Clarifying the revised Behavioural Inhibition System as a Risk Factor for Anxiety-Related Alcohol Misuse in Young Adulthood: New Insights from Experimental and Prospective Studies

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ABSTRACT

Clarifying the revised Behavioural Inhibition System as a Risk Factor for Anxiety-Related Alcohol Misuse in Young Adulthood: New Insights from Experimental and Prospective Studies

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Theoretical models posit that anxious persons drink alcohol to self-medicate negative emotions. However, existing data suggest that the anxiety pathway is complex. While there is high comorbidity of anxiety and alcohol use disorders in adults, evidence earlier in the risk trajectory (in young adulthood) is highly mixed. Gray's Reinforcement Sensitivity Theory (RST) provides a useful framework for clarifying the anxiety-drinking pathway in young adults. The RST implicates the behavioural inhibition system (BIS) as a risk factor for alcohol misuse. Important theoretical revisions were made to the BIS 15 years ago, but these changes have been slow to enter the empirical literature. The revised BIS is a motivational conflict system. In response to competing goals (e.g., reward vs. punishment), the revised BIS inhibits behaviour, giving rise to high anxiety, attention to threat, and behavioural ambivalence. Accordingly, BIS-anxiety may promote self-medication drinking, while sensitivity to motivational conflict may lead to indecisiveness about drinking and attention to threat. Theory suggests that a strong Behavioural Approach System (BAS) should enhance the anxiolytic effects of alcohol use, which should be salient to those high in the BIS. However, few studies have been able to examine these interactive effects since most work has not tested the predictions of the revised RST. Using experimental (Study 1) and prospective (Study 2) studies, the primary aim of this dissertation was to clarify the BIS-related pathway to alcohol misuse among young adults. Study 1 (N = 110) was an experimental design that aimed to examine the cognitive mechanisms of this pathway. Results demonstrated that individuals with a strong BIS and a strong BAS expected elevated positive mood (rather than reduced anxiety) in response to an alcohol cue when feeling anxious. Study 2 (N = 119) sought to examine the BAS as a moderator of BIS-risk for alcohol misuse during the transition out of university. Findings indicated that those high in the BIS showed impeded maturing out of alcohol misuse during this transition if they were also strong in BAS impulsivity. Conversely, young adults with a strong BIS rapidly reduced alcohol misuse if they were concurrently low in BAS impulsivity. Overall, the moderating role of the BAS clarified

BIS-risk for alcohol misuse. Findings shed light on the cognitive mechanisms underlying BIS-related drinking and provide a first look on how the BIS and the BAS interact to set the stage for long-term alcohol problems in young adulthood.

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CONTRIBUTIONS OF AUTHORS

Study 1

In collaboration with my supervisor, Dr. Roisin O'Connor, I created the research question, obtained ethics approval, designed the study protocol, trained research staff to test participants, conducted statistical analyses, and wrote the final manuscript. Dr. O'Connor independently secured external funding Canadian Institutes of Health Research and we were also successful in obtaining seed funding from Concordia University to support this research. Drs. O'Connor and Colder provided extensive feedback on drafts of the manuscript and gave valuable conceptual input. The final manuscript represents a substantial combined effort from all authors.

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CHAPTER 1
GENERAL INTRODUCTION

Scope of the Problem

Alcohol use follows a developmental course. The prevalence of heavy drinking increases in late adolescence, peaks in the early 20s, and decreases sharply thereafter (Baer & Carney, 1993; Dawson, Grant, Stinson, & Chou, 2004; Johnston, O'Malley, & Bachman, 1998). While heavy drinking is linked to serious negative health (e.g., liver cirrhosis) and psychological (e.g., depression) outcomes across the life span (Meyerhoff et al., 2005), a large body of literature points to specific risks in young adulthood. The most recent Canadian Campus Survey revealed that 30-40% of Canadian undergraduates drink at levels considered harmful by the World Health Organization (2014) (Adlaf, Demers, & Gliksman, 2005). Additionally 44% of students report experiencing problems associated with heavy drinking, such as feelings of guilt, memory loss, blacking out and/or physical injury (Adlaf et al., 2005). Despite increased attention to prevention and intervention efforts in the past few decades, alcohol misuse among young adults remains a serious health concern.

Theoretical models of addiction identify multiple pathways to alcohol misuse (Cooper, 1994; Pihl & Peterson, 1995). Some pathways are less well understood than others. Specifically, we still have much to learn about the contributing factors and mechanisms in the anxiety-relevant pathway to alcohol misuse (Corr, 2008; Keough & O'Connor, 2014; Keough, Hines, Winslade, & O'Connor, 2015; Schuckit & Hesselbrock, 1994). It has long been theorized that anxious people use alcohol to self-medicate negative emotions (Conger, 1956; Kushner et al., 1990), which is believed to put them at risk for alcohol misuse. Supporting the theory, the prevalence for alcohol use disorders is about two times higher in persons diagnosed with anxiety disorders (8%) than in those without anxiety disorders (4%) (Chilcoat & Menard, 2003; Kessler, Chiu, Demler, & Walters, 2005; Kushner & Specker, 2011). However, in subclinical samples at earlier stages of the risk trajectory (i.e., young adults, undergraduates), the association between anxiety and alcohol misuse is inconsistent. Some studies with young adult samples demonstrate that anxiety increases alcohol misuse risk (e.g., Buckner, Ecker, & Proctor, 2011; Zimmermann et al., 2003), whereas other work shows that anxiety decreases risk (e.g., Eggleston et al., 2004; Ham, Bonin, & Hope, 2007; Wagner, 2001). No association between anxiety and alcohol use has also been commonly reported among young adults (e.g., Ham & Hope, 2005).

As a whole, data suggest that the anxiety pathway to alcohol misuse is complex. Given the high comorbidity of anxiety and alcohol use disorders later in adulthood (Magee, Eaton, Wittchen, McGonagle, & Kessler, 1996), it behooves researchers to isolate risk factors for alcohol misuse early in young adulthood. This is the developmental stage when drinking is heaviest and, accordingly, some young adults may form problem drinking habits that put them on a trajectory to alcohol use disorders later in adulthood (Jackson, Sher, Gotham, & Wood, 2001). Being able to identify the risk factors for alcohol misuse in young adulthood has the potential to advance etiological models and to improve early clinical intervention programs for anxiety-related alcohol misuse.

Although psychological well-being improves overall in young adulthood, there is a paradoxical increase in the number of people diagnosed with anxiety and mood disorders (Donnellan, Conger, & Burzette, 2007). About 82% of Canadians attend university/college and they face new demands (e.g., living independently from parents) (Shaienks et al., 2008). Anxious students may have particular difficulty dealing with these challenges, and theory suggests that they should turn to drinking as a means to cope with negative affect (Conger, 1956; Cooper, 1994). Given that heavy drinking is socially condoned and is often encouraged by university peers (Johnston et al., 1998), it follows that anxious young adults have ample opportunities to learn that alcohol use reduces anxiety. Through repeated drinking, anxious persons form strong positive associations with alcohol (e.g., "drinking alcohol makes me feel relaxed"), which in turn propel them to drink when anxious (Goldman, 1999). While data shows that those who drink to cope with anxiety are at elevated risk for alcohol-related problems during the undergraduate years, they do not appear to drink more heavily than those who do not (or rarely) use alcohol as a way to cope (Keough, Badawi, Nitka, O'Connor, & Stewart, 2016; Kuntsche, Knibbe, Gmel, & Engels, 2005; LaBrie, Ehret, Hummer, & Prenovost, 2010). They may not standout during this time in terms of levels of alcohol use, presumably because it is normative for most students to drink heavily.

When young adults make the transition out of university, there is a normative *maturing out* of alcohol misuse (Littlefield, Sher, & Wood, 2009; O'Malley, 2005; O'Malley & Johnston, 2002). Leaving university is generally a period when individuals adopt new adult roles (e.g., finding a meaningful career) (O'Malley, 2005). During this transition, it is believed that young adults come to view heavy drinking as being incompatible with newfound adult responsibilities

(Gotham, Sher, & Wood, 2003; Yamaguchi & Kandel, 1985) and; therefore, they tend to substantially reduce levels of alcohol use. However, while maturing out is the normative trend, there remains an appreciable minority of young adults who continue to drink heavily after graduation (Arnett, 2005; Zimmermann et al., 2003). Sustained heavy drinking after university is believed to reflect drinking habits that presage the development of alcohol use disorders in adulthood (Jackson et al., 2001).

Evidence suggests that coping-motivated drinking is a key predictor of impeded maturing out of alcohol misuse following university graduation (Patrick & Schulenberg, 2011; Perkins, 1999). Motivational models identify anxious young adults, in particular, as the ones who continue to drink for coping reasons during the transition out of university. The stressful and uncertain nature of this transition should further reinforce alcohol's anxiolytic effects and hence should solidify the anxiety-alcohol misuse relation. Yet, there has been little work to date on how anxiety and alcohol use play out after university graduation. Examining anxiety as an early indicator of post-university heavy drinking can inform clinical efforts, where the goal is to mitigate risk pathways to alcohol use disorders as anxious people progress into adulthood.

The overall goal of this dissertation is to use experimental and prospective studies to advance our understanding of the anxiety pathway to alcohol misuse in young adulthood. Grounded in personality-risk models (Gray, 1987; Gray & McNaughton, 2000) and cognitive theories (Goldman, 1999; Stacy & Wiers, 2010) of addiction, this dissertation aims to unpack the individual differences and cognitive mechanisms that influence drinking among anxious young adults. To foreshadow, this work addresses a key limitation in the literature on personality-risk models. Namely, studies to date have largely relied on out-dated theory to examine anxiety-related drinking. As will be argued in this dissertation, contemporary personality models can clarify the contributing factors and mechanisms of the anxiety pathway in young adulthood.

Theoretical Background

Grays's Reinforcement Sensitivity Theory (RST) is a useful personality-risk model for conceptualizing anxiety-related alcohol use. The RST implicates the Behavioural Inhibition System (BIS) as a risk factor for self-medication drinking, given its strong links with the neurobiology of anxiety (Corr, 2008; Gray & McNaughton, 2000). To date; however, the data linking the BIS to alcohol use have been highly mixed (Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008; Kimbrel, Nelson-Gray, & Mitchell, 2007). Revisions were made to the RST well

over a decade ago (Gray & McNaughton, 2000), which resulted primarily in extensive changes to the BIS. Despite this, the majority of studies on personality-risk models of alcohol misuse continue to use Gray's original theory. As I have argued elsewhere (Keough & O'Connor, 2014), this is problematic because the revised RST has key implications for advancing the role of the BIS in etiological models of alcohol use. The focus of this dissertation is to elucidate the revised BIS as a risk factor for alcohol misuse among young adults.

The Original RST. The original BIS was conceptualized as a punishment-sensitive system, which subsumed control over sensitivity to conditioned aversive stimuli. Thus, the BIS was believed to be activated by conditioned punishment cues. Activation of the BIS by punishment cues was thought to lead to behavioural inhibition, and this inhibition gave rise to negative affect – primarily anxiety (Smillie, Pickering, & Jackson, 2006). The BIS was assumed to be located in the subiculum and septo-hippocampal structures of the brain (Corr, 2008). At the personality level, those with an elevated BIS are characterized by high anxiety, and they experience intense ruminative thoughts (Windle, 1994). Given that BIS activation is believed to result in anxiety, the BIS was hypothesized to map onto the anxiety pathway to alcohol misuse. Yet, empirical support for BIS as a risk factor in alcohol misuse has been inconsistent, with studies showing positive (Voigt et al., 2009), negative (Kimbrel et al, 2007; O'Connor, Stewart, & Watt, 2009; Pardo, Aguilar, Molinuevo, & Torrubia, 2007), and even null (Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008; Kambouropoulos & Staiger, 2007) associations. This mixed evidence is not surprising because on the one hand, individuals with a high BIS may self-medicate their anxiety by drinking; while on the other hand, hypersensitivity to punishment cues (e.g., alcohol induced hangover) may lead to avoidance of alcohol use.

In addition to the BIS, the RST also identifies two other neurobiological systems that are important for individual differences in affect, behaviour, and motivation: the Behavioural Approach System (BAS) and the Fight/Flight System (FFS). The BAS was hypothesized to be a reward-sensitive system that controls approach responses to positively reinforcing stimuli (Corr, 2008). Activation of the BAS by reward cues moves individuals towards appetitive goals, leading to increased self-reports of desire and wanting. This activation gives rise to positive affect and has been associated with the personality traits of extraversion (i.e., "outgoing" and "fun-seeking") and impulsivity (Smillie et al., 2006). The neural substrate of the BAS was assumed to be located in "reward-sensitive" dopaminergic areas of the limbic system (Reuter,

2008). As such, the BAS theoretically maps onto the positive reinforcement pathway to alcohol misuse. Supporting theory, there is consistent evidence for elevated BAS sensitivity as a risk factor for alcohol misuse (Colder & O'Connor, 2002; O'Connor & Colder, 2005).

Gray's FFS was hypothesized to be sensitive to unconditioned aversive stimuli that signalled immediate threat or danger, giving rise to primal emotions of fear, panic and rage (Corr, 2008). Accordingly, the output of the FFS was either fight, if the threat was proximal and unavoidable (manifested in defensive aggression) or flight (manifested in rapid escape) if the threat was distal and could be easily avoided. The neural structure of the FFS was assumed to be complex and included several regions of the amygdala, the hippocampus, and the midbrain (Corr, 2004; Corr, 2008). Given that the FFS was thought to be reflexive of extreme fear or danger, its implications for alcohol misuse were not readily apparent.

The Revised RST. One problem with the original RST is that it equated fear (i.e., FFS output) with anxiety (i.e., BIS output) and this equivalence permeated the psychometric and laboratory assessment of the RST systems (Carver & White, 1994; Torrubia, Avila, Molto, Caseras, 2001). This means that studies of BIS may have tapped fear, anxiety, or both; and this may account for the mixed BIS-alcohol misuse findings. The fear-anxiety equivalence was contended, giving rise to the revised RST (Gray & McNaughton, 2000). Changes were made to each of the three motivational systems.

The BIS is now conceptualized to be a motivational conflict resolution system in the brain (Corr, 2008), located neurally along the septo-hippocampal system and the amygdala (Gray & McNaughton, 2000; Wacker, Chavanon, Leue & Stemmler, 2010). In the revised RST, the BIS no longer controls responses to punishment cues. Instead, the BIS functions to resolve conflict between competing motivational goals. Simultaneous reward and punishment cues provide a key source of conflict that activates the BIS, but the BIS is also activated by reward-reward and punishment-punishment conflicts (Corr, 2008). The BIS inhibits ongoing behaviour in response to goal conflict and engages a risk assessment that includes scanning the environment and memory for threat-relevant information (Corr, 2002). This results in high anxiety, attention to threat, and behavioral ambivalence (Smillie et al., 2006). While behaviour is inhibited, the BIS increases the negative valence of stimuli until conflict is resolved in favour of approach or avoidance.

