect spurious findings, and indeed none achieves significance after Bonferroni correction.

These analyses were re-run controlling for level of use at T1, in case baseline variations were masking predictive relationships. The results of these analyses are not presented in detail; however, after Bonferroni corrections were applied ($p<0.0077^{\alpha}$), no trends or significant associations were found.

Substance change groups

T-tests and Mann-Whitney *U* tests were also used to compare the various substance 'change' groups previously specified in terms of their scores on indices of impulse control at T1. There were no significant differences between the substance change groups on any indices of impulse control. Overall, these results provide no support for the hypothesised associations between impulse control and substance use.

Hypothesis II – Changes in various facets of impulsivity will correlate with changes in substance use

To explore this hypothesis, change scores for indices of approach, avoidance, and control were correlated with change scores on AUDIT-Total (among alcohol users) and ASSIST-Total (among ever-drug users). Table 5.59 presents the results of these analyses.

There were a trend towards an associations ($p<0.05$) between higher Trait-Control and decreases in illicit drug use. This effect is likely to be spurious given the number of analyses conducted and after Bonferroni correction did not reach significance. Additionally, the correlations were re-run controlling for T1 scores in AUDIT and ASSIST-Total; again, there were no significant correlations ($p<0.0077^{\alpha}$).

[α] Bonferroni-correction: *$p<0.10$ divided by 13 correlations (per substance use measure) gives $p<0.0077$ (one-tailed)*

Table 5.59: Correlations between change scores for AUDIT-Total and ASSIST-Total with change scores for indices of approach, avoidance, and control.

	AUDIT-Total change scores (n=76)			ASSIST-Total change scores (n=64)		
Change scores (T2-T1):	n	r	p	n	r	p
Indices of approach						
Trait-Approach	67	0.05	0.711	55	0.14	0.316
GNG Reward expectancy	76	-0.03	0.769	64	0.13	0.324
GNG Reward responses	76	0.05	0.677	64	0.13	0.304
Indices of avoidance						
Trait-Avoidance	67	-0.02	0.862	55	-0.06	0.687
GNG Punishment expectancy	76	-0.14	0.215	64	-0.02	0.902
GNG Punishment responses	76	0.15	0.189	64	0.11	0.400
Indices of control						
Trait-Control	67	-0.23	0.066	55	**-0.27**	**0.047**
GNG Reversal expectancy	76	-0.00	0.995	64	0.15	0.249
GNG Reversal responses	76	0.05	0.676	64	0.11	0.395
IGT Net Score	70	0.25	0.037‡	59	-0.11	0.426
AST Accuracy	55	-0.05	0.744	47	-0.23	0.117
AST Interference	55	-0.03	0.816	47	-0.11	0.444
DDT Discounting Rate	76	0.04	0.755	64	-0.01	0.960

No correlation is significant at p<0.0077[†]; ‡Result is in the opposite direction to 1-tailed hypothesis; Missing cases: Trait measures: 9; IGT 6; AST: 21

Substance change groups

T-tests were used to compare the substance 'change' groups specified for ASSIST-Count, ASSIST-Freq, and ASSIST-Prob on impulse control change scores. The results are presented in Table 5.60.

There was a pronounced trend (p<0.01) for stable non-problem drug users and increasers to differ on change in GNG Reward Expectancy scores (see Figure 5.42).

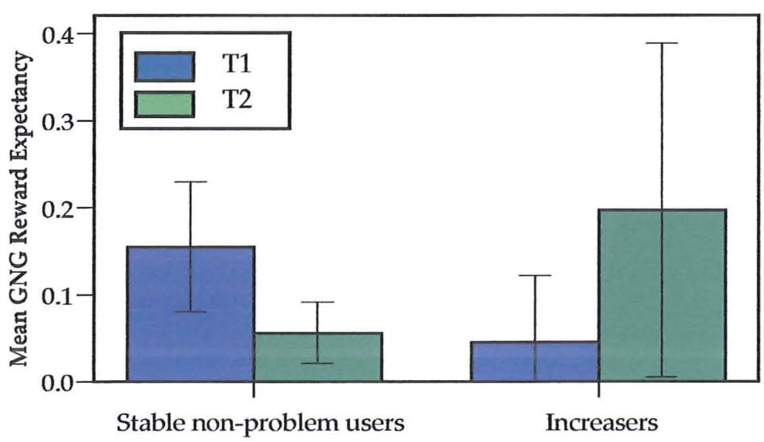

Figure 5.42: T1 and T2 GNG Reward Expectancy data for 'stable non-problem users' (n=26) and 'increasers' (n=6) (error bars=95%CIs).

[†] Bonferroni-correction: p<0.10 divided by 13 analyses gives p<0.0077 (one-tailed)

Table 5.60: Tests of differences between substance 'change' groups on change scores for indices of approach, avoidance, and control.

Change scores (T2-T1)	ASSIST-Count Stable low users (*n*=19) vs. increasers (*n*=22)		ASSIST-Freq Stable moderate users (*n*=6) vs. Decreasers (*n*=8)		ASSIST-Prob Stable non-problem users (*n*=26) vs. increasers (*n*=6)		ASSIST-Prob Stable problem users (*n*=12) vs. decreasers (*n*=8)	
Indices of approach								
Trait-Approach	t(32)=1.97	*p*=0.058	t(9)=-0.65	*p*=0.532	t(24)=-0.30	*p*=0.767	t(16)=0.14	*p*=0.891
GNG Reward expectancy	t(39)=-1.30	*p*=0.201	t(12)=-0.24	*p*=0.815	**t(30)=-2.86**	***p*=0.008**	t(18)=-0.99	*p*=0.336
GNG Reward responses	t(39)=-0.40	*p*=0.695	t(12)=-2.10	*p*=0.057	t(30)=-0.43	*p*=0.668	t(18)=-0.96	*p*=0.349
Indices of avoidance								
Trait-Avoidance	t(32)=0.47	*p*=0.644	t(9)=0.48	*p*=0.645	t(24)=-0.65	*p*=0.519	t(16)=-0.49	*p*=0.631
GNG Punishment expectancy	t(39)=-0.86	*p*=0.395	t(12)=-1.02	*p*=0.325	t(30)=2.93	*p*=0.006‡	t(18)=0.70	*p*=0.492
GNG Punishment responses	t(39)=-0.08	*p*=0.940	t(12)=0.05	*p*=0.962	t(30)=1.85	*p*=0.075	t(18)=-1.79	*p*=0.091
Indices of control								
Trait-Control	t(32)=0.97	*p*=0.338	t(9)=-1.06	*p*=0.316	t(24)=0.33	*p*=0.745	t(16)=-1.98	*p*=0.065
GNG Reversal expectancy	t(39)=-1.72	*p*=0.093	t(12)=1.22	*p*=0.245	t(30)=0.10	*p*=0.918	t(18)=-1.40	*p*=0.178
GNG Reversal responses	**t(39)=-2.12**	***p*=0.041**	t(12)=0.07	*p*=0.945	t(30)=-0.26	*p*=0.796	t(18)=0.27	*p*=0.793
IGT Net Score	**t(36)=2.54**	***p*=0.015**	t(12)=-1.53	*p*=0.153	t(27)=0.75	*p*=0.460	t(18)=1.06	*p*=0.307
AST Accuracy	t(28)=1.32	*p*=0.196	t(9)=1.53	*p*=0.160	t(22)=1.52	*p*=0.143	t(14)=-0.65	*p*=0.529
AST Interference	t(28)=1.23	*p*=0.229	t(9)=0.77	*p*=0.459	t(22)=-1.39	*p*=0.180	t(14)=0.08	*p*=0.935
DDT Discounting Rate	t(39)=-0.60	*p*=0.550	t(12)=-1.44	*p*=0.175	t(30)=1.07	*p*=0.293	t(18)=0.11	*p*=0.913

No t-test is significant at $p<0.0077$[†]; ‡Result is in the opposite direction to 1-tailed hypothesis

[†] Bonferroni-correction: $p<0.10$ divided by 13 analyses gives $p<0.0077$ (one-tailed)

It can be seen that stable non-problem users had lower expectations of reward at T2 than T1, whereas reward expectations increased among participants who developed problems with their drug use. This association is in the direction predicted; however, they must be interpreted in the context of the large number of analyses, the lack of other similar associations, and the small sample. These issues will be addressed in the discussion. Similarly, of the participants who used some illicit drugs in T1, those who went on to try additional new drugs showed parallel reductions in two indices of control (IGT/GNG) whilst those who did not showed slight increases in their control indices. These differences were in the predicted direction but fell short of significance after Bonferroni correction.

Overall, then, there was very limited support for the hypothesis that changes in impulsivity would parallel changes in substance use.

Attitudinal factors & Life stress as predictors of change in substance use

It was hypothesised that change in substance use would be predicted by T1 measures of attitudes towards drug use, the perceived riskiness of alcohol/drugs, intentions to use alcohol/drugs, whether participants reported religious-restrictions, and life stress measured at T1 and T2. Table 5.61 presents correlations of AUDIT-Total and ASSIST-Total change scores with T1 attitudinal measures, T1 Life Stress, and T2 Life Stress.

Table 5.61: Associations of change scores for AUDIT-Total and ASSIST-Total with T1 attitudinal factors, T1 Life Stress, and T2 Life Stress.

		AUDIT-Total change scores (n=76)		ASSIST-Total change scores(n=64)	
		n		n	
T1	Attitudes	76	r=-0.04, p=0.74	64	r=-0.06, p=0.65
	Riskiness-Alcohol	76	r=0.10, p=0.40		
	Riskiness-Illicit			64	r=-010, p=0.41
	Alcohol-Intentions	75	Rho=- p=0.59		
	Illicit-Intentions			64	r=0.00, p=0.97
	Religious Restrictions	76	$t(73)$=1.6 p=0.10	64	$t(62)$=0.5 p=0.59
	Life Stress	59	r=0.01, p=0.92	49	r=0.19, p=0.18
T2	Life Stress	76	r=-0.01, p=0.94	64	r=-0.02, p=0.90

No correlation is significant at p<0.017[†]

[†] Bonferroni-correction: p<0.10 divided by 6 analyses gives p<0.017 (one-tailed)

There were no significant associations. As previously, the analyses were re-run controlling for variation in T1 levels of substance use. The results are not presented here but they revealed no significant associations, nor any trends.

Comparisons between substance change groups (ASSIST-Count, ASSIST-Freq, and ASSIST-Prob) on T1 attitudinal factors, T1 Life Stress, and T2 Life Stress are shown in Table 5.62.