The BAS remains relatively unchanged when compared to the other two RST systems. The BAS continues to function as a reward system. However, in contrast to Gray's original RST, the BAS is now posited to mediate approach responses to *all* appetitive stimuli, not simply conditioned cues of reward (Smillie et al., 2006; Corr, 2008). The dopaminergic limbic structures are still assumed to underlie reactivity to reward. Finally, the FFS was renamed as the Fight, Flight and Freeze System (FFFS) to account for observations of fear responses in animals. The new FFFS is theorized to mediate responses to *all* aversive stimuli (both conditioned and unconditioned). The output of the FFFS is the "get me out of here" emotion of fear (Corr, 2008, pg. 10), not anxiety. Individuals with a strong FFFS should be biased in their attention to negative or potentially punishing stimuli. Increased FFFS activity manifests in such overt traits as fear-proneness and avoidance (Corr, 2008; DeYoung, 2010).

As in the original theory, the BIS is still posited to be a risk factor for anxiety-related drinking; however, this relation remains complex (as in the original theory). Specifically, BIS activation gives rise to high levels of anxiety, which theoretically may lead to self-medication drinking, thus supporting an anxiety pathway. Alternatively, the BIS as a conflict resolution system may serve as a protective factor, as activation of the BIS leads to anxiety, behavioural ambivalence about alcohol use, and increased attention to threat (i.e., alcohol's negative outcomes). The result of this process may deter heavy drinking. In contrast, the BAS is still believed to map onto the positive reinforcement pathway, and has been shown to be a risk factor for alcohol misuse (Corr, 2004; Corr, 2002; Franken, 2002; O'Connor et al., 2009).

The Joint Subsystems Hypothesis. One of the primary strengths of the revised RST is that it goes beyond looking at these behavioural systems as unique correlates of risk behaviour. In particular, the *joint subsystems hypothesis* (Corr, 2002) suggests that there may be utility in looking at the interactive effects of the BIS and the BAS on behaviour. In the original theory, these systems were assumed to be orthogonal, meaning that each system had its own independent influence on behaviour (Corr, 2008; Gray 1972). In contrast, the initial joint subsystems hypothesis predicts that the BIS moderates the influence of BAS on engagement in alcohol use for positive reinforcement. Without a strong BIS drawing attention to threat (i.e., the negative outcomes of drinking), a high BAS should be associated with behavioural impulsivity, and risky drinking behaviour. In other words, individuals with a strong BAS and weak BIS should be at elevated risk for behavioural disinhibition and substance misuse (Corr, 2002). A study by

O'Connor and Colder (2009) supported this interaction, as participants with the high BAS, but low BIS combination more readily activated positive relative to negative cue-elicited alcohol attitudes on a priming task.

Recently, the joint subsystems hypothesis has been extended to clarify the role of the BIS as a risk factor for anxiety-related drinking by considering BAS as a moderator (Keough & O'Connor, 2014; Wardell et al., 2011). Theory would predict that in order for those high in BIS to engage in self-medication drinking, they need to focus on alcohol's negatively reinforcing effects rather than the potentially negative outcomes of drinking. A concurrently strong BAS is believed to make the tension-reducing effects of alcohol salient to individuals high in BIS, leading to the resolution of conflict in favour of approach and drink to alleviate anxiety. Without a strong BAS, theory would predict that those with a strong BIS should focus on alcohol's potentially negative outcomes and thus avoid heavy drinking. Therefore, the revised RST posits that the BIS can either be a high or low-risk factor depending on the relative strength of the BAS (Corr, 2002; Keough & O'Connor, 2014). This conceptualization helps to provide context for the mixed literature and offers a framework to better understand the etiology of BIS-related drinking.

Support for the moderating role of BAS on BIS-risk for alcohol misuse comes from two correlational studies. First, Wardell and colleagues (2011) showed that elevated self-report BIS prospectively predicted increases in alcohol use and related problems, but only when self-report BAS was also elevated. As noted by the authors, a limitation of this study was that the measure of the BIS was based on the original theory (sensitivity to punishment) and was not well suited to assess the new conceptualization of the BIS as a conflict system. In fact, this remains a limitation of most work linking the BIS to alcohol use. We addressed this key limitation in the literature by developing a new laboratory task to capture the revised BIS as a conflict system (Motivational Flanker Task [MFT]) (Keough & O'Connor, 2014). Using this improved measure, we found that the BIS was positively associated with alcohol use, but only at elevated self-report BAS.

The rRST predicts that stable and distal individual differences (like the BIS and the BAS) influence alcohol misuse through more malleable and proximal mechanisms. Accordingly, an important next step in this line of research is to elucidate the key *in-the-moment* mechanisms that underlie alcohol misuse among those high in the BIS and the BAS. A better understanding of the mechanisms of anxiety-related drinking can inform clinical prevention and intervention efforts. In particular, the revised RST posits that the BIS and the BAS shape learning processes or

cognitions that are believed to be proximal predictors of drinking (Corr, 2008). That is, the relative strength of the BIS and the BAS should give rise to differences in how individuals attend to and process alcohol-related information. Particularly relevant to the current study, theory would predict that a strong BAS should enhance the anxiolytic effects of drinking, which should be highly salient to a person who is anxious (i.e., high in the BIS). Over time, this biased learning may lead to the formation of cognitions that support risky drinking for the goal of anxiety reduction. Thus, examining the proximal cognitive factors in the anxiety pathway may help explain why those high in the BIS and the BAS are at risk for adverse outcomes when drinking. Once understood, it is possible for such cognitive factors to be targets for clinical interventions aimed at mitigating risky anxiety-related drinking.

Cognitive Mechanisms of BIS-Risk for Alcohol Misuse

Social learning and cognitive theories conceptualize alcohol use as a learned, goal-directed behaviour (Goldman, 1999). Accordingly, cognitions are key mechanistic predictors of alcohol use. Over time and through experience, persons form associations with alcohol in memory and these are thought to influence subsequent alcohol use (Stacy & Wiers, 2010). To illustrate, anxious people are theorized to be highly sensitive to the negatively reinforcing effects of drinking (Conger, 1956; Kushner et al., 1990) and hence theory would predict that they should form strong tension reduction associations with alcohol. In turn, when emotionally distressed, an anxious person is theorized to drink alcohol because s/he expects anxiety relief as an outcome. Therefore, tension reduction cognitions should increase the likelihood of heavy drinking and experiencing related problems among anxious drinkers.

Dual-process models are useful for conceptualizing the cognitive mechanisms of alcohol misuse (Goldman, 1999; Stacy & Wiers, 2010). According to dual-process models, cognitions are processed at both automatic and controlled levels (Chaiken & Trope, 1999). Automatic cognitive processes are measured using implicit reaction time tasks (e.g., the Implicit Association Test [IAT]) and are thought to give rise to alcohol use via a cue-activated or impulsive process (Houben & Wiers, 2007). In contrast, controlled cognitive processes are most often measured using explicit self-report measures of alcohol expectancies and reflect cognitions that exert self-regulatory influences on alcohol use (Fromme et al., 2003). For clarity; henceforward in this dissertation, I will simply refer to automatic processes as *implicit* and controlled processes as *explicit*.

There is a large body of literature examining how implicit and explicit cognitions relate to drinking behaviour. Broadly, the evidence to date suggests that both domains of cognition influence alcohol use (see Reich, Below, & Goldman, 2010 for a meta-analysis). However, there are different perspectives on how to conceptualize (and test) dual-processes in alcohol misuse. Traditionally, research in this area has taken an either/or approach, which pits these cognitions against each other (often in the same model) to examine how each independently predict alcohol misuse (Reich et al., 2010). The inherent goal of this approach is to identify which of these processes is a better predictor of alcohol use. For example, it has often been argued that implicit or impulsive processes should be most pivotal to spontaneous and risky drinking (e.g., Strack & Deutsche, 2004). However, emerging evidence suggests that it is erroneous to view alcohol misuse (and behaviour in general) as guided simply by either implicit *or* explicit cognitions (Wiers et al., 2007). Rather, contemporary dual-process perspectives state that both cognitive processes are important determinants of alcohol misuse (Stacy & Wiers, 2010).

Bringing the rRST and cognitive models together, the BIS and the BAS should interact to effect alcohol cognitions (see Figure 1.1 for a conceptual model). Through experience, those with an elevated BIS, who also have an elevated BAS, should preferentially attend to the anxiolytic effects of drinking (Wardell et al., 2011) and thus should form strong implicit and explicit alcohol cognitions related to anxiety reduction. In turn, when those high in BIS and BAS are feeling anxious, they should activate these cognitions and thus engage in drinking (Houben & Wiers, 2007). This prediction has indirect support from a related body of literature showing that those who drink to cope (versus enhancement-motivated drinkers) show both strong attentional biases for alcohol (Grant et al., 2007) and increased relief expectancies following anxious mood inductions (Birch et al., 2004). Without a strong BAS drawing attention to the potentially rewarding aspects of alcohol, those with a strong BIS may form strong negative alcohol cognitions because of their increased focus on alcohol's negative outcomes. Strong negative alcohol cognitions may deter drinking. Overall, a better understanding of the cognitive processes that influence anxiety-related alcohol misuse is critical, as they are malleable and can be targeted with intervention efforts (Goldman, 1999; Wiers et al., 2011).

Anxiety-Related Drinking and the Transition Out of University

The early years of adulthood are marked by naturally-occurring and stressful transitions, which may be important for solidifying the association between anxiety and alcohol use. It is

normative for young adults to move through undergraduate studies in about 3-5 years and then transition out after graduation. As they leave university, young adults are faced with the daunting task of adopting new adult roles, which may include finding meaningful employment, starting a family, or even pursuing further education. Research shows that as young adults greatly reduce their alcohol intake (i.e., mature out) as they take on these added responsibilities. However, there is an appreciable minority of individuals who continue to drink problematically during this transition and this is believed to relate to the later development of alcohol use disorders. In particular, it has been shown that young adults who drink to cope with negative affect are less likely to mature out of alcohol use relative to those who drink for other purposes. Taking this a step further, theory would predict that anxious individuals – who are prone to experience high levels of negative affect, especially in times of stress and uncertainty – may continue to rely on alcohol use as a means to cope during the transition out of university. This period of sustained coping-related drinking post-university may be the initial stages of a trajectory to alcohol use disorders later in adulthood. However, there is a lack of prospective research in this domain; therefore, we still have much to learn about how anxiety and alcohol misuse play out the transition out of university.

The rRST provides a useful framework for understanding how anxiety-related drinking unfolds as young adults make the transition from university to adult roles. Learning processes are central to the rRST (and substance use theories broadly), such that the joint effects of the BIS and BAS should determine the degree to which alcohol misuse is rewarding or punishing (Corr, 2002; 2008). Theory would predict that those high in BIS should experience significant apprehension and uncertainty during the transition out of university – given that this time is marked by conflicting signals of potential reward (e.g., finding a dream job) and punishment (e.g., remaining unemployed). These conflicting motivational cues should give rise to heightened anxiety among those high in BIS, providing a context for continued self-medication drinking and associated consequences, but only if they are also high in BAS. For anxious individuals, who are low in BIS, they should focus on the negative impacts of alcohol misuse on life functioning – leading to more rapid maturing out.

Overview of the Current Research

The young adult years may be central to the development of problem anxiety-related drinking patterns. As I have argued throughout, the rRST has important implications for

clarifying the contributing factors and mechanisms underlying the anxiety pathway to alcohol misuse in young adulthood. However, with the exception of some recent studies (Keough & O'Connor, 2014; Wardell et al., 2011); there have been relatively few empirical tests of the rRST in alcohol misuse. The overarching objective of this thesis is to examine the revised BIS – a motivational conflict system – as a risk factor for alcohol misuse. Within this approach, I provide support for the central moderating role of the BAS in cross-sectional and longitudinal associations between BIS and alcohol misuse outcomes. The main goal of study 1 was to test the cognitive mechanisms underlying anxiety-related drinking. Specifically, an experimental design was used to test how implicit and explicit cognitive processes unfold, *in-the-moment*, when those high in BIS and high in BAS are anxious. The primary goal of study 2 was to test the trajectories of BIS-related alcohol use over the critical transition out of university studies. A repeated measures longitudinal online study was used to examine the joint effects of the BIS and the BAS on alcohol misuse during the one-year following graduation.

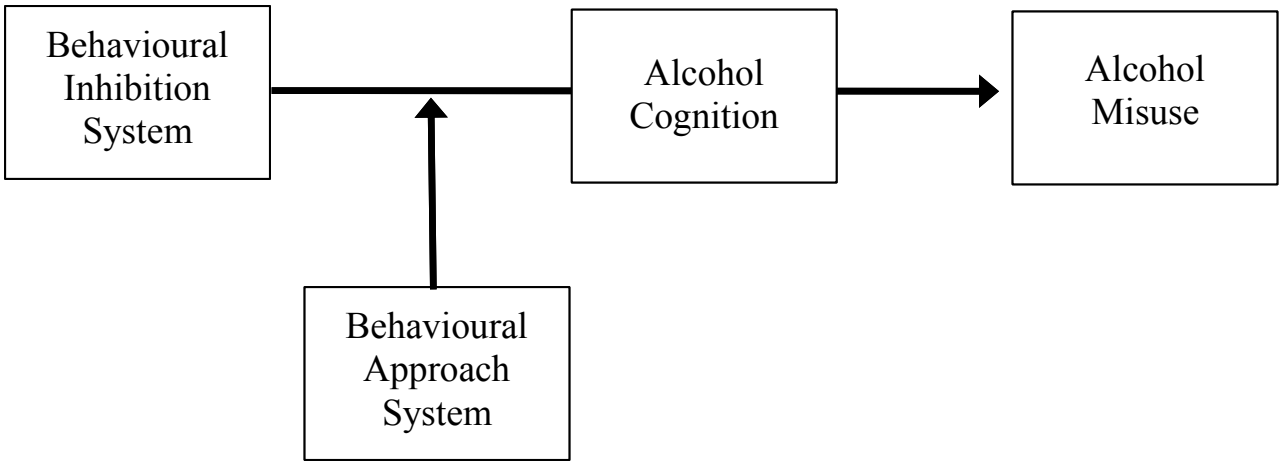

Figure 1.1. Conceptual model of the joint effect of the BIS and the BAS on alcohol cognition.

CHAPTER 2
STUDY 1

Testing the Implicit and Explicit Cognitions Underlying BIS-related Drinking in Young Adults

Keough, M. T., O'Connor, R. M., & Colder, C. R. (under review). *Alcoholism: Clinical and Experimental Research*.

Abstract

Background: There is great interest in the role of the behavioural inhibition system (BIS) and behavioural approach system (BAS) in the etiology of alcohol use because of the strong links of these systems to neuroscience and cognitive models of addiction. The revised Reinforcement Sensitivity Theory suggests that the strength of the BIS and BAS jointly influence behavior, so called the joint systems hypotheses (Corr, 2002). Yet, relatively little work has examined this hypothesis, particularly with respect to alcohol-information processing. Grounded in dual process theories of alcohol-information processing, this study aimed to clarify the roles of implicit (i.e., automatic processes) and explicit (i.e., controlled processes) cognitions in BIS-related drinking. When anxious and presented with an alcohol (vs. neutral) cue, we expected those with an elevated BIS to have increased implicit and explicit alcohol cognitions related to tension-reduction, but only at elevated BAS. Shifts in cognitions following cue-exposure were expected to positively correlate with alcohol misuse. **Method**: Students (*N*=110) completed baseline measures followed by the Trier Social Stress Test. This was followed by a cue-exposure (random assignment to alcohol or water cue); during which participants completed post-mood assessments of implicit/explicit alcohol cognitions. **Results**: Overall, participants' implicit alcohol cognition was negative. The effect of BIS on implicit and explicit cognitions was moderated by BAS; however, results were not as hypothesized. In the alcohol condition only (when controlling for baseline implicit cognition), BIS predicted relatively weak negative implicit alcohol cognition, but only at low BAS. Interestingly, in the alcohol condition only, BIS predicted increased explicit reward (but not relief) expectancies, but only at high BAS. Changes in explicit reward expectancies positively correlated with alcohol misuse. **Conclusions**: Our results suggest that explicit cognitions may be relevant to drinking among anxious individuals who are also reward responsive. Cognitive-behavioural interventions should target reward expectancies to reduce anxiety-related drinking.

Introduction

Alcohol misuse, including heavy drinking and alcohol-related problems (e.g., blackouts) is common among young adults. To illustrate, one-third of Canadian undergraduates drink at harmful levels, and 17% report experiencing alcohol-related physical and/or sexual assault (Adlaf et al., 2005). Despite ongoing intervention and prevention efforts, alcohol misuse among young adults continues to be a major public health concern (O'Connor & Stewart, 2010).

Gray's Reinforcement Sensitivity Theory (RST; Gray, 1987) is useful for understanding risk for alcohol misuse. The RST was revised by Gray and McNaughton (2000) over a decade ago; the changes have key implications for research on the etiology of alcohol misuse (Keough & O'Connor, 2014; Wardell et al., 2011). The revised RST (rRST) attributes individual differences in motivation, affect, and behavior to the relative strength of the Behavioral Approach System (BAS), the Fight-Flight-Freeze system (FFFS), and the Behavioral Inhibition System (BIS). The revised BAS controls approach behavior to both conditioned – as in Gray's (1987) original theory – and unconditioned reward cues. The BAS is linked to reward responsiveness and approach behavior (Smillie et al., 2006). The revised FFFS controls responses to all aversive stimuli, not only to unconditioned punishment cues as in Gray's original theory. The outputs of the FFFS are fear and active avoidance of threat (Corr, 2008). The revised BIS is conceptualized as a motivational conflict resolution system, which is distinct from the original theory, which viewed the BIS as purely a punishment sensitivity system. Competing reward and punishment cues is a primary source of conflict that activates the BIS, but the BIS is also activated by reward-reward and punishment-punishment conflicts (Gray & McNaughton, 2000). The BIS inhibits ongoing behaviour in response to goal conflict and engages a risk assessment that includes scanning the environment and memory for threat-relevant information (Corr, 2002). This results in anxiety, attention to threat, and behavioral ambivalence (Smillie et al., 2006). While behaviour is inhibited, the BIS increases the negative valence of stimuli (providing input to the FFFS) until conflict is resolved in favor of approach or avoidance.

The BIS and the BAS have conceptual links to reinforcement pathways to alcohol misuse (Corr, 2008). Empirical evidence links a strong BAS with alcohol misuse for positive reinforcement (i.e., increase positive emotion) (Colder & O'Connor, 2002). Like in the original theory, the rRST implicates the BIS in drinking for negative reinforcement; however, support for the BIS as a risk factor for alcohol misuse is inconsistent (Hundt et al., 2008; Kambouropoulos &

Staiger, 2004b O'Connor & Colder, 2005). The revised conceptualization of the BIS as a motivational conflict system provides insights into these mixed findings, as it suggests the BIS-alcohol misuse association is more complex than originally thought (Corr, 2008; Kambouropoulos & Staiger, 2004b; Gray & McNaughton, 2000). On the one hand, individuals with a strong BIS may drink to alleviate anxiety. On the other hand, the conflicting reward (e.g., tension-reduction) and punishment (e.g., health risks) cues associated with alcohol should lead to behavioral ambivalence and inhibition of drinking among persons with a strong BIS. We propose that the influence of BIS on negative reinforcement drinking depends on the strength of the BAS.

Corr's (2002) joint subsystems hypothesis suggests that the BAS may moderate the BIS-alcohol misuse association. A concurrently strong BAS should bias BIS conflict in favor of alcohol approach behaviour by enhancing the tension-reducing effects of drinking and thereby shift attention away from alcohol's potentially negative outcomes. Results from two correlational studies support this prediction. In one study, Wardell and colleagues (2011) showed that elevated self-report BIS prospectively predicted increases in alcohol use and related problems, but only when self-report BAS was also elevated. As noted by the authors, one central limitation of their study was that their measure of the BIS was based on the original theory (punishment sensitivity) and was not well suited to assess the new conceptualization of the BIS as a conflict detection system. In fact, this remains a limitation of most work linking the BIS to alcohol use. In Keough and O'Connor (2014) we aimed to address this limitation by developing a new laboratory task (i.e., Motivational Flanker Task [MFT]), which captures the revised BIS as a conflict system. In this study, using the MFT, we found that BIS was positively associated with alcohol use, but only at elevated self-report BAS. In the current study, our goal is to extend these previous investigations by testing information processing mechanisms that may underlie the joint effects of a high BIS and a high BAS.

Cognitive theories indicate that learned alcohol associations are proximal and mechanistic predictors of drinking behaviour that mediate the effects of individual differences (i.e., BIS, BAS) on alcohol misuse (Goldman, 1999). According to dual-process models, cognitions are processed at both automatic and controlled levels (Chaiken & Trope, 1999). Automatic cognitive processes are measured using implicit reaction time tasks (e.g., the Implicit Association Test [IAT] and its variants, such as the Single Category IAT [SC-IAT]; Karpinski & Steinman, 2006). These cognitions are believed to give rise to alcohol use via a cue-activated

process (Houben & Wiers, 2007). In contrast, controlled cognitive processes are assessed using explicit self-report measures of alcohol expectancies and reflect the cognitions that are thought to exert self-regulatory influences on alcohol use (Fromme et al., 2003). Moving forward, for clarity, we label automatic cognitive processes as *implicit* and we refer to controlled cognitive processes as *explicit*.

Contemporary dual process models posit that it is erroneous to view alcohol misuse (and behaviour broadly) as guided simply by either implicit or explicit cognitions (Wiers et al., 2007; Gladwin et al., 2011). Rather, alcohol misuse is the product of both cognitive processes (Stacy & Wiers, 2010) and this view has been incorporated recently in the scoring/interpretation of the IAT and SC-IAT (Conrey et al., 2005; O'Connor et al., 2012). This work challenges the assumption that these tasks measure purely implicit cognitions and provides support for the quadruple process model (*quad model*) of task performance. Accordingly, the quad model approach suggests that IAT, SC-IAT (and similar) task performance is influenced by the strength of implicit cognitions (or biases) *and* the ability to overcome these biases – which is an explicit or controlled process (Conrey et al., 2005). The strength of the quad model is that the implicit cognitive process can be isolated (from more explicit processes), leading to an improved measurement of the cognitions that are central to alcohol misuse.

Bringing the rRST and cognitive models together, we speculate that the joint effects of the BIS and the BAS influence alcohol cognitions. Through experience, those with an elevated BIS, who also have an elevated BAS, should preferentially attend to the anxiolytic effects of drinking (Wardell et al., 2011) and thus should form strong implicit and explicit alcohol cognitions related to tension-reduction. In turn, when those high in BIS and BAS are anxious, they should activate these cognitions and thus engage in anxiety-related drinking (Houben & Wiers, 2007). Without a strong BAS drawing attention to the potentially rewarding aspects of alcohol, those with a strong BIS may form strong negative alcohol cognitions because of their increased focus on alcohol's negative outcomes. Strong negative alcohol cognitions may deter drinking. While cognitive mechanisms are inferred, limitations of existing work preclude an understanding of implicit and explicit cognitions as mechanisms in the BIS-pathway to alcohol misuse.

The rRST predicts that anxious mood triggers drinking (via its effects on alcohol-related cognitions) among those high in BIS and BAS; but, this remains to be tested experimentally. A

related body of literature on coping-motivated drinking suggests that those who drink to cope (versus enhancement-motivated drinkers) show both strong attentional biases for alcohol (Grant et al., 2007) and increased relief expectancies following anxious mood inductions (Birch et al., 2004). Extending this to our study, we used experimental methods to examine how alcohol cognitions unfold when individuals with an elevated BIS and an elevated BAS are anxious.

We aimed to test the joint effects of BIS and BAS on implicit and explicit cognitive processes using a laboratory-based experiment. Using the quad model to measure implicit alcohol cognition, along with explicit alcohol expectancy measures, we hypothesized that when anxious; those with an elevated BIS would activate strong implicit tension-reduction alcohol cognitions and report increased explicit anxiety relief alcohol expectancies, but only when BAS was also elevated. These effects were expected following an alcohol (vs. neutral) cue. Alcohol-related cognitions assessed post alcohol cue-exposure were expected to positively correlate with alcohol misuse.

Materials and Method

Participants and Procedure

Undergraduates (N=110; 68% female; M_{age}=21.40, SD=2.66) were recruited from English-speaking universities in Montreal to participate in the 2-hour laboratory study. Eligibility was determined via a brief telephone questionnaire. Eligibility criteria were: (a) 18-25 years old (i.e., young adults of legal drinking age in Quebec); (b) fluent in English; (c) not abstaining from alcohol use (i.e., >1 drinks/week); and (d) no history of very heavy drinking (i.e., ≥35 drinks per week). Many participants lived at home with family (70%), while 27% lived in a residence off-campus (not with family) and 3% lived on campus. Many participants were Caucasian (65%) and minority groups were Hispanic (8%), South Asian (7%), East Asian (6%), Middle Eastern (6%), African Canadian (4%), and Aboriginal (4%). Participants were compensated with either course credit or money ($10/hour)

First, participants completed baseline measures of BIS/BAS, drinking habits, alcohol cognition (SC-IAT, alcohol expectancies), and mood. Next, participants completed the Trier Social Stress Test (TSST) (Kirschbaum et al., 1993). Briefly described, the TSST is a well-validated public speaking task, where participants first give a 5-minute mock interview speech followed by 5-minutes of mental arithmetic. The TSST tasks were completed in front of a panel

of confederates who were dressed in lab coats and who were described as being experts in behavioural analysis for signs of stress (see Kirschbaum et al., 1993 for the full TSST protocol).

Immediately after the TSST, mood was re-assessed and participants then underwent a cue-exposure. Before the cue-exposure, participants were told that the purpose of the study was to see how cognitively demanding tasks affect food and drink perceptions (e.g., visual size, taste). Participants were randomly assigned to either receive an alcohol-cue or neutral-cue (water) beverage. During the cue-exposure, participants in the alcohol condition were exposed to their preferred drink (i.e., wine, beer, or mixed vodka drink) (Carter & Tiffany, 1999). All drinks were non-alcoholic, but the rim of the glass was rubbed with alcohol to give the cue a characteristic odor. Also, the beverage was poured in front of participants to increase cue salience. The cue remained in front of participants while they completed the post-TSST alcohol cognition measures (SC-IAT, alcohol expectancies). Once they had completed these measures, participants were allowed to consume the beverage. To increase ecological validity, both the TSST and cue-exposure sessions took place in a realistic laboratory bar.

Measures

Motivational Flanker Task (MFT). The MFT (Keough & O'Connor, 2014) was used to measure BIS and BAS. Participants viewed stimuli consisting of three words presented in the middle of the screen in random order (1500 milliseconds each). The center words were positive, negative, or neutral targets. Targets were flanked by distracter words. Participants were told to categorize *only* the center words using a key press and ignore the distractors. There were congruent (valence of distracters matched the target) and incongruent (valence of distracters opposite of target) trials. Congruent trial types included all positive, all negative, or all neutral words; the latter served as a control. Incongruent trial types included positive or negative targets flanked by oppositely valenced distracters, or valenced targets flanked by neutral words, which served as a control. A masking stimulus appeared after each trial to reduce priming effects. There were 50 trials per trial type.

Participants began with 250 points and were encouraged to earn as many points as possible. Correct responses to positive targets resulted in a 50-point gain (reward), while incorrect responses to negative targets resulted in a 50-point loss (punishment). Incorrect responses to positive and correct responses to negative targets were not rewarded nor punished. To reduce response set bias and promote responding on all trials, correct and incorrect responses

on neutral trials resulted in a 5-point gain or loss, respectively. Fast median reaction times (RTs) of correct responses on positive congruent trials (relative to control trials) reflected strong BAS. Slow median RTs of correct responses on incongruent trials, which included positive targets and negative flankers, (relative to control trials) reflected a strong BIS. Theory indicates that slowed reaction times on these trials likely reflects *cautious approach* behaviour characteristic of those high in the BIS (McNaughton & Corr, 2004). Consistent with Keough and O'Connor (2014), unstandardized residual scores were derived for the BIS and BAS on the MFT by regressing median critical trial RTs on median control trial RTs. Small positive congruent trial residuals indicated fast responding to reward (i.e., strong BAS), whereas, large incongruent trial (positive targets, negative flankers) residuals indicated slow responding to motivational conflict (i.e., strong BIS).

The split-half reliabilities of the BIS and BAS critical and control trials were adequate (r=.70-.75). The MFT BIS/BAS scores have been shown to correlate with widely used self-report measures of these systems, thus supporting good concurrent validity of the MFT (Keough & O'Connor, 2014). In the current sample, MFT BIS positively correlated with self-report BIS-anxiety items (e.g., r=.19, p=.03 with "I feel worried when I think I have done poorly at something important"), and the MFT BAS positive correlated with self-report BAS items (e.g., r=-18, p=.05, "When I see an opportunity for something I like I get excited right away" (Carver & While, 1994).

Single Category Implicit Association Test (SC-IAT). An adapted SC-IAT (Karpinski & Steinman, 2006; O'Connor et al., 2012) was used to assess implicit alcohol cognitions at baseline and at post-TSST. The SC-IAT is computerized and participants are asked to categorize stimuli from a single object category (i.e., alcohol pictures) and words from contrasting evaluative dimensions (i.e., tension-reduction words [e.g., "calm"] and negative words [e.g., "sick"]. The SC-IAT began with 10 practice trials followed by two blocks of 72 trials. In block one, alcohol pictures were paired with the response key for negative words and tension-reduction words were on a separate response key. In block two, alcohol pictures were then paired with the response key for tension-reduction words and negative words were on a different response key. If participants more easily pair alcohol with tension-reduction words in block two (vs. with negative words in block one), then they are said to have strong tension-reduction associations with alcohol. While there are multiple variants of the IAT, the SC-IAT is advantageous for

measuring associations for object categories that do not have a natural "opposite", like alcohol (see Karpinski & Steinman, 2006 for a full rationale). Also, the bivalent nature of evaluative dimensions in our SC-IAT ("positive" vs. "negative") has ecological validity for assessing alcohol use attitudes because drinking contexts often have positive and negative cues that compete for attention (O'Connor et al., 2012).