There was only one significant effect: as shown in Figure 5.43, students whose drug use decreased from T1 to T2 had in fact indicated less intention to use in the future than had those who maintained the same levels of use across the two time points. Thus, intention did (weakly) predict behaviour.

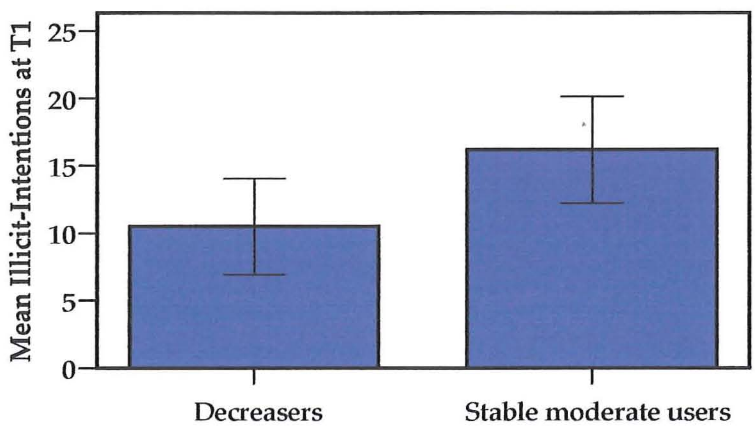

Figure 5.43: T1 Illicit Intentions data for 'stable moderate users' (n=6) and decreasers (n=8) on ASSIST-Freq. (error bars=95% CIs)

There were no other significant associations between any of the attitudinal factors or life stress and change in substance use. Therefore, overall, there is some support for the hypothesis that intentions predict substance use, but no support for any of the hypotheses regarding the predictive utility of attitudes to drug use, perceived riskiness of drug use, religious-restrictions, or life stress.

Combined predictors of changes in substance use

While it was intended that regression analyses would be used to assess the combined effect of individual predictors of change in ASSIST-Total and AUDIT-Total, since analyses revealed no significant predictors, these analyses were not performed.

Table 5.62: Tests of differences between substance change users on T1 measures of attitudinal factors and Life Stress

	ASSIST-Count Stable low users (n=19) vs. increasers (n=22)	ASSIST-Freq Stable moderate users (n=6) vs. Decreasers (n=8)	ASSIST-Prob Stable non-problem users (n=26) vs. increasers (n=6)	ASSIST-Prob Stable problem users (n=12) vs. decreasers (n=8)
T1 Attitudes	$t(38)=-0.55$ $p=0.588$	$t(12)=0.75$ $p=0.465$	$t(30)=-1.20$ $p=0.239$	$t(18)=1.79$ $p=0.090$
T1 Riskiness-illicit	$t(38)=0.54$ $p=0.593$	$t(11)=0.80$ $p=0.439$	$t(29)=1.63$ $p=0.113$	$t(18)=-0.04$ $p=0.970$
T1 Illicit-intentions	$t(38)=-1.10$ $p=0.277$	**$t(12)=-3.31$ $p=0.006$***	$t(30)=-0.57$ $p=0.582$	$t(18)=1.90$ $p=0.074$
T1 Religious-Restrictions	$\chi^2(1)=0.04$ $p=0.839$	$\chi^2(1)=0.81$ $p=0.369$	$\chi^2(1)=4.47$ $p=0.188$	$\chi^2(1)=1.48$ $p=0.495$
T1 Life Stress	$t(30)=-0.29$ $p=0.771$	$t(7)=-0.84$ $p=0.430$	$t(23)=-0.53$ $p=0.599$	$t(13)=-1.07$ $p=0.304$
T2 Life Stress	$t(38)=0.11$ $p=0.915$	$t(12)=-1.27$ $p=0.227$	$t(30)=-1.49$ $p=0.146$	$t(18)=0.95$ $p=0.357$

*Analysis is significant at $p<0.013$ - one-tailed$^{\alpha}$

$^{\alpha}$ Bonferroni-correction: *$p<0.10$ divided by 6 analyses gives $p<0.013$ (one-tailed)*

Discussion

The primary aim of this study was to conduct a prospective exploration of the relationships between impulsivity and substance use. Surprisingly, the results suggest a near-complete absence of any causal relationship between indices of the two variables; moreover, they present very little evidence that attitudinal factors or life stress serve as useful predictors of change in substance use. While there are some important limitations to this study that must be addressed and will be acknowledged in later sections, this discussion will first consider the implications of these findings in relation to the extant literature and assumptions of the IIC Framework.

Testing the causal link between impulse control & substance use

There is some empirical evidence, reviewed at the start of this chapter, both that impaired impulse control is an important predictor of substance use initiation and that substance use leads to impaired impulse control. However, the requisite longitudinal studies needed to clarify the causal link between impulsivity and substance use do not yet exist, and a primary aim of the prospective research described in this chapter was to contribute to this body of empirical data. It sought to test possible bi-directional causal relationships; to that end, three separate hypotheses were tested: 1) that impulse control would predict change in substance use; 2) that substance use would predict change in impulse control; and 3) that changes in substance use would parallel changes in impulse control.

The IIC framework assumes that impulsive behaviour results from the combination of three functions: two competing systems generate approach and avoidance impulses, resulting in action tendencies to either engage in or avoid the behavioural outcome; and a third, cognitive control, system acts to inhibit action tendencies that oppose an individual's intentional state. Impulse control data were gathered to tap these three systems: three trait measures (Trait-Approach, Trait-Avoidance, and Trait-Control) and four laboratory tasks (Go-No Go task [GNG], Iowa Gambling Task [IGT], Delay Discounting Task [DDT], and Antisaccade task [AST]). Eighty-seven undergraduate students (aged 18-21) were tested on two occasions (T1 and T2) across an interval of 12-

27 months. Two substance use measures were also administered at both time-points: one of overall alcohol use (AUDIT-Total) and one of overall illicit drug use (ASSIST-Total). In addition to deriving continuous scores from these, 'substance change groups' were formed by matching participants on aspects of their baseline use (number of drugs used, frequency of use, drug use problems) and comparing participants with stable levels of use across the two time-points with those whose use increased or decreased.

1) Does impulse control predict change in substance use?

After controlling for variation in levels of substance use at T1, and after Bonferroni corrections were applied, there were no significant associations between self-report or laboratory task indices of impulsivity at T1 and increases in overall alcohol use (n=76) or drug use (n=64) at T2. Thus, baseline impulse control did not predict change in substance use in this sample.

Taken at face value, these results suggest that variation in impulse control - as defined and assessed in this study – is not strongly related to whether or how individuals change their substance use over time. The Impulse, Intentions and Control (IIC) framework assumes that approach, avoidance, and control processes are important factors that influence whether an individual initiates substance use, and also whether they progress to dependency. As discussed in Chapter 1, these assumptions derive in part from the focus in addiction literature upon the importance of brain reward systems and inhibitory control mechanisms, and in part from the growing empirical and theoretical literature that links various indices of impulsivity with substance use/abuse.

Trait-Control is derived from established questionnaire measures of impulsivity and novelty seeking and, while care was taken to remove items directly associated with substance use from questionnaire subscales, many other items describe behaviours or responses that one might expect from someone who is inclined to explore recreational drug use or engage in risky behaviours (e.g. "When nothing new is happening, I usually start looking for something that is thrilling or exciting"). While responses to such questions at any given time-point are unsurprisingly associated with an individual's current substance use, any possible effect that they have in increasing the propensity to escalate substance use in the future could not be detected in the present moderately sized sample within which – in reality – very few changed their behaviours substantially.

The laboratory task measures of 'response inhibition', 'delay discounting', and 'cognitive decision-making' all tap processes that were hypothesised to influence whether an individual engages in substance use: response inhibition reflects an individual's ability to suppress automatic responses, perhaps including urges to engage in substance use; delay discounting assesses an individual's preference for immediate over delayed reward, and may manifest in his/her ability to refrain from drug use and focus instead on the delayed rewards of a healthier drug-free lifestyle; and cognitive decision-making may be more or less risky or conservative, and underlie real life choices about whether to take a potentially dangerous chemical substance with possible pleasurable effects. However, the present study found no association between the strength of inhibitory control mechanisms as tapped by the antisaccade task, or delayed gratification as measured by the delay discounting task, and whether an individual subsequently increases their drug use. Counter-intuitively, in fact, individuals who used new illicit drugs between T1 and T2 actually made significantly more conservative (low risk) choices on the Iowa Gambling Task than students who did not increase their substance use between testing sessions. In Chapter 3, a similarly unexpected association ($p<0.05$) was noted between better IGT performance and higher alcohol use, though there was also a trend in the expected direction towards an association with the number of drugs ever used. Other associations with the delay-discounting task in Chapter 3 were also not in the expected direction.

It may be that the hypothesised associations do exist but are simply not large enough to be detected in the present sample, which was limited in terms of age, occupation, and to some extent socio-economic status and of motivations relevant to substance use. For instance, all are by definition intellectually able and aspirational, two factors that may have a pronounced dampening effect on their substance use. Relatedly, it may be that subgroups of the populations with very high/clinical levels of impulsivity were not strongly represented in this sample, thus reducing the power to detect predictive associations. This might explain the apparent contradiction between the present findings with associations reported between clinical levels of impulsivity, adolescent developmental disorders (e.g. ADHD, CD), and subsequent substance use and abuse (e.g. Caspi, Moffitt, Newman, & Silva, 1996; McClernon et al., 2008; Pardini et al., 2007); and also the associations between impulsivity and substance use found in large representative samples, which by definition include individuals with clinical levels of impulsivity. It is notable that two studies reporting significant associations between impulsivity and drug use had included large samples (Slutske et al. n=939; Elkins et al. n>1100), and that smaller prospective studies have failed to find similar significant associations (e.g. Leff et al. n=59).

2) Does change in substance use parallel change in impulse control?

After controlling for variation in T1 levels of overall alcohol and illicit drug use, and after applying Bonferroni corrections for multiple comparisons, there were no significant associations between variation in T2 levels of substance use and variation in changes in impulse control.