Two SC-IATs were given, one to assess implicit tension-reduction alcohol cognition and the other to assess enhancement alcohol cognition (i.e., alcohol will elevate positive mood). We used two scoring methods for the SC-IAT. First, scores were derived using the traditional d-score method, which uses reaction times (difference between blocks divided by pooled standard deviation) (Karpinski & Steinman, 2006). Positive SC-IAT d-scores indicated strong tension-reduction cognitions (i.e., faster responding when alcohol and tension-reduction words were paired together relative to when alcohol was paired with negative words), while negative SC-IAT d-scores reflected strong negative cognitions.

Second, SC-IAT data were analyzed according to the quad model (Conrey et al., 2005; O'Connor et al., 2012), which models error rates. The first step in quad model scoring is to identify the valence of the compatible association or implicit bias. Overall error rates for the baseline SC-IAT revealed more errors when alcohol was paired with tension-reduction (9%) compared to negative (5%) words. This suggests that the paring of alcohol with negative was compatible, such that the average bias of the sample is characterized by a negative-alcohol attitude. While initially somewhat unexpected, a review of the literature using the traditional IAT d-score in adults clearly demonstrates that young adults tend to have stronger negative, relative to positive, associations with alcohol (e.g., Wiers et al., 2002). Next, using the multinomial processing tree and corresponding equations outlined in O'Connor et al. (2012), a negative-alcohol AC1 bias parameter estimate for each participant, which is thought to be a more "pure" measure of implicit alcohol cognitions than the d-score. The negative-alcohol AC1 is a single score and reflects the probability that the automatic activation of negative associations with alcohol influenced SC-IAT responding. High and low AC1 values indicate a strong and a weak implicit negative-alcohol cognition, respectively. Four other parameters were also extracted for each participant and added as covariates in the models (automatic activation of a general positive category [AC2], guessing [G], overcoming bias [OB], and accurate detection [D]). See O'Connor and colleagues (2012) for a formulae appendix to score the SC-IAT according to the quad model.

Explicit Alcohol Expectancies. An abridged version of the Alcohol Cravings Questionnaire (Singleton et al., 1994; Watt et al., 2009) was used to assess explicit alcohol cognitions at baseline and at post-TSST. Two 9-item subscales were included in this study to reflect relief and reward expectancies. Participants responded to items on a response scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Mean subscale scores were calculated. Previous work demonstrates that these subscales have high internal consistencies and good structural validity (Birch et al., 2004). Our internal consistencies for relief (α=.89) and reward (α=.86) were good.

Subjective Mood. A visual analogue scale (VAS) was used to assess mood at baseline and post-TSST. Participants indicated their rating of three adjectives (*anxious*, *sad, happy*) describing mood on a 100-point horizontal line anchored with 0 (*not at all*) to 100 (*very much*). Reponses to the anxiety item were used to assess the mood manipulation effect.

Typical weekly alcohol use. Participants indicated their typical weekly frequency (days/week) and quantity (number drinks/occasion) of alcohol use over the past month. Responses were multiplied to yield a composite reflecting total weekly alcohol use. The quantity by frequency product is commonly used in the alcohol literature (e.g., Wardell et al., 2011).

Hazardous drinking. The Alcohol Use Disorders Identification Test (AUDIT; Saunders et al., 1993) is a 10-item measure of hazardous drinking. Participants responded to items on response scales, with the first 8-items ranging from 0 (*Never*) to 4 (*Four or more times a week*), while items 9 and 10 range from 0 (*No*) to 2 (*Yes, during the last year*). Total sum scores were used and the AUDIT has been shown to have adequate internal consistency and very good test-retest reliability (Selin, 2003). The internal consistency of the AUDIT total scores was adequate (α=.73).

Alcohol-related problems. The Young Adult Alcohol Consequences Questionnaire (YAACQ) is a 48-item self-report measure of alcohol-related problems (Read et al., 2006). Participants indicated whether or not they experienced each alcohol-related problem in the past year (1=yes; 0=no). "Yes" responses were summed to provide a total score. The YAACQ total score has demonstrated good reliability (α=.89), as well as good concurrent and predictive validity (Read et al., 2006). Using tetrachoric correlations, our Cronbach's α=.93.

Data Analytic Overview

All data were screened before analyses (Kline, 2009). Following preliminary analyses, several moderation analyses were used to test hypotheses (Aiken & West, 1994). We were underpowered to test three way interactions given our sample size. Accordingly, we tested the two-way BIS (predictor) by BAS (moderator) interaction predicting post-TSST alcohol cognitions for alcohol- and water-cue conditions, separately. Baseline cognitions for the relevant IAT of interest and other relevant post-TSST cognitions (i.e., other quad model parameters, and the negative-alcohol cognition AC1 from the IAT not tested as the outcome) were controlled for in the models. Predictor variables were centered and supported moderation effects were followed by simple slopes analyses. The simple slopes of BIS predicting outcomes were conditioned at high (+1SD) and low (-1SD) values of BAS. Correlations were used to assess the relations between in-lab changes in alcohol cognitions and measures of alcohol misuse.

Results

Data Screening and Preliminary Analyses

RT Measures. Consistent with Keough and O'Connor (2014), incorrect (4.5% of trials) and anticipatory (RTs<250 *ms*) responses (<0.01% of trials) on the MFT were excluded from analyses. Regarding the SC-IAT, treatment of fast responding (RTs<350 *ms*) differed from d-score to quad model estimates. Calculation of d-scores is based on RTs and we followed the scoring procedures outlined by Karpinski and Steinman (2006). Of particular note, trials with no response (<2% of trials) and trials with fast responses (<1% of trials) were excluded. In contrast, the quad model uses error rates. Within this framework, correct/incorrect responses made in less than 350*ms* may reflect guessing and are therefore included in the analysis. One participant was excluded from analyses because he had an SC-IAT error rate above 40%.

Descriptive Statistics and Bivariate Correlations. See Table 1 for a summary of descriptive statistics and bivariate correlations. All variables had acceptable skew (<3.0) and kurtosis (<10) indices (Kline, 2009) and there was no missing data. Relative to published reports in Canadian undergraduates, our sample had slightly lower typical weekly alcohol use (Adlaf et al., 2004), had lower hazardous drinking symptoms (Balodis et al., 2010), but had comparable alcohol-related problems (Keough & O'Connor, 2014). Consistent with previous work (Keough & O'Connor, 2014) and theory (Corr, 2008), BIS was uncorrelated with alcohol misuse

outcomes at the zero-order level. Unexpectedly, BAS was also uncorrelated with drinking outcomes.

Manipulation Check. As expected, participants reported statistically significantly higher levels of anxiety immediately after the TSST relative to baseline ($t_{(109)}$=-9.740, p<.001) and this corresponded to a substantial effect size (d=-1.22).

Hypothesis Testing

Traditional d-scores. Post-TSST tension-reduction d-scores were regressed on baseline tension-reduction d-scores and post-TSST enhancement d-scores (covariates) followed by BIS, BAS, and the BIS by BAS interaction of interest in each cue condition. The first order effects of BIS and BAS and the interaction were not statistically significant in either condition (ps>.28) and did not account for much criterion variance ($\Delta R^2_{alcohol}$=.020, ΔR^2_{water}=.000).

Implicit negative-alcohol cognition AC1. Two regression models were run. In the first model of interest, post-TSST implicit negative-alcohol cognition AC1 scores from the tension-reduction SC-IAT were regressed on relevant covariates (the four remaining quad model parameters for the post-TSST tension-reduction SC-IAT [AC2, OB, G, D], baseline negative-alcohol cognition AC1 for the tension-reduction SC-IAT, and the post-TSST negative-alcohol cognition AC1 for the enhancement SC-IAT) followed by BIS, BAS and the BIS by BAS interaction. The BIS by BAS interaction was statistically significant in the alcohol- ($\Delta R^2_{alcohol}$=.090), but not in the water-cue condition (ΔR^2_{water}=.000). Unexpectedly, simple slopes analyses showed a negative relation between BIS and negative implicit alcohol cognition at low (B=-0.002, $t_{(44)}$=-3.156, p=.003, f=.230) but not at high (B<-0.001, $t_{(44)}$=-0.902, p=.372, f=.018) BAS (see Figure 1a). This suggests that those high in BIS had weak implicit negative-alcohol cognition in response to an alcohol-cue if they were low in BAS. In the second model, post-TSST implicit negative-alcohol cognition scores from the enhancement SC-IAT were regressed on relevant covariates (see Table 4) followed by BIS, BAS and the BIS by BAS interaction. The BIS by BAS interaction was non-significant in both alcohol- ($\Delta R^2_{alcohol}$=.005) and water-cue ($\Delta R^2_{alcohol}$=.003) conditions.

Explicit Alcohol Expectances. Two regression models were run. In the first model, post-TSST relief expectancies were regressed on baseline relief expectancies (covariate), post-TSST reward expectancies (covariate), BIS, BAS, and the BIS by BAS interaction (see Table 2). Counter to hypotheses, the interaction was not statistically significant in the alcohol-

($\Delta R^2_{alcohol}$=.013) or in the water-cue (ΔR^2_{water}=.000). In the second model, post-TSST reward expectancies were regressed on the same predictors as in model one, with the exception of baseline reward expectancies and post-TSST relief expectancies as covariates (see Table 3). The BIS by BAS interaction was statistically significant in the alcohol- ($\Delta R^2_{alcohol}$=.070) but not in the water-cue (ΔR^2_{water}=.000) condition. Simple slopes analysis revealed that BIS was positively associated with reward expectancies at high (B=0.009, $t_{(44)}$=3.032, p=.004, f=.201), but not at low (B=0.001, $t_{(44)}$=0.233, p=.817, f<.001) BAS (see Figure 2). This suggests that those with a high BIS showed increases in reward expectancies in response to an alcohol-cue, but only if they also had high BAS.

Alcohol Cognition and Alcohol Misuse Associations. Regarding implicit cognitions, counter to predictions, post-TSST tension-reduction d-scores and implicit negative-alcohol cognition AC1 scores were not statistically significantly correlated with drinking outcomes (rs<.170, ps>.100). In contrast, as expected, post-TSST explicit relief expectancies were positively associated with hazardous drinking (r=.368, p<.001), with alcohol-related problems (r=.362, p<.001), and with typical weekly alcohol use (r=.216, p=.024). Post-TSST explicit reward expectancies were also correlated with hazardous drinking (r=.294, p=.002), with alcohol-related problems (r=.296, p=.002) and with typical weekly alcohol use (r=.270, p=.005).

Discussion

We conducted an experiment to test how the joint effects of BIS and BAS influence implicit and explicit cognitive processes believed to be relevant for anxiety-related drinking. Using a mood manipulation with an alcohol cue-exposure, we assessed how alcohol cognitions unfold when those high in the BIS and the BAS are anxious. To our knowledge, systematic work of this kind has not previously been done for BIS-related drinking. We found that the BAS moderated the effects of BIS on implicit and explicit cognitions; however, results were not as hypothesized. Following an alcohol cue-exposure, individuals with a strong BIS had relatively weak implicit negative-alcohol cognition at low BAS (rather than at high BAS which was hypothesized). Unexpectedly, after alcohol cue-exposure, persons with a strong BIS reported increased explicit reward (but not relief) expectancies, but only at high BAS. Changes in reward and relief expectancies were correlated with self-report measures of alcohol use, hazardous drinking, and problems.

Regarding implicit alcohol cognition, our results were inconsistent with theoretical predictions. We conducted post-hoc analyses in an attempt to provide context to our results. There is literature indicating that those with an elevated BIS, but a weak BAS, are prone to depressed affect (e.g., Kasch et al., 2002). Because they experience negative mood, theory would suggest that these individuals should also form strong negative reinforcement (i.e., reduction in negative mood) associations with alcohol. It is possible that those high in BIS, but low in BAS, responded to the TSST with increased depressed, rather than anxious, affect and this may have resulted in weak implicit negative-alcohol cognition. This speculation was not supported; however, since we did not find support that the BIS by BAS interaction predicted increases in sadness ratings following the TSST.[1]

In contrast, those high in BIS and BAS had increased thoughts about the rewarding outcomes of drinking after a social stressor and exposure to an alcohol cue. We told participants that they would be able to consume the alcoholic cue beverage, but only after completing additional measures (i.e., SC-IAT, self-report expectancies). In the context of the broader literature, the cue exposure may have promoted some craving among those high in BIS and BAS. While craving involves many cognitive, physiological, and emotional factors, theories posit that deliberate processes are central to craving. To illustrate, Marlatt's (1985) outcome expectancy theory indicates that exposure to alcohol cues triggers strong beliefs about the positive effects of drinking. Furthermore, in his information-processing model, Tiffany and Conklin (2000) argue that alcohol use is primarily an automatized behavior formed through experience; whereas he posits that craving is a deliberate process thought to result when automatized alcohol use is impeded. Extending craving models to our study, we speculate that anxious, reward responsive persons became reflective about alcohol's rewarding outcomes when experiencing anxious feelings because we temporarily prevented them from drinking when it would have been rewarding for them to do so. This interpretation aligns with work showing that anxious drinkers more readily retrieve explicit alcohol-related memories when they were exposed to alcohol cues (Zack et al., 2003).

[1] The results are not summarized in text due to space limitations. We tested whether the BIS by BAS interaction predicted increases in sadness from pre- to post-TSST and no support was found for the interaction (p<.66). Also, the correlation between in-lab changes in sadness and post-TSST implicit negative alcohol cognition was non-statistically significant (r=-.04 p=.66).

Theory and previous work help to interpret why we observed increased reward *rather than* relief expectancies in those high in the BIS and the BAS. In particular, the Acquired Preparedness Model (Anderson, Smith, Fischer, 2003; McCarthy, Kroll, & Smith, 2001) and Incentive Sensitization Theory (Robinson & Berridge, 1993) indicate that individual differences (and the underlying neural substrates) characterized by disinhibition/impulsiveness (e.g., the BAS) are central to shaping the learning of alcohol expectancies. That is, such traits increase one's focus on the rewarding and pleasant effects of alcohol use and away from alcohol's negative outcomes (Settles et al., 2010). This learning process is believed to support the formation of positive alcohol expectancies, which gives rise to increased wanting for alcohol and subsequent misuse (Berridge & Robinson, 1995; Corbin et al., 2011). Consistent with this, previous work shows that the BAS is associated with increases in positive urges to drink when exposed to alcohol cues (Kambouropoulos & Staiger, 2004a). However, not much is known about how a strong BAS influences alcohol cognition in the context of a strong BIS (individuals prone to anxiety). Our findings suggest that a concurrently strong BAS may promote anxious individuals to form expectations of elevated positive mood, rather than decreases in negative mood. Our findings also suggest that these expectancies may explain why individuals high in BIS and high in BAS are at risk for alcohol misuse (Keough & O'Connor, 2014).