If impulsivity and substance use are reciprocally causally related, one would expect them to covary over time, and that this should be particularly evidence during a state of transition. It is possible that causal relationships were not captured here because very few or no students were in the state of transition from abstinence to initiation, or from controlled to dependent use. In fact, there is some evidence that impulsivity *decreased* on average between T1 and T2: after adjustment for multiple tests, there was a trend for TPQ-Novelty Seeking scores to be lower at follow-up than at baseline [p=0.007], and mean AST-Accuracy scores were significantly higher at T2, indicating that participants were better able to inhibit eye-movements in antisaccade trials, relative to prosaccade trials than at T1 (it is possible that these improvements reflect practise effects, but unlikely, given the long gap between testing sessions and absence of similar effects in other behavioural tasks). It is also possible that participants curbed their substance use, since at T2 many were in the final year of their degree and were tested during the months prior to their final exams. It may be that the larger samples in the cohort studies studies by Slutske et al. (2005) and Elkin et al. (2007), which did report positive associations, included more individuals in stages of transition.

As discussed in the introduction, support for the argument that substance use triggers change in impulse control derives mostly from cross-sectional studies of addicts, whose behaviour appears indicative of impaired control and who also demonstrate abnormal brain functioning in neuro-imaging studies (e.g. Volkow et al., 2003; 2004) which is argued to result from their prolonged exposure to substances of abuse (Jentsch & Taylor, 1999). There has been inconsistent support from studies of recovery in abstinent addicts, and while psychopharmacological theories describing the mechanisms by which drug use may lead to impaired control processes are convincing, there has been little corroborative evidence from human research. The null findings reported in the present study contribute no new support for this hypothesis.

As was noted earlier, theories such as Goldstein and Volkow's (2002) Impaired Response Inhibition and Salience Attribution model (I-RISA) provide an account of the addictive state, but do not explain substance use initiation, or why impaired control may predict future recreational substance use. Due to a lack of relevant longitudinal research, it is not clear whether a critical quantity or frequency of drug use may trigger functional abnormalities and inhibitory deficits; thus it may be that participants in the present study have simply not engaged in sufficient quantities or frequencies of substance use for deficits to become apparent. Equally, however, it may be that substance use genuinely has no causal influence on impulse control and that the abnormal functioning reported among addicts actually reflects pre-existing abnormalities. The absence of any evidence for either direction of causal association between substance use and impulsivity in the present study makes it impossible to draw clear conclusions, and replication of this finding, and, as already noted, the negative findings could reflect methodological factors such as characteristics of the sample, the modest sample size, or the relatively short time frame. Further longitudinal research in larger, and more heterogeneous samples is therefore needed.

Attitudinal factors and life stress as predictors of change in substance use

In Chapter 3, strong cross-sectional associations were found between alcohol and drug use and measures of a range of attitudinal factors and life stress. In the present study, attitudes towards drug use, perceived riskiness of alcohol/drug use, intentions to engage in future drinking/alcohol use, religious restrictions against substance use, and a measure of reported life stress over the previous 12 months (assessed at T1 and T2) were all evaluate a potential predictors of change in consumption. However, none of these measures predicted overall alcohol use, or overall drug use at T2, after controlling for variation in baseline (T1) use. Participants who reported stable and moderately frequent drug use at T1 and T2 reported significantly higher intentions to engage in future drug use at T1 than did drug users who were similar to them in frequency of drug use at T1 but who decreased their use by T2. This finding is consistent with many other prospective studies reporting that intentions to use drugs predict subsequent drug use (e.g. Huchting, Lac, & LaBrie, 2008). However, there was no evidence for the involvement of other attitudinal factors, or if life stress, in predicting change in substance use.

It is notable that of the many studies which have reported associations between attitudinal factors and alcohol/drug use, very few have been longitudinal studies. Thus, although Huchting, Lac, and LaBrie (2008) found prospective associations between attitudes, intentions, and behaviour, these were across an interval of just one month. Elsewhere, however, Fisher et al. (2007) identified positive attitudes to alcohol as an important predictor of alcohol use initiation and binge drinking in a large (n=5511) prospective cohort study which followed participants from 11 to 18 years of age, and Skara, Sussman, and Dent (2001) found that intentions to smoke predicted the transition from irregular to regular smoking across an interval of one year. Skara et al.'s finding is consistent with the significant association found here between intentions to use drugs and actual frequency of use. Clearly, Fisher et al.'s findings are not consistent with those in the present study; however, their sample was far larger and the participants were assessed over a much longer period of time. This may have enabled them to detect even small associations, which may have been most pronounced in subgroups of the population that were not represented in the present study. Furthermore, Fisher et al. focused upon the likelihood of alcohol use initiation and binge drinking, neither of which was directly assessed in the present study.

Other findings of note

While the focus of this study was to explore predictors of change in substance use, it also provided an opportunity to investigate methodological issues surrounding the conceptualisation and measurement of impulsivity.

Results from the present study add to the concerns raised in previous chapters regarding the construct validity of the Go-No Go (GNG) task as an index of impulsivity. At both T1 and T2, more than a third of participants did not show *any* learning, and overall learning was slower than previously reported (Zinbarg & Mohlman, 1998). This is likely due to the novel use of a probabilistic reinforcement schedule to increase task difficulty; this may have made the task too difficult for many participants, and it is not clear whether factors other than approach-avoidance tendencies came into play as a result (e.g. general intelligence or working memory). Throughout this thesis, where significant associations between GNG indices and substance use were found, they were often in the *opposite* direction to that hypothesised, making the findings difficult to interpret within the extant literature, or the IIC Framework. Lastly, there was no association between scores at T1 and those at T2 on any of the six GNG measures, suggesting that the processes assessed by this task are not stable over this time period. Together, these points suggest that it is unlikely that this task is measuring the processes postulated within the IIC framework systems. Given that some GNG indices – particularly self-reported expectancies of reward and punishment - were significantly associated with, and predictive of substance use, albeit in the wrong direction, it is unfortunate that there is no way within the present design to determine what it actually *is* measuring.

In Chapter 2, the lack of significant intercorrelations between self-report and laboratory task indices of impulsivity was noted to be consistent with a growing literature that reports similar findings (e.g. G. Dom et al., 2006; Lane, 2003; B. Reynolds & Schiffbauer, 2005). Dom et al. (2006) suggested that laboratory tasks tap transient states, whereas questionnaires tap comparatively stable traits; however, the present prospective study offers little support for this argument since the two types of measure showed comparable degrees of stability from T1 to T1. Correlations for questionnaire scores and the three derived trait measures ranged from moderate (r=0.41 for BAS-Reward

Responsiveness) to high (*r*=0.80 for Trait-Avoidance). While there was almost no association between baseline and T2 GNG measures, there was a small but significant association for the Iowa Gambling Task (IGT; *r*=0.33), a sizeable association (*r*=0.71) for the Delay Discounting Task (DDT), and moderate correlations for the two AST measures (*r*=0.46 for accuracy; *r*=0.62 for interference).

It is interesting that there was such variation in the strength of the association between T1 and T2 laboratory task indices. One explanation for the stronger correlation shown by delay discounting rates may be that these are self-reported responses, in that the participant is presented with a series of hypothetical options and asked to report which they *think* they would actually select. It is notable however, that studies have found no significant difference between participants responses on this task when faced with real and hypothetical rewards (Madden et al., 2004); however, for obvious reasons, no study has tested real vs. hypothetical rewards using the magnitude of reward or duration of delay used in the classic paradigm (i.e. £1000 delayed up to 25 years). Notably, T1 and T2 scores were moderately correlated for self-report questionnaire responses and DDT performance, but only very modestly correlated for IGT responses were. In the IGT, actual choices must be made and are reinforced by hypothetical rewards and punishments; thus, the participant observes the immediate consequences of his/her behaviour. It may be that T1-T2 correlations are lower on this task *because* it more directly taps specific behavioural responses which could be expected to vary with state factors and thus fluctuate across an interval of a year or more; whereas self-report modes of assessment, since they tap more general tendencies, are more stable. It is notable that the reaction time measure of AST performance was more stable over time than saccadic accuracy. Klein and Fischer (2005) likewise reported higher stability for saccadic reaction time than errors across a 19-month test-retest interval, possibly reflecting the finding elsewhere that variation in reaction times may be strongly genetically influenced (Kuntsi et al., 2006).

Study Limitations

As already noted, the modest number of participants and relative homogeneity of the sample limits the extent to which the null findings reported here can be interpreted as a genuine absence of association. The limited amount of variation in substance use between T1 and T2 also restricted the types of analyses which could be performed, and necessitated the use of ASSIST-Total, a rather loose measure of illicit drug use, rather than the individual indices of drug use frequency, etc, that were employed in Chapter 3. In future research, a larger sample would enable the comparisons between clearly defined groups matched for baseline use, and whose substance use increases or decreases by a substantial amount. This would facilitate exploration of the more theoretically interesting transitions between the initiation of use and the early stages of alcohol/drug use; between irregular and regular alcohol/drug use; and between controlled and uncontrolled substance use.

Conclusions

This study was a preliminary exploration of the causal relationships between impulse control and substance use. In this sample of university students there was no evidence of any causal link between indices of these measures. Furthermore, attitudinal factors also failed to predict change in substance use. The small, relatively homogeneous sample may partly or completely explain this lack of association and replication of this study in larger and more diverse samples is needed.

One of the reasons to seek better understanding of risk factors for substance use/abuse is in order to target interventions on individuals who are most at risk of developing harmful or abusive levels of use. In reality, although many substance users may report some problems resulting from their use, only a small minority become heavy, dependent users; whether these individuals are categorically different from other users or lie at the extremes of one or more risk factors is not yet known. In the present study, there appeared to be no clear causal relationship between impulsivity – one factor strongly implicated in relation to substance use and abuse – and variation in recreational levels of substance use. If replicated, this finding would contradict the widespread assumption regarding the importance of impulsivity in relation to substance use; however, it may be that causal links between impulsivity and substance use (in either or both directions) are most apparent in clinical samples and that other factors are more important in recreational levels of substance use. A great deal of prospective research is needed to clarify the complex interrelationships likely to exist between impulse control and substance use/abuse.

CHAPTER SIX

General Discussion

The identification of factors implicated in the aetiology of substance use, abuse and dependency has been the focus of a large literature of research. Partly as a result of recent neurological studies identifying neural commonalities between processes underlying control and those implicated in addiction, and partly because of the important role that impaired control appears to play in behaviours indicative of, and used in the diagnosis of addiction, links between substance use and impulse control have been posited within several major accounts of addiction (e.g. Goldstein & Volkow, 2002; Jentsch & Taylor, 1999; West, 2006). The premise that impulse control is directly involved in substance use raises questions about the nature of this causal relationship that are important to understanding how to prevent the adverse effects of drug abuse and dependency. To that end, the primary aim of this thesis was to explore the involvement of self-control and inhibitory control mechanisms in the early stages of drug use and abuse.

In Chapter 1, the Intention, Impulse, and Control (IIC) framework - drawn from various contemporary perspectives related to addiction and impulsivity - provided a speculative account of how impulse control and a variety of other known risk factors may combine to influence behaviour. In Chapter 2, this framework was applied to existing conceptualisations of impulsivity and behavioural control, and trait measures were derived to serve as indices of these constructs in subsequent chapters. In Chapters 3 and 4, cross-sectional associations were explored between individual and combined risk factors from all levels of the IIC framework and alcohol and illicit drug use, and cigarette use respectively; In Chapter 5, longitudinal research was used to investigate the predictive nature of these relationships.

The present chapter will discuss the findings of this research programme, both in relation to the IIC framework, and in the wider contexts of impulsivity and substance use. The following sections will firstly discuss the extent to which the findings support the framework's structure – i.e. its account of the processes underlying impulsivity or impaired inhibitory control - and secondly, the extent to which the findings corroborate the framework's contents as a whole – i.e. the validity of including attitudinal, situational, impulse and control factors. Subsequently, discussion will turn to how findings from this programme of research contribute our understanding of the role of impulsivity in substance use and abuse.

Conceptualising impulse control within the IIC framework

Given that impulsivity research has lacked a "clearly defined operational definition and experimental implementation" (Grant, 2004; p.1505), one aim of this thesis was to seek clarity regarding the conceptualisation of impulse control. The literature is littered with "jingle" fallacies, where the term 'impulsivity' is used to describe various distinct constructs (e.g. reaction times and sensation seeking) and "jangle" fallacies, whereby distinct labels are applied to overlapping constructs (e.g. disinhibition and inhibitory control). Similarly, laboratory tasks individually described as measures of impulsivity differ greatly in the processes and abilities that they assess: some tap inhibitory control, others measure delayed gratification, and others assess cognitive decision-making. Within the IIC framework, it was assumed that interrelations between three systems (approach, avoidance, and control) underlie impulsive responding to both self-report and laboratory task measures. The first challenge of the thesis was to empirically test this assumption.

Deriving self-report indices of approach, avoidance, and control

A review of past research conducted to disentangle impulsivity revealed a lack of consistency in the number and nature of dimensions suggested by previous studies using factor analysis (e.g. Flory et al., 2006; Harmstead & Lester, 2000; E. Miller et al., 2004; Whiteside & Lynam, 2001). In chapter 2, the factor analysis of nine self-report questionnaires revealed three distinct factors that mapped directly onto the IIC framework's conceptualisation of approach, avoidance and control systems (see Fig. 2.1; page 58): Trait-Approach comprised measures of sensitivity to reward and behavioural activation, Trait-Avoidance comprised measures of sensitivity to punishment and harm avoidance, and measures of novelty seeking and impulsivity loaded negatively on Trait-Control.

This solution proved to be robust across split-half samples (Chapter 2) and reliable across a 12-24 month period (Chapter 5), and was also consistent across London and Brisbane samples (Chapter 2); given cross-cultural differences and the wider age-range of the Australian sample, this added further evidence of the solution's robustness. Thus, the obtained solution fit well with predictions derived from the IIC framework, and supported its basic assumptions regarding the existence and nature of approach, avoidance, and control systems.

Associations between laboratory task indices

In parallel to these self-report data, four laboratory tasks were used to assess distinct aspects of impaired impulse control.

The Go-No Go (GNG) task

The Go-No Go (GNG) task, a modified version of a task devised by Zinbarg & Mohlman (1998), provided a range of indices that were purported here to tap approach, avoidance, and inhibitory control processes. However, questions were raised about the validity and reliability of these task indices:

1) More than a third of participants showed no learning on the task;
2) Learning was slower than that reported by other researchers (Zinbarg & Mohlman, 1998); a probabilistic reinforcement schedule was included in the current version which may have made the task too difficult and perhaps brought other factors/processes (e.g. intelligence/working memory) into play as a result;
3) Test-retest correlations were almost zero (Chapter 5) suggesting either that the processes assessed by this task were highly transient, or that different processes were assessed at the two time-points – either explanation casts uncertainly on the interpretation of findings involving these indices.

For these reasons, results from this task will not be considered in the remainder of this chapter.

The IGT, AST, and DDT

Three other laboratory tasks were employed: an oculomotor antisaccade task (AST) to index response inhibition; a delay discounting task (DDT) to measure an individual's preference for immediate over delayed gratification; and the Iowa Gambling Task

(IGT) to index risk tolerance and decision-making. With regards to the IIC framework's three impulse control systems (approach/avoidance/control), AST indices were assumed to tap control processes, the IGT was proposed to tap all three systems - since it included aspects of reward, punishment, and inhibitory control - while for similar reasons the DDT was proposed to tap both approach and control systems. In Chapter 2 there were no significant or sizeable correlations within or between task indices for the IGT, AST, or DDT, which is not entirely surprising given that most of the indices were purported to reflect different aspects of impulse control. The lack of association was also consistent with previous studies that reported no associations between laboratory task indices (e.g. Lane, 2003; Swann et al., 2002). It was therefore hypothesised that associations predicted within the IIC framework would be revealed though correlations between laboratory task indices and trait measures.

Associations between trait and laboratory task indices

In Chapter 2, 13 directional associations were hypothesised between laboratory task indices and trait measures; following Bonferroni corrections, only one of these was supported empirically: accuracy on the AST was modestly but significantly (r=0.31) positively correlated with Trait-Control. While the absence of any other significant correlations between laboratory tasks and trait measures was disappointing – especially since the sample here was far larger than that used in many previous studies - it was consistent with a growing literature that reports a similar lack of associations (e.g. G. Dom et al., 2006; Lane, 2003; B Reynolds et al., 2006).

Various explanations have been offered to account for the lack of association typically reported between trait and laboratory task measures of impulsivity. Dom *et al.* (2006) suggested that laboratory tasks tap transient states, whereas questionnaires tap comparatively stable traits. However, longitudinal research in Chapter 5 of this thesis did not support this argument. Indeed, test-retest correlations for some laboratory task indices (i.e. DDT and AST-Interference) were higher than for the widely validated self-report questionnaires used to derive trait measures in Chapter 2 (which ranged from 0.41 to 0.75). These results indicated that the processes tapped by laboratory tasks used in this thesis are not more transient than those tapped by questionnaire measures.

Reynolds *et al.* (2006) suggested that self-report measures involve self-awareness and insight, whereas laboratory tasks do not. Likewise, Barratt (1993) proposed that, while some aspects of impulsivity can be assessed via self-report questionnaires, those involving cognitive processes are better quantified using laboratory task indices. It is true that questionnaire items inform the participant exactly what is being assessed, whereas a participant may or may not be able to understand the purpose behind tasks such as the DDT or AST. Thus, it is also possible that demand characteristics and response bias towards social desirability influenced self-report indices more strongly than laboratory task performance. However, the significant correlation reported here between a trait measure of control and an AST index of inhibitory control demonstrates that there can be some shared variance (around 9% in this case) between the two types of measures. However, it is not clear why this correlation was the only one to reach statistical significance, and possible that the result may have occurred by chance. Further research is therefore needed to identify the exact processes tapped by the AST and how they relate to those assessed by self-report.

Differences between test-retest correlations for indices of the three tasks may shed some light on the processes that they tap. For example, on the one hand, IGT performance reflected the number of advantageous decisions made and AST-Accuracy measured the proportion of correct saccadic eye-movements; in longitudinal analyses, both indices obtained modest test-retest correlations (0.33-0.46). On the other hand, DDT discounting rates tapped the ability to delay gratification and AST-Interference measured reaction times; neither included a measure of correctness and both obtained comparatively higher test-retest correlations (0.62-0.71) than the preceding two measures. It may be that AST-Accuracy and IGT indices tapped processes that were less stable over time than those tapped by DDT and AST-Interference, and therefore possibly accounting for the lower retest reliabilities. A better understanding of the exact processes tapped by all of these tasks is needed to provide a clearer interpretation of these results.

Summary

Predicted associations between self-report measures received strong empirical support and trait indices of approach, avoidance, and control were derived from existing questionnaires in line with predictions of the IIC framework. The Factor Analysis solution was robust between samples and over time. Laboratory task indices provided less support for the IIC framework's assumptions, although this was principally due to their lack of association with self-report measures; this reflects findings reported elsewhere and is yet to be fully explained. Data from the longitudinal research contributed important findings to this issue, demonstrating that the processes tapped by laboratory tasks were not more transient than those measured using self-report questionnaires. However, the lack of any existing "gold standard" measures of approach, avoidance, or control meant that it was impossible to test how accurately either self-report or laboratory tasks tapped these constructs, or to fully explain the lack of association between measurement-types.

How valid are assumptions of the IIC framework

Level 1: Attitudinal Factors

Attitudinal factors were included in the framework under the assumption that an individual's intentional state is relevant to the role of inhibitory control in substance use. According to the IIC framework, conflict between approach tendencies and intentional states leads to the involvement of effortful control processes and so attitudinal factors play a vital role in whether substance use will take place.

Attitudes towards substance use

In Chapter 3, the favourability of attitudes towards drug use was significantly and positively associated with all alcohol use indices and with all illicit drug use indices except problem illicit drug use: as predicted, the more favourable an individual's attitudes were towards substance use, the more likely it was that they had initiated alcohol and illicit drug use, and the greater the level of substance use likely to be reported. When combined predictors of each substance use measure were tested, attitudes emerged as one of the strongest predictors of overall alcohol use, the frequency of binge-drinking, whether an individual was a current illicit drug user, the number of illicit drugs used, *and* the frequency of illicit drug use. These findings suggest a key role for attitudes in the initiation and frequency of alcohol and illicit drug use, and in the escalation to increased and potentially more harmful levels of use; however, correlational data do not speak to the causal direction of any association, and it is equally plausible that past substance use contributed to the formation of current attitudes, or indeed that attitudes and substance use were both influenced by the presence of a third variable to which they are both related.