We found that in-lab changes in explicit, but not implicit, cognitions correlated with self-reported alcohol use, hazardous drinking, and alcohol-related problems. The lack of association between implicit cognition and alcohol use is inconsistent with some published work (O'Connor et al., 2012). However, there are two possible, but not mutually exclusive, explanations for this. First, we correlated in-lab implicit cognitions with retrospective self-reports of alcohol misuse rather than allowing participants to freely drink following the TSST. This is relevant because implicit processes are believed to be particularly central to spontaneous, *in the moment*, decisions to drink when anxious (Strack & Deutsch, 2004). Although such decisions presumably accumulate over time and influence longer term drinking patterns and associations, it is possible that implicit processes would have predicted increased alcohol use in the lab if we allowed participants to drink when experiencing elevated anxiety (i.e., a tighter coupling of anxious mood and drinking). A related possibility is that the effects of implicit cognitions on alcohol use (and substance use broadly) depend on other factors (Wiers et al., 2007). Contemporary dual-process models predict that implicit cognitions only predict alcohol use when self-regulatory processes

(e.g., executive functioning) are low and this has been supported in the literature (e.g., Thush et al. 2008). When self-regulation is high, explicit processes are believed to better predict alcohol use behavior than implicit processes. It is possible that when allowed to freely drink when anxious, a concurrently high BAS would be associated with increased alcohol consumption via an impulsive process among those high in BIS. In contrast, when BAS is low, self-regulatory processes (e.g., motives for drinking) would need to come into play to promote alcohol misuse among anxious individuals. Future work should test the speculations using an anxious mood manipulation followed by in-lab free drinking procedures.

Although this study provided some important insights in the joint effects of BIS and BAS on alcohol cognitions, there are some limitations of our experiment. First, we are limited in making firm conclusions about alcohol cognitions as mediators of the joint effects of BIS and BAS on alcohol misuse. This is because we assessed alcohol use retrospectively. Nevertheless, the correlations among in lab changes in expectancies and alcohol misuse outcomes provide a promising foundation for future work testing mediation explicitly. Second, given our small sample size, we were unable to consider additional moderators. Namely, individuals with history of heavy drinking are expected to have stronger implicit alcohol cognitions that promote use than those who drink lightly (Goldman, 1999). For example, some work shows that heavy, problem drinkers tend to have weaker negative implicit cognition for alcohol relative to non-problem light drinkers (Wiers et al. 2002). Future work in larger samples should examine level of drinking as an additional moderator.

Our study has notable scientific and clinical implications. Regarding scientific merit, our study advances etiological risk models of anxiety-related drinking. Our results suggest that anxious, inhibited young adults are at risk alcohol misuse because they expect rewarding outcomes from drinking. Our study identifies reward expectancies as a malleable target for cognitive-behavioural interventions aimed at reducing anxiety-related drinking and associated risks.

Table 2.1

Descriptive Statistics and Correlations

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.MFT BIS	1.00	-.10	.00	.08	-.01	-.14	.08	.06	-.04
2.MFT BAS		1.00	-.07	.02	.09	.06	.09	.13	.04
3.AC1 (tension-reduction SC-IAT)			1.00	.28[b]	-.01	.01	-.04	-.03	.03
4.AC1 (enhancement SC-IAT)				1.00	-.05	-.02	.07	.01	.03
5.Reward Expectancies					1.00	.51[b]	.19[a]	.20[a]	.27[b]
6.Relief Expectancies						1.00	.11	.17	.23[a]
7.Weekly Alcohol Use							1.00	.63[b]	.58[b]
8.Hazardous Drinking								1.00	.77[b]
9.Alcohol-related Problems									1.00
M	0.00	0.00	0.06	0.06	3.26	2.54	5.28	5.74	8.45
SD	27.32	37.02	0.11	0.08	1.04	1.09	4.99	3.68	6.42
Skew	0.80	0.12	2.99	2.43	0.22	0.30	1.50	1.09	0.75
Kurtosis	1.76	0.30	9.63	8.74	0.36	0.68	1.72	0.73	0.10

Note. MFT=Motivational Flanker Task; AC1= implicit negative-alcohol cognition; SC-IAT=Single Category Implicit Association Test. All variables are those that were collected at baseline.

[a]$p<.05$

[b]$p<.01$.

Table 2.2

The Interactive Effects of BIS and BAS in Predicting Post-TSST Implicit Negative-Alcohol Cognition (AC1) from the tension-reduction SC-IAT

Post-TSST Implicit Negative-Alcohol Cognition AC1 from tension-reduction SC-IAT (Criterion)						
	B	*SE*	*β*	R^2	*t*	*p*
Alcohol Cue (*n* = 55)						
Covariates (other quad model parameters)						
Baseline AC1 (tension-reduction SC-IAT)	0.642	0.176	0.457		3.552	.001
Post-TSST AC1 (enhancement SC-IAT)	0.419	0.179	0.299		2.336	.024
Post-TSST AC2 (tension-reduction SC-IAT)	0.330	0.265	0.158		1.245	.220
Post-TSST OB (tension-reduction SC-IAT)	-0.007	0.029	-0.029		-0.226	.822
Post-TSST G (tension-reduction SC-IAT)	0.060	0.061	0.124		0.983	.331
Post-TSST D (tension-reduction SC-IAT)	-0.116	0.114	-0.131		-1.016	.315
Predictors of Interest						
MFT BIS	-0.001	0.000	-0.360		-2.653	.011
MFT BAS	0.000	0.001	-0.075		-0.566	.575
MFT BIS x BAS	<-0.001	0.000	0.364		2.570	.014
				.392[.26-.56][a]		
Water Cue (*n* = 55)						
Covariates (other quad model parameters)						
Baseline AC1 (tension-reduction SC-IAT)	0.184	0.053	0.446		3.468	.001
Post-TSST AC1 (enhancement SC-IAT)	0.058	0.114	0.069		0.508	.614
Post-TSST AC2 (tension-reduction SC-IAT)	0.202	0.177	0.169		1.141	.260
Post-TSST OB (tension-reduction SC-IAT)	-0.025	0.020	-0.174		-1.275	.209
Post-TSST G (tension-reduction SC-IAT)	0.062	0.037	0.213		1.662	.104
Post-TSST D (tension-reduction SC-IAT)	-0.077	0.080	-0.137		-0.965	.340
Predictors of Interest						
MFT BIS	0.001	0.000	0.153		1.140	.260
MFT BAS	< 0.001	0.000	0.002		0.013	.990
MFT BIS x BAS	< -0.001	0.000	-0.020		-0.155	.877
				.333[.17-.50][a]		

Note. SC-IAT=Single Category Implicit Association Test; AC1= implicit negative-alcohol cognition; AC2=activation of general positive/tension reduction category; OB=overcoming bias; G=guessing; D=detection; MFT=Motivational Flanker Task; BIS=behavioural inhibition system; BAS=behavioural approach system.

[a]95% confidence interval.

Table 2.3

The Interactive Effects of BIS and BAS in Predicting Post-TSST Implicit Negative-Alcohol Cognition (AC1) from the enhancement SC-IAT

Post-TSST Implicit Negative-Alcohol Cognition AC1 from enhancement SC-IAT (Criterion)						
	B	*SE*	*β*	R^2	*t*	*p*
Alcohol Cue (*n* = 55)						
Covariates (other quad model parameters)						
Baseline AC1 (enhancement SC-IAT)	0.298	0.178	0.286		1.676	0.101
Post-TSST AC1 (tension reduction SC-IAT)	0.075	0.125	0.105		0.599	0.552
Post-TSST AC2 (enhancement SC-IAT)	-0.094	0.246	-0.053		-0.382	0.704
Post-TSST OB (enhancement SC-IAT)	-0.015	0.032	-0.079		-0.454	0.652
Post-TSST G (enhancement SC-IAT)	0.047	0.060	0.126		0.788	0.435
Post-TSST D (enhancement SC-IAT)	-0.041	0.100	-0.087		-0.409	0.685
Predictors of Interest						
MFT BIS	< 0.001	0.000	0.178		1.225	0.227
MFT BAS	0.001	0.000	0.335		2.312	0.026
MFT BIS x BAS	< -0.001	0.000	-0.118		-0.754	0.455
				.243[.12-.37][a]		
Water Cue (*n* = 55)						
Covariates (other quad model parameters)						
Baseline AC1 (enhancement SC-IAT)	-0.048	0.135	-0.057		-0.358	0.722
Post-TSST AC1 (tension reduction SC-IAT)	0.039	0.187	0.032		0.206	0.838
Post-TSST AC2 (enhancement SC-IAT)	0.117	0.247	0.071		0.474	0.638
Post-TSST OB (enhancement SC-IAT)	0.012	0.025	0.073		0.471	0.640
Post-TSST G (enhancement SC-IAT)	0.041	0.048	0.128		0.868	0.390
Post-TSST D (enhancement SC-IAT)	-0.154	0.078	-0.309		-1.985	0.053
Predictors of Interest						
MFT BIS	0.000	0.000	-0.202		-1.228	0.226
MFT BAS	0.000	0.000	0.155		1.026	0.310
MFT BIS x BAS	< 0.001	0.000	0.095		0.630	0.532
				.132[.02-.24][a]		

Note. SC-IAT=Single Category Implicit Association Test; AC1= implicit negative-alcohol cognition; AC2=activation of general positive/enhancement category; OB=overcoming bias; G=guessing; D=detection; MFT=Motivational Flanker Task; BIS=behavioural inhibition system; BAS=behavioural approach system.

[a]95% confidence interval.

Table 2.4

The Interactive Effects of BIS and BAS in Predicting Post-TSST Relief Expectancies

Post-TSST Relief Expectancies (criterion)						
	B	*SE*	*β*	R^2	*t*	*p*
Alcohol Cue (*n* = 55)						
Covariates						
Baseline Relief Expectancies	0.403	0.132	0.326		3.058	.004
Post-TSST Reward Expectancies	0.898	0.158	0.622		5.671	.000
Predictors of Interest						
MFT BIS	-0.005	0.005	-0.099		-1.105	.275
MFT BAS	0.002	0.003	0.040		0.472	.639
MFT BIS x BAS	0.001	0.001	-0.135		-1.429	.160
				.694[.57-.81][a]		
Water Cue (*n* = 55)						
Covariates						
Baseline Relief Expectancies	0.621	0.135	0.409		4.614	.000
Post-TSST Reward Expectancies	0.843	0.129	0.573		6.542	.000
Predictors of Interest						
MFT BIS	0.003	0.005	0.048		0.595	.555
MFT BAS	0.001	0.003	0.011		0.134	.894
MFT BIS x BAS	0.001	0.000	0.054		0.655	.516
				.690[.57-.81][a]		

Note. MFT=Motivational Flanker Task; BIS=behavioural inhibition system; BAS=behavioural approach system. [a]95% confidence interval.

Table 2.5

The Interactive Effects of BIS and BAS in Predicting Post-TSST Reward Expectancies

Post-TSST Reward Expectancies (criterion)						
	B	*SE*	*β*	R^2	*t*	*p*
Alcohol Cue (*n* = 55)						
Covariates						
Baseline Reward Expectancies	0.261	0.080	0.297		3.253	.002
Post-TSST Relief Expectancies	0.400	0.063	0.577		6.339	.000
Predictors of Interest						
MFT BIS	0.005	0.003	0.135		1.679	.100
MFT BAS	0.002	0.002	0.057		0.727	.471
MFT BIS x BAS	0.001	0.001	0.166		1.959	.056
				.734[.62-.84][a]		
Water Cue (*n* = 55)						
Covariates						
Baseline Relief Expectancies	0.274	0.101	0.257		2.719	.009
Post-TSST Reward Expectancies	0.446	0.065	0.657		6.893	.000
Predictors of Interest						
MFT BIS	-0.002	0.003	-0.040		-0.441	.661
MFT BAS	0.001	0.002	0.040		0.429	.670
MFT BIS x BAS	<-0.001	0.001	-0.059		-0.635	.528
				.611[.47-.75][a]		

Note. MFT=Motivational Flanker Task; BIS=behavioural inhibition system; BAS=behavioural approach system.

[a]95% confidence interval.

Figure Captions

Figure 2.1. This diagram represents the experimental sequence.

Figure 2.2. Simple slopes for the Behavioral Inhibition System predicting post-TSST implicit negative-alcohol cognition AC1 at high (+1SD) and low (-1SD) levels of the Behavioral Approach System for the alcohol-cue condition (n = 55).

Figure 2.3. Simple slopes for the Behavioral Inhibition System predicting post-TSST reward expectancies at high (+1SD) and low (-1SD) levels of the Behavioral Approach System in the alcohol-cue condition (n = 55).

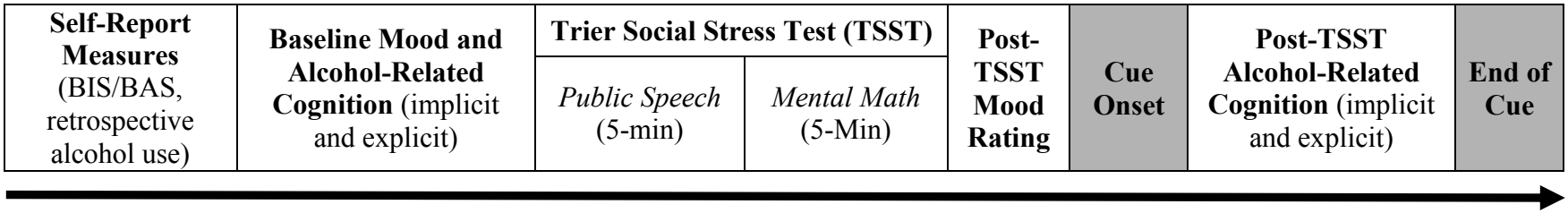

Figure 2.1. The Experimental Sequence.

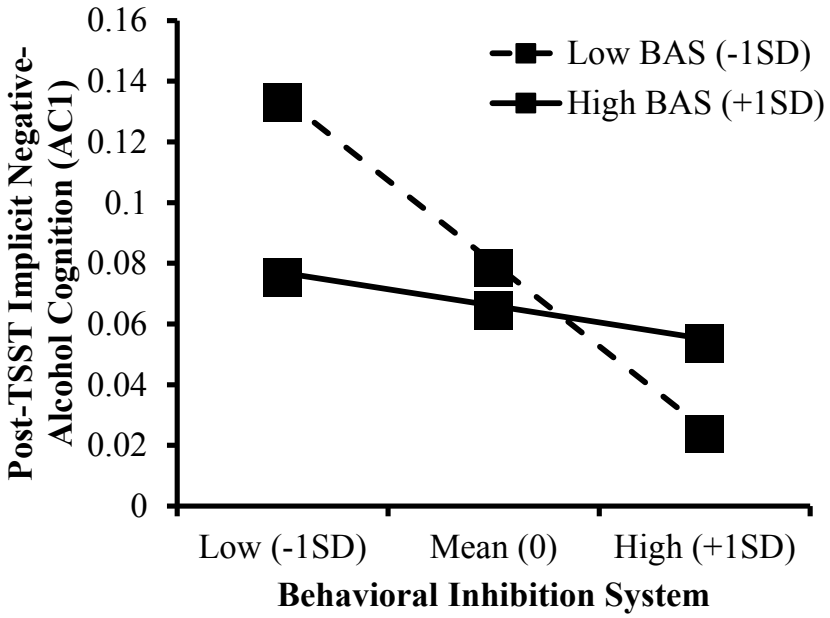

Figure 2.2. Simple Slopes for the BIS Predicting Post-TSST Implicit Negative-alcohol Cognition (AC1) at High and Low Levels of the BAS.