When causal associations between these variables were explored in Chapter 5, no association was found between baseline measures of attitudes towards substance use and change in substance use over an interval of 12 to 27 months. Thus, participants' opinions about substance use did not predict whether they subsequently increased, decreased or maintained stable levels of substance use between assessments, with correlations being close to zero. At face value, this does not support the assumption, central to theories such as Ajzen's Theory of Planned Behaviour (TPB; Ajzen, 2002), that attitudes lead to behaviours. Instead, it suggests that at any one time-point an individual's attitude towards substance use predicts his/her current, but not future, substance use. However, limitations to these studies that will be explored in later sections constrain interpretation of these findings and further longitudinal research is needed. In particular, the reverse causal relationship – i.e. the influence of substance use on attitudes towards drugs – was not assessed.

Intentions towards future substance use

Chapter 3 described strong evidence that intentions were associated with all alcohol and illicit drug use indices (except the incidence of problem illicit drug use), and with all indices of cigarette use. Indeed, so close were these associations that intentions were excluded from analyses of combined predictors of substance use, so as to allow the detection of more theoretically interesting relationships.

The lack of association between intentions and problem illicit drug use was not surprising, since presumably the harmful effects of drug use are unwanted, rather than intended, consequences. Likewise, the positive associations between intentions and substance use were predictable, since those individuals who currently use drugs are logically more likely to report future intentions to take drugs than are individuals who do not currently use drugs. It was therefore of greater interest to examine associations with dependent substance use, where conflict was expected between intentions not to use and the compulsion to use. The assessment of dependent smokers in Chapter 4 presented the best opportunity to do this and interestingly there was a small positive association between "problem" smoking and intentions to smoke. However, there were very few dependent smokers in the sample, which limits the generalisability of this finding to dependent smokers in general.

As with attitudes, intentions toward substance use did not predict change in substance use in the longitudinal study, and there was no evidence that an individual's intentions regarding future substance use had any bearing on their actual behaviour. This is inconsistent with findings from other longitudinal research, where intentions were found to predict later substance use (e.g. Huchting, Lac, & LaBrie, 2008; Fisher *et al.*, 2007; Skara, Sussman, & Dent, 2001). Again, the reverse causal relationship was not tested. Given the results reported here, it would be informative for future research to disentangle temporal associations between intentions to smoke and smoking initiation, progression, and dependency. However, this would require very frequent and precise measures of all relevant variables and would be logistically very challenging and resource-intensive.

The perceived riskiness of substance use

There was mixed support for the hypothesis that perceived riskiness would be associated with substance use: individuals who perceived alcohol to be less risky were more likely than individuals with higher risk perceptions to have "ever used" alcohol but did not differ from them in level of current consumption or frequency of binge-drinking. Those who perceived illicit substances to be more risky were significantly less likely than those who rated them as less risky to have ever used illicit drugs; and, if they were current users, to engage in less drug use. However, there was no effect of risk perception on the incidence of illicit problem use. Finally, risk perceptions were not significantly associated with any aspect of cigarette use.

It appears from these results that, for alcohol and illicit drug use, perceived riskiness did not reduce susceptibility to increased substance use in those who had already initiated use; for cigarette use, on the other hand, perceived riskiness appeared to have no effect at all. One speculative explanation for these results – suggested in Chapter 4 – is that the extent to which risk is an accepted part of substance use may vary between substances. The harms associated with smoking are widely acknowledged and accepted and therefore an individual who engages in cigarette use does so *despite* the known detrimental effects; likewise, the harmful effects of binge-drinking are widely documented and individuals who do choose to so – especially given the level of education common to participants in the present sample – are likely to be well aware of the potential harms, and to continue *despite* these cautions, rather than *because* of their risk perceptions. There may be less clarity regarding the likely harm associated with some drugs of abuse (especially cannabis) and individuals may therefore choose which drugs to use and in what quantities based in part upon their own personal risk perceptions. Another explanation is that past experiences have influenced subsequent risk perceptions; however the reverse causal relationships were not assessed here. To explore these issues further, it would be interesting to examine associations between risk perceptions and substance use in relation to specific illicit drugs; however, this would require a very large sample in order to obtain sufficiently large numbers experimenting with substances which are used by only very small percentages of the population.

Chapter 5 reported no association between baseline risk perceptions and change in alcohol or illicit drug use across the 12-27 month interval. As for other attitudinal factors, this finding suggests that perceived riskiness played no causal role in influencing changes in substance use; however, caution should be taken in interpreting this result, given the study limitations already noted.

Religious restrictions and prohibitions

Consistent with past research (e.g. Marsiglia et al., 2005; Merrill et al., 2005; Sanchez et al., 2008), religiosity did appear to serve as a protective factor against some aspects of substance use. In Chapters 3, 4, and 5, participants who reported religious restrictions – including any reported religious affiliations that limited or prohibited substance use -

were significantly less likely to have ever used cigarettes, alcohol, or illicit substances, and religious-restrictions emerged from analyses of combined factors as one of the strongest predictors of ever use of all three substance groups. However, among those who had used alcohol or cigarettes, religious restrictions were not associated with current level of use or the incidence of problem use – though there were insufficient illicit drug users with religious restrictions to test associations with problem drug use. At face value, these findings are consistent with previous studies that have suggested that religiosity is protective against substance use, but not abuse (e.g. Patock-Peckham et al., 1998).

Elsewhere it has been noted that religiosity is most strongly associated with reduced drinking only when it is accompanied by a personal religious commitment (e.g. Galen & Rogers, 2004; Sanchez *et al.*, 2008), and, unfortunately, level of religious commitment was not assessed in the present research and so this issue could not be explored. It should also be noted that some past studies that did demonstrate associations with level of or problem use used very large samples (e.g. Heath *et al.*, 1997); here, by contrast, of the 39 students reporting religious restrictions, the number who reported substance use was very low (26 for drinking; 12 for illicit drug use; 21 for smoking) and there may well have been insufficient power to detect some effects. While further research is needed to clarify the precise protective role religiosity plays in substance use and abuse, these findings provide further evidence of the importance of its role in reducing the likelihood of substance use initiation.

Level 2: Situational Factors

An extensive body of research implicates a range of situational factors as important predictors of substance use. These factors include peer or sibling substance use (Kokkevi et al., 2007; Li et al., 2002), family environment (Nation & Heflinger, 2006), socio-economic status (Fothergill & Ensminger, 2006), educational attainment (Guxens, Nebot, & Ariza, 2007), and the experience of stressful life events (Feldner et al., 2007). It was not feasible to explore all of these factors in the current programme of research; instead, a relatively homogeneous group of students were selected, who were assumed to be well-matched on socio-economic status and educational attainment, and the focus was specifically on only life stress.

Life Stress

The measure of life stress employed here required participants to indicate whether any of 74 life events, each of which had an estimated relative magnitude of stress, had occurred in the previous year. The total score represented an estimate of the cumulative magnitude of life stressors that were encountered over that period. Associations between life stress and substance use varied between the difference substance groups: life stress did not significantly differ between ever and never alcohol users, and was not significantly associated with frequency of binge drinking, but was significantly associated with current levels of alcohol consumption; on the other hand, life stress was significantly higher among students who had ever used cigarettes and illicit drugs, but was not associated with current levels of use or incidence of problem use for either substance.

One examination of the temporal associations between smoking and trauma in individuals with a history of post-traumatic stress disorder suggested that traumatic events led to increased smoking (Feldner, Babson, and Zvolensky, 2007). Longitudinal research (in Chapter 5), however, provided no evidence to support this, although reverse temporal associations were not explicitly tested. However, given that life stress was higher in students who had "ever used" cigarettes or illicit drugs, but not in students who had "ever used" alcohol, this suggests that life stress may be differentially involved in the probability of using specific types of substances. It may be that the data in the present sample reflect a link between stress-proneness and smoking/substance use (causal direction unclear), but that social drinking is so prevalent that an association is harder to detect in a modest sample.

Although linked with the probability of using cigarettes and illicit substances, life stress over the prior 12 months was not predictive of higher current consumption or problem use of these substances; on the other hand, it was significantly associated with higher current alcohol consumption. Calhoun *et al.* (2000) found that post-traumatic stress disorder diagnosis among veterans was associated with greater depressant use (e.g. alcohol) compared with stimulant use (e.g. nicotine, amphetamines, cocaine). Elsewhere, Zimmerman *et al.* (2007) argued that the stress-dampening effect of alcohol may underlie the development of problem drinking. Thus, it may be that stressed individuals found the characteristics of depressant drugs, but not stimulants, more effective for alleviating their distress. Alternatively, it could simply be that alcohol is a socially acceptable form of substance use engaged in by the majority of people. Consequently, stressed individuals are more likely to increase levels of drinking than smoking or illicit drug use and, given the low numbers of smokers in the present sample, there was less statistical power to detect stress-related variation in smoking than in drinking. Neurobiological studies also provide evidence that exposure to stressors modifies subsequent physiological responses to nicotine (Lutfy *et al.*, 2006) and it may be that stressful life experiences differentially influence brain systems that respond differently to particular substances of abuse, thus explaining the different patterns of association found here. Clearly, further research is needed to replicate and fully explain this finding.

The association between life stress and substance use may not be a causal relationship, and could reflect links between stressful life events and other factors associated with the increased risk of substance use. Interestingly, life stress did not uniquely contribute to predicting overall alcohol consumption or illicit drug use when included alongside a trait measure of control (Chapter 3), and while it did independently contribute to predicting ever smoking, its unique contribution was not significant after religious restrictions were taken into account (Chapter 4). Thus, while life stress appeared to be associated with some aspects of substance use/abuse, its influence overlapped with aspects of religiosity and cognitive control. It could be that both religiosity and higher cognitive control equip an individual with better coping strategies, or reflect differences in socio-economic factors. However, there is mixed evidence concerning whether coping strategies or spirituality mediate the causal relationship between stress and substance use (Arevalo, Prado, & Amaro, 2008; Chen & Cunradi, 2008); further research is needed.

Level 3: Competing impulses

Akin to the Behavioural Activation or Approach System and the Fight, Flight, and Freezing System (FFFS) of Gray's Reinforcement Sensitivity Theory (RST; Gray & McNaughton, 2003), the IIC framework proposed that subcortical responses to appetitive and aversive substance-use related cues produce competing action impulses;

appetitive impulses propel the individual towards substance use (approach) and aversive impulses propel him/her away from substance use (avoidance). Approach and avoidance impulses compete, resulting in action tendencies to either engage in or avoid specific behaviours; the strength of these impulses is determined by an individual's reward or punishment sensitivity and expectations regarding pleasurable or harmful outcomes associated with a stimuli. The following paragraphs consider associations between substance use and measures of these constructs derived in Chapter 2.

The approach and avoidance systems

There were no significant associations between trait approach and substance use or abuse, and analyses in the prospective study showed no predictive relationship between trait approach and change in substance use. Given that associations with substance use were previously reported for the BIS/BAS (e.g. Franken *et al.*, 2006) and SPSRQ measures (e.g. Genovese & Wallace, 2007) - both of which were used in Chapter 2 to derive the trait measure of approach used throughout this thesis - this lack of association was surprising and provided no evidence that this measure tapped any aspect of reward sensitivity that was related to substance use.

Past research using the questionnaire measures contributing to the trait measure of avoidance used in this thesis have reported conflicting findings. Some studies indicated that lower harm avoidance – i.e. *under*-activity of the avoidance system – was the stronger risk factor for substance use (e.g. Magid *et al.*, 2007; Moran *et al.*, 2006; Dughiero, Shifano, & Forza, 2001), and others implicated higher sensitivity to punishment – i.e. *over*-activity of the avoidance system (e.g. Magid *et al.*, 2007; Pardo *et al.*, 2007; Franken & Muris, 2006). Given the large literature positively linking anxiety with substance use disorders (e.g. Kushner & Sher, 1993; Kessler *et al.*, 1997; Buckner *et al.*, 2008), a curvilinear relationship was postulated, such that initial recreational alcohol use is higher in individuals with an under-active avoidance system, who perhaps enjoy its disinhibiting effects, but that alcohol is used at higher, more problematic levels for its mood suppressant effects by people with clinical levels of anxiety and an over-active avoidance system. While this relationship may be apparent in large population-based studies, the student sample used in this thesis was unlikely to include many participants with clinical levels of anxiety or dependence. A linear negative association was therefore hypothesised between level of substance use and avoidance. In addition, it was hypothesised that high levels of anxiety would be associated with an increased risk of problematic use/abuse.

However, there was, in fact, no relationship of avoidance with alcohol use/abuse, illicit drug use/abuse, or cigarette use/abuse. Scatterplots were examined for evidence of the postulated curvilinear association, but there was none; moreover, while anxiety correlated moderately with avoidance – providing some construct validity for the measure - it also was not significantly associated with substance use.

Explaining the lack of association between substance use and approach/avoidance

As noted in Chapter 3, past studies have detected associations between avoidance/approach-related measures and substance use in smaller samples, suggesting that the 400 plus students included here should have been sufficient to detect modest effects.

One explanation for the lack of association is that the self-report indices did not accurately tap the approach/avoidance systems. Smillie, Pickering, and Jackson (2006) noted that, since humans are not able to accurately introspect about the activation of individual systems of Gray's RST. Thus, although questionnaire items and scales try to focus on individual response systems, in practice when an individual reflects on how s/he behaves in the situation described, his/her probability of behaving in a particular way is determined by the interaction between systems, and thus questionnaire responses can not give "pure" indices of a single system.

Given the above cautions regarding self-report measures of approach/avoidance, laboratory task measures were expected to provide more objective, precise measures of reward and punishment sensitivity. Regrettably, the laboratory task measures used to tap approach and avoidance in this thesis (i.e. reward/punishment expectancies and responses on the GNG task) also had limitations. The DDT and IGT both theoretically tap aspects of reward and/or punishment sensitivity, since they include hypothetical monetary rewards and – in the case of the IGT – monetary punishment. Thus, it is possible that associations of substance use indices with these tasks, which will be discussed in the following section, did in fact reflect the involvement of the approach or avoidance systems.

For future research, it would be constructive to include putatively 'purer' measures of reward/punishment sensitivity: for example, Powell *et al.* (2002) devised a simple experimental measure of reward motivation known as the CARROT (Card Arranging Reward Responsiveness Objective Test); the speed of card sorting is compared between trials with and without financial incentive, yielding a measure of 'reward responsiveness'. This is arguably likely to be a 'purer' measure of reward sensitivity than the laboratory tasks employed here. A similar paradigm could be employed to assess punishment sensitivity, whereby the speed of card sorting is perhaps compared without and with financial penalties for not meeting specified goals. As will be discussed further in the next section, the complexity of the DDT and IGT tasks - both of which are purported to tap multiple systems - complicates interpretation, whereas simpler tasks – such as the CARROT and the AST – may serve as better indicators of the strength of the three individual impulse control systems.

Level 4: Cognitive Control

The IIC framework proposed that a cortical control system is super-ordinate to approach and avoidance impulses, and engages drive and inhibition systems in situations where these action tendencies conflict with an individual's intentional state. Their role is to either foster or suppress actions generated by the subcortical approach and avoidance systems. For example, an individual may believe that drugs are morally wrong but also be high in reward sensitivity and therefore become tempted to explore drug use; here, inhibitory control mechanisms come into play to ensure that drug use does not take place. These control processes were postulated to be manifest in cognitive, particularly executive processes, and behaviourally as self-regulatory control and disinhibition. Self-report and laboratory task measures were selected to measure the strength of the control system; these will be considered in turn.

Trait control

In Chapter 2, a measure of trait control was derived from three existing self-report questionnaires: the 'Novelty-Seeking' subscale of the TPQ, 'Fun Seeking' from the BIS/BAS, and Eysenck and Eysenck's (1978) 'IVE-Impulsiveness' questionnaire. Previous studies employing these measures have reported positive associations between impulsivity (the opposite construct to control) and substance use and/or abuse (e.g. Franken & Muris, 2006b; Parrott et al., 2000; Sher et al., 2000; Soloff et al., 2000). In line with these findings, and with the proposed role of the control system, it was hypothesised that trait control would be negatively associated with all aspects of substance use – i.e. the stronger the control processes, the better able the individual is to inhibit the desire to initiate substance use or progress to higher levels of use and/or abuse.

Chapters 3 and 4 tested associations between trait control and alcohol, illicit drug use and smoking, and there was strong support for the hypothesised associations. Lower trait control was significantly associated with a higher likelihood of ever using alcohol, higher current alcohol consumption, more frequent binge drinking, and using more illicit substance groups. Trait control was also significantly lower in current or ex- illicit drug users than never users and in ever-smokers than never-smokers. However, there were no significant associations with frequency of illicit substance use, smoking frequency or incidence of problem drug or cigarette use. This may suggest a stronger role for control in substance use initiation than in increases in consumption or problem levels of substance use, or could reflect that there was less power to detect effects on levels of consumption in the smaller groups of smokers and illicit drug users than in the larger group of drinkers.

When combined predictors of each substance use measure were tested, trait control emerged as one of the strongest predictors of overall alcohol consumption, binge-drinking frequency, number of illicit drugs used, and ever use of a cigarette. Trait control uniquely explained 13 per cent of the variance in overall alcohol consumption, and uniquely contributed around 10 per cent to the variance accounted for in the other substance use measures. These results again suggested that the processes tapped by the derived trait control measure were to some extent protective against the initiation of or experimentation with alcohol or cigarettes and were implicated in the frequency of alcohol or illicit drug use, but were not protective against increased frequencies of smoking or illicit drug use. However, further research using larger samples of smokers and illicit drug users is needed to ensure that these test whether these findings resulted from a lack of power to detect effects in these groups.

It is interesting that, while neither trait approach nor avoidance was associated with any aspect of substance use, associations with trait control were widespread. It is argued that the control system comes into play in instances where there is conflict between reflexive action tendencies and attitudinal factors. Assuming that the indices used did actually tap the three impulse and control systems, the pattern of results may indicate a) that substance use primarily involves control, and does not strongly involve reflexive action tendencies; or b) that conflict between appetitive and aversive aspects of substance use mean that control processes are consistently engaged in the early stages of substance use, before substance use became uncontrollable or abusive. While replication of these findings is needed, this would explain both the lack of association with reflexive approach/avoidance measures, and also stronger associations between trait control and substance use initiation, frequency, or consumption, compared with problematic substance use.

Laboratory task indices of control

Three laboratory tasks were included alongside the trait control measure; each was postulated to tap either specific control processes, or multiple impulse control systems.

The oculomotor antisaccade task (AST) was assumed to be a relatively pure measure of control. It involves the suppression of an automatic eye movement towards a visual target; indices include the accuracy of responses (commission errors: AST-Accuracy) and speed of accurate anti-saccadic responses (AST-Interference). The same predictions were made as for trait control.

Notably, the AST was the only laboratory task that correlated with self-report measures: there was a modest (r=0.31) significant positive correlation between trait control and AST-Accuracy and a small near-significant positive association with AST-

Interference (r=0.21). This provided initial support for the hypothesised positioning of this task in the IIC framework. Interestingly, AST-Accuracy was the only measure for which performance differed significantly between test-retest assessments in the longitudinal analyses: significant improvements were found across the 12-27 month interval. Luna *et al.* (2004) found that inhibitory control processes on an AST improved throughout adolescence and that accuracy continued to improve till around age 19. Given that the sample described in Chapter 5 were aged 18 to 21 at baseline, age-related maturation may account for this finding, although it is also plausible that the improvement resulted from practice effects.

When AST performance was assessed in relation to substance use, only one significant association was noted: individuals who used illicit substances on average less than fortnightly showed significantly less AST-Interference than more frequent drug users. No significant associations of either AST-Accuracy or AST-Interference were found with any of the illicit drug use or smoking indices, and no predictive relationship was found between AST performance and change in substance use in longitudinal analyses. Thus, there was no evidence for any causal link between AST performance and substance use, making it unclear what the significant association with frequency of illicit drug use means; the result may be spurious, or may indicate that both inhibitory control and increased frequency of drug use were influenced by other factors that were not assessed here.

The second task employed to assess control processes was the Iowa Gambling Task (IGT) which was developed by Bechara, Damasio, Damasio, and Anderson (1994) and has been widely used to assess risk tolerance and decision-making impairments in clinical samples, including drug addicts (e.g. Bechara *et al.*, 2001); Participants select between decks of cards that offer either small gains and small losses, or larger rewards but far larger losses; the key index, IGT Net Score, is computed by subtracting the number of disadvantageous choices (i.e. larger gains & losses) from the number of advantageous choices. Cocaine addicts and heroin users have shown poorer performance on this task than controls (Verdejo-Garcia et al., 2006). Goudriaan, Grejin, and Sher (2007) found that frequent binge drinkers performed worse than less frequent binge drinkers, but that IGT performance was unrelated to the age of onset of alcohol use, suggesting that it may tap processes implicated in abuse rather than initiation/experimentation. However, in the present studies there were no significant associations with either use or abuse of any of the substances explored.