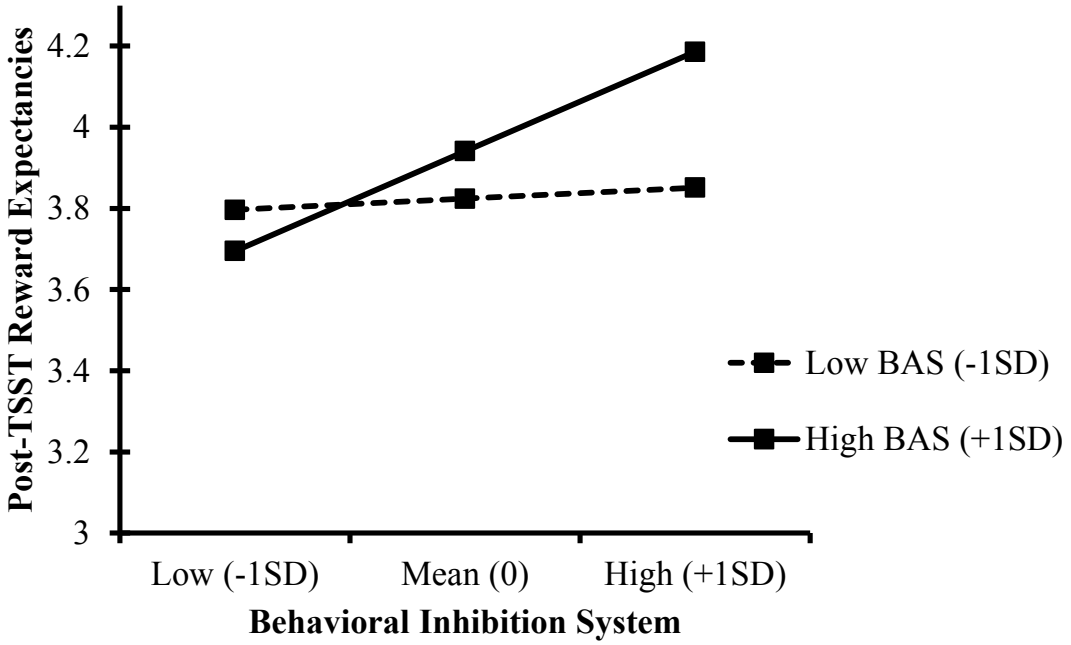

Figure 2.3. Simple Slopes for the BIS Predicting Post-TSST Reward Expectancies at High and Low Levels of the BAS.

CHAPTER 3
TRANSITION TO STUDY 2

The main purpose of study 1 was to use an experimental manipulation to examine how the BIS and the BAS jointly influence alcohol-related cognition among young adults. Based on theory, it was posited that those high in both the BIS and the BAS would readily bring to mind alcohol-related cognitions (implicit and explicit) that pertain to tension reduction when experiencing heightened anxious mood. Results indicated that the joint effects of the BIS and the BAS influenced implicit and explicit cognitions differently. The main finding was that those high in the BIS and high in the BAS endorsed strong reward (rather than relief) outcome expectancies from alcohol when anxious and this positively related to risk for problem drinking outcomes. Also, explicit, but not implicit, processes correlated with alcohol misuse outcomes.

Overall, study 1 is a key first step to understanding the relevant learning processes in the BIS-pathway to drinking. Informed by the evidence suggesting that the association between anxiety and alcohol use solidifies during adulthood, an important next step is to examine the learning processes of alcohol misuse through longitudinal research. Specifically, cognitive and motivational theories indicate that the learning processes that are central to alcohol misuse are shaped over time and through experience, which can be captured directly through longitudinal perspectives. Prospective designs also have the potential to shed light on the unfolding nature of the co-occurrence of anxiety and alcohol use as individuals move through adulthood.

Evidence from a limited number of longitudinal studies indicates that anxiety is a prospective risk factor for later alcohol misuse outcomes in young adults. In one study, Kushner and colleagues (1999) examined the associations between anxiety and alcohol use disorders over a period of seven years in young adults. Results indicated that individuals with an anxiety disorder in college were 3.5 to 5 times more likely to develop a new alcohol use disorder 7 years later relative to college students without an anxiety disorder. In another study, Zimmermann and colleagues (2003) demonstrated that baseline social phobia predicted later onset (after 4 years) of regular alcohol use and hazardous drinking. Also, social phobia was positively related to the persistence of dependence symptoms over this 4-year period. Furthermore, results indicated that baseline panic disorder symptoms prospectively predicted onset of hazardous drinking and alcohol abuse and also related to persistent alcohol/drug dependence symptoms.

While this evidence suggests a temporal association between anxiety and alcohol use, we still have very much to learn about the factors that relate to unfolding alcohol misuse among anxious young adults. Young adulthood may be an important time for strengthening the anxiety-alcohol association, given that this developmental stage is characterized by naturally-occurring, stressful transitions. I speculate that the normative transition out of university may be especially crucial for anxiety-related drinking. From a revised RST perspective, those with a strong BIS should experience significant apprehension and uncertainty during this transition – given that this time is wrought with conflicting reward (e.g., finding a dream job) and punishment (e.g., being unemployed) cues. These conflicting motivational cues should increase anxiety among those high in BIS (Corr, 2008). Theory would suggest that individuals high in the BIS should be the ones at risk for continued self-medication drinking and associated problems, but only if they are also high in BAS. For anxious individuals, who are low in BIS, they should focus on the negative impacts of alcohol misuse on life functioning (e.g., hangovers may interfere with work performance) and this should lead to more rapid maturing out. The primary goal of study 2 of this dissertation was to examine how joint effects of the BIS and the BAS relate to maturing out over the course of the year after university studies.

CHAPTER 4
STUDY 2

Interactive Effects of the BIS and the BAS on Trajectories of Alcohol Misuse after University Graduation

Keough, M. T., & O'Connor, R. M. (accepted, invited paper). *Substance Abuse: Research and Treatment.*

Abstract

Most young adults mature out of alcohol misuse after leaving university. However, some continue to misuse alcohol and go on to develop an alcohol use disorder. Theory suggests that a strong behavioural inhibition system (BIS) promotes continued misuse of alcohol – particularly using alcohol for its anxiolytic effects – during this transitional period, but only if the behavioural approach system (BAS) is also elevated. Our goal was to test this hypothesis. Participants (*N*=119) completed online measures prior to and at 3-month intervals over the course of the year following graduation. As hypothesized, results showed that an elevated BIS predicted impeded maturing out, but only when the impulsivity facet of BAS was also elevated. In contrast, a strong BIS predicted rapid maturing out if BAS impulsivity was weak. Clinical interventions that target anxiety-related drinking could mitigate continued alcohol misuse risk in young adults leaving university.

Introduction

Alcohol use varies developmentally – increasing in late adolescence, peaking in the early 20s and declining sharply thereafter (Baer & Carney, 1993; Dawson, Grant, Stinson, & Chou, 2004; Johnston, O'Malley, & Bachman, 1998). Alcohol use among young adults is twice that of adults and many experience problems related to heavy drinking (e.g., blackouts, sexual victimization) (Johnston, O'Malley, Bachman, & Schulenberg, 2007). While most individuals mature out of alcohol misuse (defined as reductions in both alcohol use and related problems) post-university with no lasting problems (Littlefield, Sher, & Wood, 2010), some young adults continue to drink heavily and go on to develop an alcohol use disorder (AUD) (Arnett, 2005; Zimmermann et al., 2003). Indeed, reports suggest that approximately 6.8% of Canadian adults meet criteria for an AUD each year (WHO, 2014). Accordingly, more theory-guided research is needed to identify and understand the key predictors of continued alcohol misuse risk during the transition out of university. Such work has the potential to inform clinical intervention efforts to reduce the development of AUDs in adulthood.

An estimated 82% of Canadian young adults attend college/university (Shaienks, Gluszynski, & Bayard, 2008). The typical process is to move through undergraduate studies, in about 3-5 years, and then transition out (O'Malley, 2005). When young adults graduate from university there is a normative (and expected) transition into adult roles, which include getting married, starting a family, and finding meaningful employment (O'Malley, 2005). Research shows that transitioning into these roles is associated with maturing out of alcohol misuse (Bachman et al., 1997; Leonard & Rothbard, 1999). Research also shows that this transition comes with new and often added stress (Wendlandt & Rochlen, 2008) and that young adults who drink to cope appear less likely to mature out of heavy drinking post-university relative to those who drink for other reasons (Patrick & Schulenberg, 2011).

Anxious individuals may have particular trouble navigating the uncertain and stressful transition out of university. Evidence shows that those who struggle with anxiety drink alcohol to cope with negative emotions, putting these individuals at risk for alcohol misuse (Kushner, Abrams, & Borchardt, 2000; Kushner, Sher, & Beitman, 1990). In addition, the literature consistently demonstrates a high co-morbidity of anxiety disorders and AUDs in adulthood (Chilcoat & Menard, 2003; Kessler, Chiu, Demler, & Walters, 2005). However, earlier in the risk pathway (i.e., university studies), studies linking anxiety to alcohol misuse are mixed

(Eggleston, Woolaway-Bickel, & Schmidt, 2004; Ham & Hope, 2006; Kushner & Sher, 1993). Research shows that those with elevated anxiety are at risk for alcohol problems during the undergraduate years; however, their level of alcohol use is largely indistinguishable from peers (Kuntsche, Knibbe, Gmel, & Engels, 2005; Stewart, Loughlin, & Rhyno, 2001). This is presumably because university is associated with normative heavy drinking. When we look later in young adulthood, we speculate that the transition out of university may be central for solidifying the anxiety-alcohol misuse relation. At a time when non-anxious peers normatively mature out of alcohol use, anxious persons may establish problem alcohol use patterns during this period, as a way to cope with life change, increased uncertainty, and new stressors.

Gray's reinforcement sensitivity theory (RST; Gray, 1987) posits that the behavioural inhibition system (BIS) is central to understanding the anxiety pathway to alcohol misuse. Over a decade ago, the RST was revised (rRST) and extensive changes were made to the BIS (Gray & McNaughton, 2000). These changes are only beginning to be integrated into etiological models of alcohol misuse (Keough & O'Connor, 2014; Wardell, O'Connor, Read & Colder, 2011). The revised BIS is a motivational conflict resolution system (Corr, 2008), which is distinct from the original theory, which viewed the BIS as purely a punishment sensitivity system. The BIS inhibits behaviour in response to goal conflict (e.g., reward-punishment conflict) and engages a risk assessment (Corr, 2002), which results in anxiety, attention to threat, and typically behavioural avoidance (Smillie, Pickering, & Jackson, 2006). To date, the evidence linking BIS to alcohol misuse is mixed (Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008; O'Connor & Colder, 2005). This is not surprising because the rRST predicts that the BIS-alcohol misuse relation is complex. On the one hand, BIS-anxiety may promote coping-related drinking, while on the other hand, conflicting reward (e.g., tension-reduction) and punishment (e.g., sickness) drinking cues should activate the BIS, leading to behavioural ambivalence about drinking and increased attention to alcohol's negative outcomes. Therefore, a strong BIS may reduce the likelihood of heavy use.

The rRST suggests that the Behavioural Approach System (BAS) may moderate the effect of BIS on alcohol misuse (Corr, 2002). The rRST posits that the BAS controls approach behavior to both conditioned – as in Gray's original theory (Gray, 1987) – and unconditioned reward cues. The BAS is multifaceted and is associated with biased attention to reward, goal persistence, impulsiveness, and approach behaviour (Colder & O'Connor, 2002; Corr, 2008;

Smillie et al., 2006). Accordingly, a concurrently strong BAS should enhance the negatively reinforcing effects of alcohol use and this should be salient to persons high in BIS, resulting in alcohol approach to relieve anxiety. Our published work supports this prediction (Keough & O'Connor, 2014) and we more recently showed that these individuals might be at risk for alcohol misuse because they expect rewarding outcomes from drinking (Keough, O'Connor, & Colder, under review). In contrast, BIS may reduce risk for alcohol misuse if BAS is low. Without a strong BAS drawing attention to the anxiolytic effects of alcohol use, those with a strong BIS may hyper-focus on alcohol's negative outcomes and thus should not drink heavily.

With the exception of one study (Wardell et al., 2011), most studies testing the BIS by BAS interaction are cross-sectional (Hundt et al., 2008; Keough & O'Connor, 2014; Kimbrel, Nelson-Gray, & Mitchell, 2007). Those high in BIS should experience marked anxiety during the transition out of university since it is wrought with signals of reward (e.g., getting dream job) and punishment (e.g., remaining unemployed). This high anxiety may put them at continued risk for alcohol misuse, but only if they have a concurrent strong BAS. That is, those with both a strong BIS and BAS should not be maturing out as normatively as others. In contrast, those high in BIS, but low in BAS, should focus on alcohol's negative impact on functioning during this transition (e.g., missed work due to hangover, interpersonal dysfunction). Thus, an elevated BIS may be associated with more rapid maturing out if BAS is low.

Our goal was to examine the trajectories of anxiety-related drinking as young adults make the meaningful transition out of university. While the extant literature has looked extensively at factors that predict normative maturing out (Littlefield et al., 2010; O'Malley, 2005), less attention has been given to factors that are central to continued alcohol misuse. We aimed to begin filling this gap in the literature. We used a repeated measures longitudinal online study, where we followed young adults over the course of the year following graduation. Based on theory (Corr, 2002) and evidence (Keough & O'Connor, 2014; Wardell et al., 2011), we expected that having an elevated BIS would be associated with increased prospective risk (i.e., impeded maturing out) for alcohol misuse during the transition out of university, but only when BAS was also elevated. On the flip side, we expected that having an elevated BIS would be associated with more rapid maturing out when BAS was low. Some extant literature has examined the unique effects of four facets of the BAS (e.g., impulsivity, goal-drive persistence, reward interest, and reward reactivity) on alcohol misuse (Corr & Cooper, 2015; Franken, 2002;

Keough & O'Connor, 2014). Accordingly, these facets of BAS were considered as potential moderators in the current study.

Method

Participants and Procedure

A sample of 121 undergraduates was recruited from English-speaking universities in Montreal. Two participants were excluded as they were outliers on age (>3*SD* above mean), resulting in a final initial sample of N=119 (M_{age}=23.18, SD_{age}=2.17; 71% women). All interested students completed a brief online screening to confirm eligibility before participating. To participate, students had to (a) be in their graduating year of undergraduate studies; (b) not have taken more than 1-term (i.e., four consecutive months) off from school (excluding summer and including the transition from CEGEP to university) c) be a full-time student d) be fluent in English; and e) have no history of alcohol abuse (i.e., $\geq$35 drinks per week). Participants completed 1-hour online assessments at baseline just before graduation and at 3-month intervals post-graduation for a total of five measurements spanning 1 year. Of the initial sample, 61% of students were Caucasian and minority ethnicities represented were East Asian, South-East Asian, Pacific Islander (9%); Middle Eastern, North African, Central Asian (9%); Hispanic (6%); Black (4%); South Asian (3%); Aboriginal (1%); and 7% reported "other." Participants received $15 per survey with a potential $25 bonus for completing all time points. The Ethics Review Board at Concordia University approved all study procedures.