It may be that the lack of association observed here related to the nature of the sample. That is, the impaired performance of addicts detected by Bechara's group might be specific to clinical groups, so that the low number of heavy users in the present research was not sufficient to detect an effect. Another possibility is that, within this young, healthy sample, there exists a subgroup of students who made a conscious decision to experiment with substance use. Here, those stronger in effortful control may more successfully overcome and instinctive avoidance impulses. If, as proposed within the framework, this is the case, then such an effect would oppose or even cancel out the hypothetical converse effect of control in those who plan to avoid or restrict their use.

The third task employed to assess the strength of the control system was the Delay Discounting Task (DDT). Here, participants make selections between immediate, smaller rewards and delayed larger rewards; the DDT Discounting Rate reflects the strength of an individuals' preference for immediate over delayed gratification, and the extent to which reward loses its perceived value as the delay to its delivery increases. The inability to delay gratification is one of the key features of both impulsivity and addiction; many studies have demonstrated higher discounting rates for addicts (e.g. Kirby & Petry, 2004) and one study showed associations between higher discounting rates and higher recreational levels of substance use (Kollins, 2003). It was predicted here that that higher discounting rates (i.e. more impulsive choices) would be associated with greater substance use. Consistent with hypotheses, discounting rates were significantly higher in problem smokers than non-problem smokers; however, longitudinal analyses revealed no predictive associations between DDT performance and change in smoking over time. There were no significant associations between DDT performance and alcohol use/abuse or illicit drug use/abuse.

While the majority of previous studies that demonstrated associations with the DDT did so in samples of substance abusers or addicts, Kollins (2003) was the first to show similar positive associations in a sample of 47 subclinical substance users. Kollins reported significant associations with the age of first use of alcohol, cigarettes, and marijuana, and positive correlations with the number of illegal drugs used and the number of times that a participant 'passed out from alcohol use'. However, Kollins did not correct significance levels for the 15 correlations performed and, when Bonferroni corrections are applied to his data, only one remained significant (the number of time 'passed out'); all other results may have been spurious.

The present association only with "problem smoking" could indicate either that the ability to delay gratification is a vulnerability factor for progression to substance abuse/ dependency, or that it deteriorates as a result of substance abuse. However, the absence of associations with problematic illicit drug or alcohol use in the present studies is not consistent with this interpretation, and further research would be needed to test it further.

Summary

Four levels of variables were included in the IIC framework: attitudinal; situational; impulse; and control. While strong evidence was found for cross-sectional associations of attitudinal and situational factors with substance use, there was no evidence from longitudinal analyses that any of these relationships were causal. The reverse causal relationship – i.e. that attitudinal or situational factors were influenced by substance use – was not investigated here. For many of these factors, it is likely that complex bi-directional relationships exist. Thus, while this research has illuminated some important findings between substance use, psychological variables and environmental factors, much more research is needed to fully understand the nature of these relationships.

In contrast to the substantial evidence found for the relevance of variables implicated by Levels 1 and 2 of the framework, there was no evidence for the involvement of approach or avoidance impulses (Level 3) in substance use or abuse. By contrast, support was found for the involvement of control (Level 4). Higher scores on a trait measure of control were significantly associated with a higher likelihood of ever using alcohol or illicit drugs, level of alcohol consumption, frequency of binge drinking, and number of illicit substances used. When included alongside other measures from Levels 1 to 3 of the framework, trait control emerged as a significant predictor of overall alcohol consumption, binge drinking frequency, number of illicit drugs used, and incidence of problem drug use. These results provided support for the IIC framework's hypotheses concerning the involvement of control processes in substance use.

In Chapter 3, less frequent illicit drug users were found to be significantly quicker at inhibiting antisaccadic eye-movements on the AST than more frequent users, and delay discounting rates were significantly higher for problem smokers (indicating higher impulsivity) than for non-problematic smokers in Chapter 4. While the lack of associations with performance on the IGT was surprising, these two findings did offer support for the role of control processes in substance use.

Together, the findings from this thesis validate the inclusion of three of the four levels of the IIC framework, and raise important methodological and theoretical questions about whether and how it might be possible to measure the fourth (approach/avoidance). When regression analyses were used to assess combined predictors from different levels of the framework, there was evidence for the additive nature of their contributions. Thus, these findings provide empirical evidence to support some of the contents and structures defined within the framework.

It was beyond the scope of this thesis to test all aspects of the framework: for example, analyses did not investigate whether control processes were, as postulated, activated only in situations where intentions conflicted with action tendencies. Exploring multivariate relationships in great detail would necessitate the availability of a much larger sample to enable complex statistical modelling techniques (i.e. structural equation modelling).

Assessing the utility of the IIC framework

This thesis aimed to use the IIC framework to empirically explore three research questions, which will be addressed in turn.

1. Are some aspects of impaired inhibitory control differentially implicated in specific types of substance use?

2. Do pre-existing impairments of self-control processes predispose some individuals towards substance use/abuse?
3. Does exposure to substance use lead to diminished self-control?

1. Are some aspects of impaired inhibitory control differentially implicated in specific types of substance use?

The present research provided evidence that certain aspects of impulse control are differentially associated with specific aspects of substance use. Processes tapped by a trait measure of control appeared to some extent protective against the initiation of or experimentation with alcohol or cigarettes and were implicated in the frequency of alcohol or illicit drug use; however, they were less protective against higher frequencies of smoking or illicit drug use, or the likelihood of problem substance use. Less frequent illicit drug users had better inhibitory control processes – as indexed by the AST – than more frequent drug users, and in smokers, those who were better able to delay gratification, as assessed by the DDT, were less likely to report problems as a result of their smoking.

These findings contribute important clues as to how different types of substance use may be differentially predicted by specific risk factors. Interestingly, the processes tapped by trait control – which was derived from questionnaires that assess cognitive aspects of inhibition and perseverance, and broad measures of impulsivity - were consistently implicated in substance use initiation, but not strongly linked with level of use or problem use. On the other hand, inhibitory control processes were implicated only in relation to increased frequency of *illicit drug use;* and the strength of an individual's ability to delay gratification was implicated only in relation to problem *cigarette use*. While replication of these findings is requisite before they can be interpreted with confidence, this suggests that control factors related to substance use initiation do not necessarily differentiate between substance types, whereas relationships between specific aspects of control and frequency of use or incidence of abuse may be more substance-specific. It could be that a weaker ability to delay gratification and a stronger preference for immediate reward is specifically relevant among smokers, who must ignore the probable long-term detrimental consequences so as to enjoy the immediate rewards of smoking; for reasons that are not immediately apparent, individuals with less ability to inhibit their urges seem more likely to increase the frequency of illicit drug use than alcohol use or smoking.

2. Do pre-existing impairments of self-control processes predispose some individuals towards substance use/abuse?

Longitudinal analyses indicated no connection whatsoever between baseline impulse control and change in substance use over a 12 to 24 month period. Thus, while cross-sectional associations were found between an individual's level of substance use and measures of current impulse control, inhibitory control, and the ability to delay gratification, there was no evidence that poor control predisposed individuals towards increases in substance use/abuse.

However, only a small number of students initiated substance use between T1 and T2, and very few increased their substance use substantially. This is surprising since it was originally thought that young people entering university would be particularly susceptible to increases in alcohol and drug use. With hindsight, other factors may have influenced this: the multi-ethnicity of students at Goldsmiths' college; the possibility that students would curb their substance use during the latter stages of their studies when T2 testing was carried out; and the likelihood that some students had already conducted much of their experimental substance use prior to starting university.

While the geographically "captive" nature of this sample was useful in that it enabled high retention rates for longitudinal analyses, the fact that very few participants actually increased or initiated substance use severely limited the power of the study to identify predictors. Future research should track a larger sample over a longer time period, perhaps from a younger age, in order to capture more shifts in substance use and provide greater power to detect any real causal associations between impulse control and substance use.

3. Does exposure to substance use lead to diminished self-control?

As reviewed in Chapter 5, a central tenet of many theories of addiction is that the impaired impulse control observed in addicts is the direct result of exposure to substances of abuse, through the altered functioning of the addict's subcortical reward pathways (e.g. Garavan *et al.*, 2000) and damage to the prefrontal cortex (e.g. Volkow et al., 2003). To fully explore the effect of drug use upon impulse control, a sample would be required that comprised a large number of individuals who initiated substance use between T1 and T2; in fact, in the longitudinal component of this research, only three participants initiated use of alcohol, two of cigarettes, and seven of illicit drugs between baseline and retesting sessions. Thus, there were too few such participants to investigate the effect of drug use initiation on impulse control.

Longitudinal analyses did explore correlations between change in substance use and change in impulse control between T1 and T2. However, there were no significant associations between changes in the two sets of variables, possibly because of the low number of students who initiated or increased their substance use, or possibly because there is not a strong causal relationship between impulse control and substance; these findings are therefore inconclusive. A younger sample tested at multiple intervals across a longer period would provide more power for testing these putative associations.

The following sections will first summarise study limitations, and then discuss general conclusions from this programme of research.

Study limitations and suggestions for future research

Many of these limitations have already been noted, but are summarised here for clarity.

The sample

By intention, the sample was composed of undergraduate students. Most of the students were female and white, and, given that college enrolment demands a certain level of academic success, were relatively homogenous in educational achievement and its correlates (i.e. IQ). On the plus side, the 'captive' nature of the sample facilitated longitudinal research, and the homogeneity in academic achievement limited the impact of other related psychosocial influences on substance use, such as major deprivation, educational disadvantage, and cognitive ability. However, this led to limitations of generalisability. Principally, further research would be needed to generalise these findings to more diverse samples, or to the wider population. Also, subsections of the population that the literature suggests are more likely to engage in substance use (e.g. individuals with low SES or low educational achievement) were underrepresented in this sample; thus, some of the associations that have been examined here may be evident in the wider population, but would be harder to detect in the current sample.

Although the sample was large compared to other studies exploring the multi-dimensional nature of impulsivity, it included insufficient substance users, and particularly problematic users, to enable the use of more powerful linear regression analyses, or to analyse the use of specific illicit drugs. Polydrug use is also a concern since, as noted in Chapter 4, correlations between overall alcohol use and smoking frequency suggested around 13 per cent shared variance, and between smoking frequency and frequency of illicit substances use nearly 30 per cent shared variance. On the one hand, all illicit substance use was assessed together which perhaps concealed interesting findings pertaining to specific substances; on the other hand, the presence of polydrug use may have distorted some of the findings for smoking, alcohol, or illicit drug use.

It is important to note that highly conservative corrections were made throughout this thesis. Furthermore, to protect Type I error, demographic variables that past studies have shown to be influential in relation to substance use - such as ethnicity, gender and age - were not analysed. This may have resulted in the omission of variables that were intrinsically important to providing a clearer representation of how risk factors combine to influence substance use.

Measuring substance use

Reflecting a general methodological limitation in relation to much research into natural patterns of substance use, no objective assessment was made of substance use and participants may have been inaccurate in their reports of past and current use. Several methods are available to objectively assess the use of many substances; however, it was not financially feasible to include them here.

Measuring risk factors for substance use

As for measures of substance use, self reported measures of attitudinal, situational, impulse, or control factors rely upon participants' ability and willingness to report accurately; some problems with this assumption, especially with respect to measures of approach/avoidance, have already been discussed. Furthermore, in some cases proxy indices were used that may not have captured the specific intended construct with precision. For example, 'religious restrictions' on substance use were assessed globally rather than in respect of particular individual drugs. It may have been better to detail restrictions on the use of specific substances (e.g. smoking, alcohol, etc) and to explore how each related to actual substance use.

Given the near-lack of association between self-report and laboratory task indices, there is little evidence that behavioural measures in this study accurately tapped the systems that they were proposed to measure. Additionally, some tasks – e.g. the IGT and DDT - were complex and therefore purported to tap multiple systems. Most of the laboratory task measures used in the present study lack ecological validity, in that they present unrealistic scenarios in which to test impulse control. It might have been interesting to use more 'realistic' assessments of behavioural restraint and control. For example, Friese *et al* (2009) used the consumption of a tempting product in a 'taste-and-rate' task to explore whether individual differences in self-control mediated the relationship between self-reported levels of impulsivity and behaviour, and found that impulsivity translated into behaviour for individuals who were low, but not high, on a trait measure of self-control. The use of tests that tap systems involved in mediating experiences of 'natural' reward or punishment, such as tempting food as an appetitive stimulus and pain as an aversive stimulus, might provide useful behavioural paradigms with which to explore control processes and which, perhaps in combination with very specific laboratory tasks such as the AST, could provide a richer overall assessment of impulse control.

Chapter 1 considered a growing literature that has reported associations between reduced inhibitory control and specific modifications to brain pathways or levels of activity in certain areas of the addicts' brain. Unfortunately, it was not feasible to include any direct biological measures within the present study. As discussed in Chapter 5, correlations between the strength of activity in neural pathways implicated in reward or frontal brain regions linked with inhibitory control have highlighted links between addictive behaviours and impaired self control. However, as noted, many of these findings are from cross-sectional studies and do not therefore provide evidence for causal associations between substance use and these impairments; additionally, while these findings add to an important empirical literature, knowing that a neural correlate exists for a specific type of behaviour does not on its own constitute an explanation for that behaviour. Importantly, further research is needed to ascertain the extent to which behavioural tendencies labelled impulsivity are mediated by common neurological mechanisms. Incorporating cognitive, behavioural, and neurobiological measures into large scale longitudinal research would enrich explorations of the possible causal relationships between impulse control and substance use. This would bring together several important areas of research and levels of analysis, combining the knowledge gained from each and enhancing our understanding of the processes underlying complex human behaviours such as recreational drug use and addiction.

General conclusions

As quoted in Chapter 1, Buhringer (2007) commented, in relation to addiction, that understanding the nature of and interactions between "higher-order reflective cognitive processes and basic, implicit, motivational driven processes" (p. 1002) could provide a better understanding of "individual risk levels for onset, continuation and offset of problematic behaviour" (p. 1002). He described the conflict between these two types of processes as the "discrepancy between personal will and urge". The challenge faced by this thesis was to attempt to conceptualise and empirically explore how these processes relate to individual risk factors for substance use initiation, and progression to problematic levels of use.

Consistent with other theoretical approaches (e.g. Eisenberg *et al.*, 2004), the IIC framework highlighted the role of deliberate restraint or 'effortful control' as being superordinate to approach and avoidance impulses. One of the key findings from this research programme is that reflective cognitive processes (control) appeared to play a far more influential role in this sample's substance use than implicit motivational processes (approach and avoidance), and that this involvement is more pronounced for substance use initiation and frequency of consumption than for the incidence of problem use. An obvious interpretation of these findings is that the inability to inhibit the urge to engage in substance use – or "personal will" as described by Buhringer – is more important than the strength of the urge itself in protecting against non-clinical levels of substance use. Given the focus of the substance use literature upon the mesocorticolimbic reward pathways and the involvement of positive reinforcement and dopamine release in response to substance use, the fact that the present indices of reflexive appetitive and aversive impulses appeared to be unrelated to substance use is disappointing. However, there are clearly important limitations to the present research programme that must be taken into account when interpreting these findings, and replication of this pattern is essential to corroborating any broader interpretation.

Very few markers for susceptibility to problematic levels of substance use were identified here, with inhibitory control and the ability to delay gratification being specifically linked with particular types of substance use. Thus, this research programme, despite incorporating a far wider range of variables than typically used collectively in substance use research, was not able to account for or substantially predict problematic substance use, dependency, or addiction. However, the scope for it to do so was severely limited by the nature of the sample: young, generally healthy, and in full-time education; very few presented with significantly problematic substance use. It is also possible that the influence of some predictors was mediated through variables – e.g. gender – that were not included in these analyses.

The IIC framework, reflecting other contemporary theories of addiction, such as those of Jim Orford and Robert West, identified multiple levels of influence, and incorporated intentions, which have been omitted from many other accounts of addiction. The empirical evidence clearly corroborates this decision, showing that attitudinal factors feature alongside control processes as important correlates of substance use initiation and levels of consumption. Life stress has been identified by many as relevant to substance use, and the findings here support this, although they also suggest that its influence may be mediated via control processes or religiosity. Complex causal relationships with substance use are likely to exist between and within each of the levels of the IIC framework, and careful longitudinal research is needed to explore moderator/mediator influences.

The framework has by no means fully tested by this programme of research; nor was evidence found to support all of its component parts. However, the findings presented here do support the thesis of the IIC framework that complex relationships exist between attitudinal, situational, and impulse control factors, and that risk and protective factors from multiple levels of analysis should be considered to best understand and predict whether substance use and/or abuse takes place. The findings have demonstrated that bringing together disparate areas of research can enrich understanding of the interplay between risk factors for substance use, and have also identified a number of important methodological issues.

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Appendix A

Factor analysis of self-report measures

To assess variation in factor scores between T1 and T2, comparable estimates of Trait-Approach, Trait-Avoidance, and Trait-control were derived. In chapter two, factor analysis of nine questionnaire subscales revealed a three-factor solution; factor analysis was first used to assess whether an equivalent factor solution exists among the 78 cases with complete self-report data at T1 and T2.

As shown in Table A.63, correlations were sizeable and had sufficient factorability to enable factor analysis (Kaiser-Meyer-Olkin MSA= 0.69).

Table A.63: Bivariate intercorrelations between self-report measures

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. TPQ-NS	-	-0.24	-0.34	-0.11	0.06	0.64*	0.60*	0.12	-0.22
2. TPQ-HA		-	0.63*	-0.06	-0.26	-0.45*	0.01	0.02	0.78*
3. BIS			-	0.27	0.12	-0.31	-0.14	0.20	0.62*
4. BAS-RR				-	0.60*	0.29	0.12	0.48*	-0.05
5. BAS-D					-	0.38*	0.08	0.47*	-0.22
6. BAS-FS						-	0.51*	0.29	-0.31
7. IVE-Imp							-	0.21	0.10
8. SPSRQ-SR								-	0.09
9. SPSRQ-SP									-

N=78; * Correlation is significant at $p<0.0014$ [α].

Principal factors extraction confirmed a three factor-solution and Varimax rotation was used to improve the solution. Table A.64 reports factor loadings, explained variance, and eigenvalues for the solution, which explained 66.9% of the variance in the data.

Table A.64: Rotated factor loadings, eigenvalues, and variance explained

	Trait-Avoidance	*Trait-Approach*	*Trait-Control*
Eigenvalues	2.31	1.87	1.84
Proportion of variance explained	25.7%	20.8%	20.5%
TPQ-HA	*0.89*	-	-
SPSRQ-SP	*0.89*	-	-
BIS	*0.71*	-	-
BAS-RR	-	*0.81*	-
BAS-D	-	*0.78*	-
SPSRQ-SR	-	*0.59*	-
TPQ-NS	-	-	*0.83*
IVE-Imp	-	-	*0.75*
BAS-FS	-	-	*0.68*

Note: only loadings ≥ 0.4 are reported; n=78

[α] Bonferroni-correction: *$p<0.05$ divided by 36 analyses gives $p<0.0014$ (two-tailed)*

Overall, the factor structure matched that found in chapter two (see page 76); TPQ-HA, BIS, and SPSRQ-SP loaded on a single factor (Trait-Avoidance), IVE-Imp and TPQ-NS loaded on a second factor (Trait-Control); and BAS-RR, BAS-D, and SPSRQ-SR loaded on a third (Trait-Approach). The only structural difference was that, while in chapter 2 BAS-FS loaded with both Trait-Approach and Trait-Control, in the present study, BAS-FS appears to load only with Trait-Control. Thus, for the purposes of estimating factors scores for T1 and T2, BAS-FS was included in Trait-Control, and not Trait-Approach.

Estimating Factor Scores

In chapter two, standardised factor scores for Trait-Approach, Trait-Avoidance, and Trait-Control were estimated using SPSS regression. However, using similar estimation methods would produce factor scores that are influenced by characteristics that differ between T1 and T2 (e.g. mean, variance). Thus, a different approach was used to estimate factor scores in the present study. Data for each of the nine original questionnaire subscales were merged across T1 and T2; the overall mean and standard deviation of the combined data were obtained and then used to standardise the individual T1 and T2 subscales. The pseudo-standardised subscales were then summed to estimate factor scores at T1 and T2: standardised scores on TPQ-HA, SPSRQ-SP, and BIS were combined to form Trait-Avoidance, scores on BAS-RR, BAS-D, and SPSRQ-SR formed Trait-Approach, and scores on TPQ-NS, IVE-Imp, and BAS-FS were combined, and then reversed, to form Trait-Control. Estimated T1 scores were highly and significantly correlated with those estimated in chapter two [Trait-Avoidance: r=0.99; Trait-Approach: r=0.96; Trait-Control: r=0.96], indicating that the two methods have produced comparable solutions.