Of the initial sample, 85% completed the 3-month assessment (n=101); 74% completed the 6-month assessment (n=88); 70% completed the 9-month assessment (n=82); 62% completed the final 1-year assessment (n=74). Of those who completed all time points (n=66), employment status at 1-year was as follows: 52% full-time; 32% part-time; and 16% unemployed. Also, at 1-year follow-up, 71% of participants were not enrolled in any post-secondary education; 23% were in a graduate program; and a small minority (6%) returned to complete part-time undergraduate studies.

Measures

The Reinforcement Sensitivity Theory of Personality Questionnaire (RST–PQ; Corr & Cooper, 2015). The RST-PQ includes 79 items and measures the rRST systems. The item content of the RST-PQ was derived from novel items developed by Corr and Cooper (2015) and from existing measures of the original RST (e.g., Carver and White's [1994] BIS/BAS Scales).

The RST-PQ was given at baseline. Of interest in the current study was the single BIS subscale (23-items; e.g., “The thought of mistakes in my work worries me”) and the four BAS subscales, which include: BAS-reward interest (7-items; “I regularly try new activities just to see if I enjoy them”), BAS-goal drive persistence (7-items; “I put in a big effort to accomplish important goals in my life”), BAS-reward reactivity (10-items; “I am especially sensitive to reward”) and BAS-impulsivity (8-items; “I think I should ‘stop and think’ more instead of jumping into things too quickly”). Participants indicated how accurately these items described them on a 4-point response scale ranging from 1 (*not at all*) to 4 (*highly*). Responses were summed to provide a BIS and four BAS subscale scores. High scores indicate elevated sensitivity of a given rRST system. The RST-PQ subscales used in the current study have been shown to have acceptable to excellent internal reliabilities (Cronbach’s α=.76-.92) (Corr & Cooper, 2015; Stoeber & Corr, 2015). In our sample, the range of internal reliabilities was comparable (Cronbach’s α=.71-.93).

The Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The AUDIT includes 10 items and provides an assessment of alcohol misuse, which includes measurement of alcohol use and related problems (e.g., "Have you or someone else been injured as a result of your drinking?"). The AUDIT was administered at all five time points and was used as the primary measure to assess maturing out of alcohol misuse. Participants responded to items on response scales, with the first 8-items ranging from 0 (*Never*) to 4 (*Four or more times a week*), while items 9 and 10 range from 0 (*No*) to 2 (*Yes, during the last year*). Total sum scores were used. The AUDIT has been shown to have adequate internal consistency (α=.72-.76) and very good test-retest reliability (r=.84) (Neumann et al., 2012). The internal consistency of the AUDIT total scores was adequate (α=.76).

Data Analytic Overview

Following data screening and preliminary analyses (missing data analysis, descriptive statistics, bivariate correlations), latent growth curve modeling (LGM) was used to test hypotheses. Preacher and colleagues’ guidelines (Preacher, Witchman, MacCallum, & Briggs, 2008) for LGM were followed. Before examining any models, the mean trajectory of alcohol misuse over the five assessment points was plotted to better understand the nature of change (i.e., linear, quadratic) and to guide model specification. Next, model testing proceeded in two stages. First, the unconditional growth model (i.e., model without covariates) was tested, which involves testing the intercept-only model followed by examining the model with growth. Second,

provided there was good fit to the data of the unconditional model, the conditional model was tested. This involved specifying baseline (Time 1) BIS, BAS, and the BISxBAS interaction term as predictors of intercept and slope values of alcohol misuse and then examining model fit. A total of four conditional models were run, each testing a different domain of the BAS as a moderator of the effect of BIS on alcohol misuse during the transition out of university.

Model fit was considered good if the χ^2 was not statistically significant, the Comparative Fit Index (CFI; Bentler, 1990) was above .95, the Root Mean Square Error of Approximation (RMSEA) was equal to or below .05, and the Standardized Root Mean Square Residual (SRMR) was below .08 (Hu & Bentler, 1999; Kline, 2010; Weston & Gore, 2006). For supported moderation effects, we used the guidelines outlined by Aiken and West (1991) and by Preacher, Curran, & Bauer (2006) to examine simple slopes within the LGM framework. Predictor variables (BIS, BAS) were centered to reduce multicollinearity and to facilitate interpretation. The simple slopes of BIS predicting intercept and slope values of alcohol misuse were conditioned at high (+1SD above the mean) and low (-1SD below the mean) values of BAS.

Results

Missing Data Analysis

Missing data analysis indicated that those with complete data (n=66) did not differ significantly at baseline from those with incomplete (n=53) data in terms of alcohol misuse ($t_{(117)}$=1.63, p=.11), BIS strength ($t_{(117)}$=0.63, p=.53), BAS impulsivity ($t_{(117)}$=1.04, p=.30), BAS goal-drive persistence ($t_{(117)}$=-1.53, p=.13), BAS reward interest ($t_{(117)}$=1.55, p=.13), and BAS reward reactivity ($t_{(117)}$=0.36, p=.72). Also, missingness was uncorrelated with gender (r=.11, p=.25) and age (r=-.04, p=.63). Given the lack of differences, we assume that data are missing at random (MAR) (Graham, 2009). In addition to having incomplete data across assessments, the AUDIT scores were non-normally distributed at each time point. Accordingly, Full Information Maximum Likelihood (FIML) was used to estimate our LGM. FIML is considered the preferred method for handling missing data because it uses all available information to estimate model fit and parameters (Enders, 2001; Enders & Bandalos, 2001). In our study, this means that FIML uses all available data from the 119 participants to estimate the model parameters. Parameter estimates obtained using FIML have also been shown to be relatively unaffected by non-normal distributions (Enders, 2001). Furthermore, FIML requires data to be at least MAR and thus was appropriate for the current study.

Descriptive Statistics and Bivariate Correlations

Descriptive statistics and correlations are presented in Table 1. Of particular note, BIS was uncorrelated with alcohol misuse at any of the five assessments, whereas, BAS impulsivity was positively correlated with alcohol misuse at baseline, 3-months, 6-months, and 1-year post-university. Measures of the BIS and BAS-impulsivity were positively correlated at baseline, but the BIS was uncorrelated with other facets of the BAS. The correlations between assessments of alcohol misuse across time were statistically significant and positive.

Hypothesis Testing: **Latent Growth Curve Modeling**

Preliminary inspection of the mean alcohol misuse trajectory showed that growth was linear in a decreasing direction. The model with just the intercept provided poor fit to the data ($\chi^2_{(13)}$=33.01, *p*=.00, CFI=0.85, RMSEA=0.11, 90% CI [.07, .16], SRMR=0.10), suggesting that the intercept-only model did not accurately capture the data. Next, a linear slope factor (loadings were 0, 1, 2, 3, and 4) was added to the model and the intercept and slope were freely correlated. The addition of the linear slope significantly improved model fit ($\Delta\chi^2_{(3)}$=18.64, p<.001). The model provided excellent fit to the data ($\chi^2_{(10)}$=13.71, *p*=.19, CFI=0.97, RMSEA=0.05, 90% CI [.00, .12], SRMR=0.05) and; therefore, was retained as the unconditional growth model.

The mean (μ=6.59, *p* = .00) and the variance (Ψ=15.65) of the intercept factor were statistically significant, indicating that individuals reported an average starting point of growth that was different from zero, and that there was variability around this average. The significant mean of the slope factor (μ=-0.46, *p*=.00) suggests that, on average, individuals were decreasing alcohol use post-university. The variance of the slope (Ψ=0.15, *p*=.55) factor was not statistically significant; however, as discussed elsewhere (Kline, 2010; Loehlin, 2004; Wolf, Harrington, Clark, & Miller, 2013), there may still be meaningful variability in outcome changes over time, irrespective of statistical significance. In this situation, it has been argued that predictors can still tease apart meaningful variability in the slope (Muthén & Muthén, 2012). This is presumably because there is increased power when predictors of change are added to the model. Accordingly, we tested the expected conditional growth models, where baseline BIS, BAS, and the BISxBAS interaction term were specified as predictors of baseline and change in alcohol misuse post-graduation. The correlation between the intercept and slope (*r*=-.62, *p*=.02) indicated that persons who started out with high levels of alcohol use decreased drinking over time.

In the first conditional growth model, BAS impulsivity was tested as a moderator of the effect of BIS on intercept and slope alcohol misuse. This model fit the data well ($\chi^2_{(19)}$=25.25, *p*=.15, CFI=0.97, RMSEA=0.05, 90% CI [.00, .10], SRMR=0.06) (see Figure 1). BIS was not a statistically significant predictor of either the intercept or the slope factors. BAS impulsivity was a statistically significant positive predictor of intercept alcohol misuse, but not of change in alcohol misuse. As expected, the BISxBAS impulsivity interaction term was a statistically significant predictor of both intercept and slope alcohol misuse. For the intercept, simple slopes analyses revealed some (albeit non-statistically significant) support for BIS as a positive predictor of elevated baseline levels of alcohol misuse, at low (*B*=0.07 [*SE*=0.04], *t*=1.73, *p*=.08), but not high (*B*=-0.05 [*SE*=0.04], *t*=-1.48, *p*=.14) BAS impulsivity. Regarding slope, as hypothesized, simple slopes analysis (see Figure 2) revealed that elevated levels of BIS predicted impeded maturing out of alcohol misuse at high BAS impulsivity (*B*=0.03 [*SE*=0.01], *t*=1.95, *p*=.05). Also, results supported hypotheses in that BIS predicted rapid maturing out of alcohol misuse over the 1-year post-university period at low levels of BAS impulsivity (*B*=-0.02 [*SE*=0.008], *t*=-2.38, *p*=.02).

The results of the remaining three conditional LGM are reported in Table 2. All models fit the data well. First, there were no statistically significant first-order effects of BIS and of BAS goal-drive persistence on intercept or slope alcohol misuse. BAS goal-drive persistence moderated the effect of BIS on intercept (but not slope) alcohol misuse, such that BIS predicted elevated alcohol misuse prior to graduation at low (*B*=0.07 [*SE*=0.03], *t*=1.97, *p*=.05), but not at high BAS goal-drive persistence (*B*=0.01 [*SE*=0.01], *t*=1.10, *p*=.27). Second, the first-order effects of BIS and of BAS reward interest on intercept and slope alcohol misuse were not statistically significant. As expected, BAS reward interest moderated the effect of BIS on slope (but not intercept) alcohol misuse. However, follow-up simple slopes analysis did not support BIS as a predictor of the alcohol misuse slope at low (*B*=-0.01 [*SE*=0.01], *t*=-1.27, *p*=.20) or at high (*B*=0.02 [*SE*=0.02], *t*=1.14, *p*=.26) BAS reward interest. Instead, the supported BIS by BAS reward interest interaction term seemed to reflect the opposing direction of the simple slopes, and while these were not statistically significant, the direction aligns with hypotheses. Finally, no statistically significant first-order effects of BIS and of BAS reward reactivity were observed. BAS reward reactivity moderated the effect of BIS on intercept (but not slope) alcohol misuse,

such that BIS predicted elevated alcohol misuse prior to graduation at low (*B*=0.07 [*SE*=0.04], *t*=1.88, *p*=.06), but not at high BAS reward reactivity (*B*=-0.03 [*SE*=0.04], *t*=1.18, *p*=.24).

Discussion

The main objective of the present study was to examine the trajectories of alcohol misuse for BIS-related drinking as young adults transition out of university. This transition is highly stressful and uncertain and we speculated that this provides a context for those with an elevated BIS and elevated BAS to continue or even escalate alcohol misuse in an effort to cope with life changes. Consistent with previous work on maturing out (Littlefield et al., 2010; Bachman et al., 1997), we found that young adults, overall, decreased their alcohol misuse after graduating from university. Further, as expected, anxiety-prone individuals showed impeded maturing out during the 1-year post-graduation if they also had elevated BAS impulsivity. Also as predicted, those high in BIS showed rapid maturing out if they were concurrently low in BAS impulsivity. We did not find clear support for the moderating role of other facets of BAS on the effect of BIS on the trajectory of alcohol misuse over time.

Our study is the first in the literature to show that the interactive effects of BIS and BAS are useful for differentiating between those who may mature out as opposed to those who may continue to struggle with alcohol misuse. While we only looked at a short period of time, we observed that the trajectories of BIS-related drinking after university depended particularly on one's concurrent level of BAS impulsivity. Recently, it has been argued by several authors that impulsivity plays a central role in distress-related drinking (Kashdan, McKnight, Richey, & Hofmann, 2009; Keough, Hines, Winslade, & O'Connor, 2015; Keough & O'Connor, 2014; Mackinnon, Kehayes, Clark, Sherry, & Stewart, 2014; Nicholls, Staiger, Williams, Richardson, & Kambouropoulos, 2014). Inherent in this perspective is the notion that concurrently elevated impulsivity is needed to clarify why some anxiety-prone individuals – who are by nature indecisive, inhibited, and focused on threat (e.g., the negative outcomes of drinking) – approach alcohol for coping-related purposes. Our study moves this literature forward by suggesting that the stressful and uncertain transition out of university is a particularly relevant context for impulsivity and anxiety to interact to promote continued alcohol use risk. We speculate that elevated impulsivity, in anxiety-prone individuals, may bias focus on alcohol's immediately gratifying effects (e.g., anxiety relief) and thus draw attention away from the potential longer-term consequences of alcohol misuse (e.g., occupational problems) (Dick et al., 2010;

Zuckerman & Kuhlman, 2000). Conversely, anxiety-prone individuals may be more apt to over focus on drinking's negative outcomes (and its subsequent impact on functioning) if they are low on impulsivity and this may deter alcohol misuse post-university.

Our models supported three facets of BAS (i.e., impulsivity, goal-drive persistence, reward reactivity) as moderators of the BIS effect on baseline alcohol use (i.e., alcohol misuse intercept). Consistent with our previous work (Keough & O'Connor, 2014), these findings suggest that impulsivity-related and drive aspects of BAS are particularly important moderators of the effects of BIS on alcohol misuse. However, the nature of the moderating effects was unexpected, as elevated BIS was associated with increased alcohol misuse at baseline, when BAS was low. This is in contrast to what has been found with similar investigations, using cross-sectional data (Keough & O'Connor, 2014). Foremost, these findings further highlight the complexity of BIS as a risk factor for alcohol misuse. They also point to potential developmental and contextual nuances of the BIS by BAS effect on drinking, which are difficult to capture in a cross-sectional framework. We speculate that those high in BIS, and low in BAS, may not be dissuaded from alcohol use when the perceived risks are low. In our data, the baseline assessment was completed at the end of the academic year, when academic responsibilities were winding down and drinking would not have had a big negative impact. It would be an interesting direction for future research to explore what might motivate drinking by individuals with a high BIS and low BAS when anxiety may not be elevated. Taking a prospective lens, our results suggest that despite what may have promoted heavy drinking in university for those high in BIS and low in BAS, with the transition into adult roles (and arguably increased stress), these individuals showed a notable decline in their drinking.

Theory would predict that persons high in BIS and high in BAS are at continued alcohol misuse risk post-university because of cognitive mechanisms that support distress-related drinking (Kuntsche et al., 2005). While we did not examine mechanisms, our results provide direction for future work in this area. Specifically, shifts in coping drinking motives during the transition out of university may help explain our results (Littlefield et al., 2010). Drinking to cope emerges as the most prominent motivator of alcohol misuse post-university (Perkins, 1999) and coping motives are the only reasons for drinking that steadily increase from ages 22–30 (Patrick & Schulenberg, 2011). This suggests that risky coping-motivated drinking unfolds throughout the broader course of young adulthood. This may be particularly relevant for those

high in BIS and BAS, as they may strengthen coping motives in response to having difficulty navigating stressful roles of young adulthood. In turn, due to strong coping motives, they may continue to misuse alcohol when others have long-matured out. As such, future research should take a longer scope (i.e., across young adulthood, ages 20-30) and test the mediating role of coping motives in the BIS pathway. Another closely related possibility is that their drinking norms shift during the transition out of university. In particular, those high in BIS and high in BAS may come to view drinking to cope as an acceptable behaviour in adulthood (i.e., drinking to relax at the end of the day is normal, and typical for adults), whereas norms for undergraduate drinking supported social heavy use. Future work should examine shifts in coping-related drinking norms to better understand the cognitions that mediate prospective alcohol misuse risk among those high in BIS and high in BAS.

There are some limitations of our study. First, we were limited in only being able to look at drinking in the earliest stages of transition. Due to this, there are a number of important longer-term aspects of the post-university transition (e.g., getting married, starting a family) that we were unable to integrate into our models of alcohol use. This is a notable limitation because the literature shows marked changes in drinking behaviour as young adults navigate the period of time between 22-30 years old (Littlefield, Sher, & Wood, 2009). Accordingly, it would be interesting for future work to examine the trajectories of BIS-related drinking over a longer period of time (e.g., 5 years). This would provide a broader perspective on anxiety-related drinking patterns during transition and may have relevance for clarifying who is at risk for the onset of AUDs later in adulthood. Second, due to the small sample size, our study findings should be considered a preliminary step toward examining BIS-related trajectories of drinking post-university. Replication of our findings in a larger sample is warranted. Finally, we were unable to test gender-specific pathways given our preponderance of women. Research suggests that this is an important direction for future work, given gender differences for anxiety-related drinking (Keough et al., 2015) and alcohol misuse patterns post-university (Perkins, 1999).

Conclusion

Our study represents an important first step in understanding the trajectories of anxiety-related drinking post-university. We show that BIS-related drinking during the stressful transition out of university depends on impulsivity facets of the BAS. Our work has the potential to inform prevention and clinical intervention efforts. Health care providers at universities could

provide general psychoeducation (via workshops, brochures, and online resources) to students about normative maturing out and the potential costs of anxiety-related drinking. Regarding those most at-risk, clinicians should work with anxiety-prone, impulsive individuals to reduce coping reasons for drinking. This may allow them to adopt more positive coping strategies to deal with the stressful transition out of university.

Table 4.1

Descriptive Statistics and Correlations for Variables used in Latent Growth Curve Models

	1	2	3	4	5	6	7	8	9	10	Mean	SD
1. T1 BIS	1.00	.22[a]	-.04	-.14	.06	.11	.07	.12	.06	.18	55.78	13.87
2. T1 BAS impulsivity		1.00	.27[b]	.56[b]	.47[b]	.19[a]	.21[a]	.25[a]	.11	.27[b]	18.53	4.16
3. T1 BAS goal-drive persistence			1.00	.54[b]	.53[b]	-.09	-.06	-.03	-.26[b]	-.11	22.13	3.89
4. T1 BAS reward interest				1.00	.41[b]	.10	.01	.06	.00	.03	19.52	4.28
5. T1 BAS reward reactivity					1.00	.01	.05	.06	-.01	.15	29.57	4.99
6. T1 Alcohol Misuse (AUDIT)						1.00	.69[b]	.66[b]	.67[b]	.62[b]	6.84	4.71
7. T2 Alcohol Misuse (AUDIT)							1.00	.65[b]	.61[b]	.72[b]	5.53	4.57
8. T3 Alcohol Misuse (AUDIT)								1.00	.74[b]	.76[b]	5.25	4.48
9. T4 Alcohol Misuse (AUDIT)									1.00	.64[b]	4.82	4.17
10. T5 Alcohol Misuse (AUDIT)										1.00	4.46	3.70

Note. T1=baseline; T2=3-months post-university; T3=6-months post-university; T4=9-months post-university; T5=1-year post-university; BIS=Behavioral Inhibition System; BAS=Behavioral Approach System; AUDIT=Alcohol Use Disorders Identification Test.

[a] $p < .05$

[b] $p < .01$

Table 4.2

Summary of Conditional Latent Growth Curve Models

Parameter	Unstandardized Estimate (SE)	Standardized Estimate	*p*-value	Model Fit
Intercept Alcohol Misuse Factor				
BIS	0.03(0.02)	0.10	.27	
BAS goal-drive persistence	-0.09(0.10)	-0.09	.35	$\chi^2_{(19)} = 27.19$, $p = .10$, CFI=0.96, RMSEA=0.06 90% CI [.00, .11], SRMR=0.05
BIS x BAS goal-drive persistence	-0.01(0.006)	-0.17	.05	
Slope Alcohol Misuse Factor				
BIS	0.01(0.01)	0.02	.95	
BAS goal-drive persistence	-0.01(0.02)	-0.06	.81	
BIS x BAS goal-drive persistence	0.003(0.002)	0.47	.08	
Intercept Alcohol Misuse Factor				
BIS	0.03(0.03)	0.13	.32	
BAS reward interest	0.14(0.09)	0.15	.14	$\chi^2_{(19)} = 21.28$, $p = .32$, CFI=0.99, RMSEA=0.03 90% CI [.00, .09], SRMR=0.04
BIS x BAS reward interest	-0.01(0.01)	-0.14	.11	
Slope Alcohol Misuse Factor				
BIS	0.01(0.01)	0.13	.67	
BAS reward interest	-0.02(0.01)	-0.14	.40	
BIS x BAS reward interest	0.003(0.002)	0.48	.05	
Intercept Alcohol Misuse Factor				
BIS	0.02(0.03)	0.08	.43	
BAS reward reactivity	0.03(0.09)	0.04	.70	$\chi^2_{(19)} = 21.64$, $p = .31$, CFI=0.99, RMSEA=0.03 90% CI [.00, .09], SRMR=0.04
BIS x BAS reward reactivity	-0.01(0.005)	-0.21	.04	
Slope Alcohol Misuse Factor				
BIS	0.01(0.01)	0.11	.68	
BAS reward reactivity	0.02(0.02)	0.20	.33	
BIS x BAS reward reactivity	0.002(0.001)	0.38	.09	

Note. BIS=Behavioral Inhibition System; BAS=Behavioral Approach System.

Figure Captions

Figure 4.1. T1=baseline; T2=3-months post-graduation; T3=6-months post-graduation; T4=9-months post-graduation; T5=1-year post-graduation. The conditional latent growth curve model with the Behavioral Inhibition System (BIS), the impulsivity facet of the Behavioral Approach System (BAS), the BIS x BAS impulsivity interaction term predicting intercept and slope alcohol misuse. Path coefficients are presented in this order: unstandardized estimates (standard error) and standardized estimates. The path coefficients for the slope (0, 1, 2, 3, and 4) specify a linear slope at 3-month intervals for the year post-graduation.

Figure 4.2. The conditional growth trajectories of alcohol misuse over time for the interactive effects of the Behavioral Inhibition System (BIS) and the impulsivity facet of the Behavioural Approach System (BAS IMP).

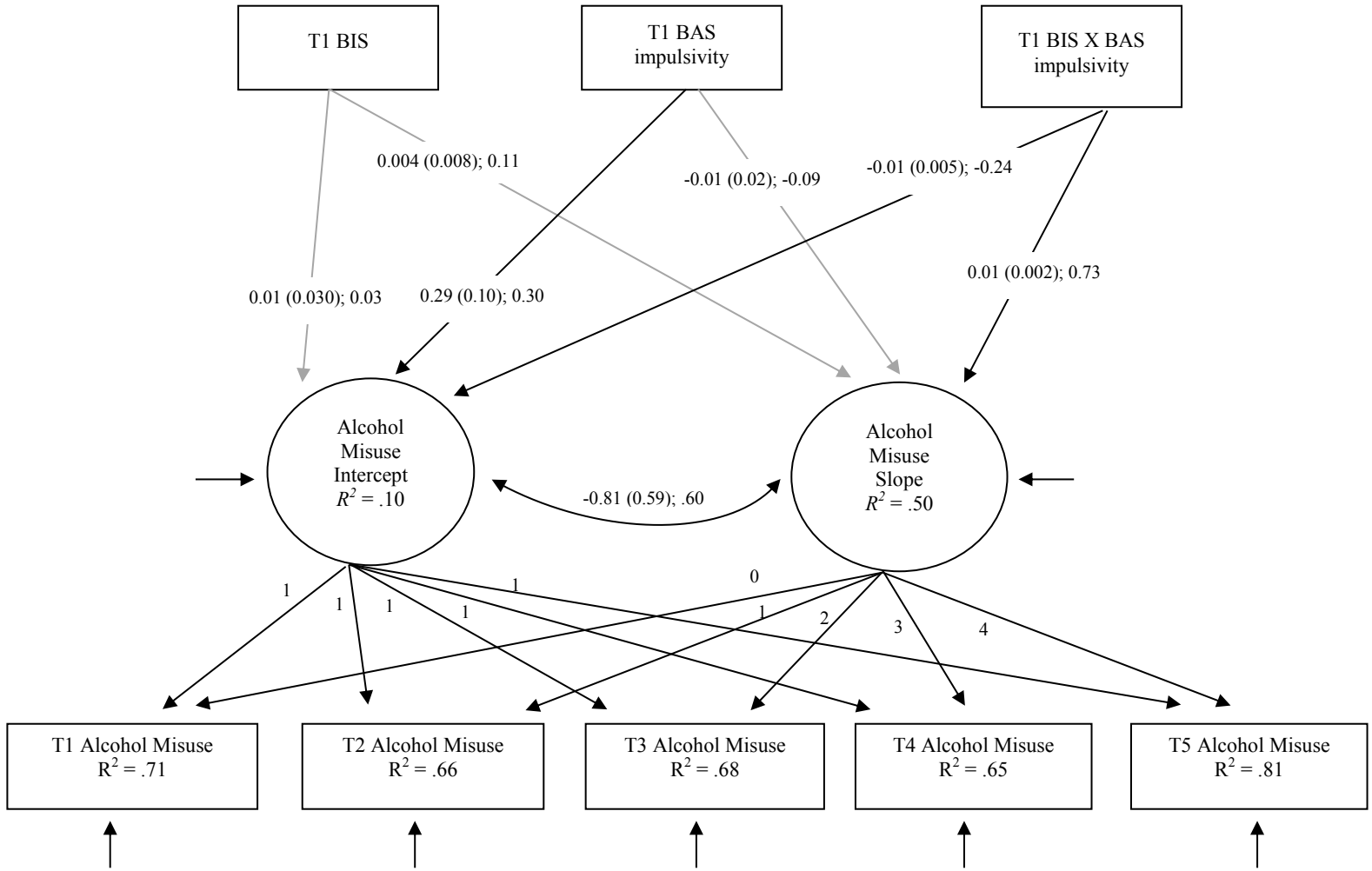

Figure 4.1. The Latent Growth Curve Model for the Interactive Effects of BIS and BAS Impulsivity on Post-University Alcohol Misuse.

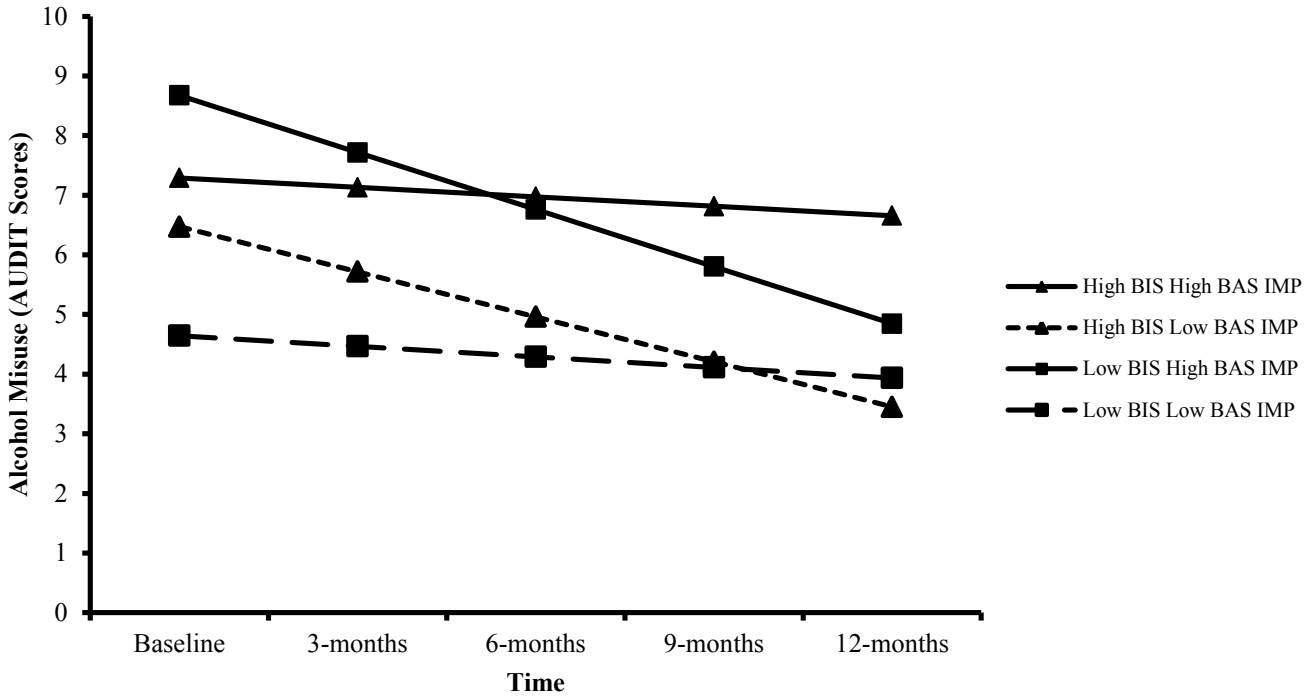

Figure 4.2. The Conditional Growth Trajectories of Alcohol Misuse Over Time for the Interactive Effects of BIS and BAS Impulsivity.

CHAPTER 5
GENERAL DISCUSSION

Summary of Findings

The purpose of this dissertation was to clarify the anxiety pathway to alcohol misuse in young adulthood. For decades, it has been theorized that the BIS plays a central role in anxiety-related drinking, given its strong links with the neurobiology of anxiety (Corr, 2008; Gray, 1972; 1987). However, data have provided inconsistent support for the link between the BIS and alcohol misuse (e.g., Hundt et al., 2008; O'Connor & Colder, 2005). Extensive revisions were made to the BIS over 15 years ago; however, these changes have been slow to enter the literature. As I have argued in previous work (Keough & O'Connor, 2014), the revised RST has important implications for clarifying BIS-related drinking. Specifically, the revised RST posits that the association between BIS and alcohol misuse is more complex than previously thought. On the one hand, high BIS-anxiety may promote drinking for self-medication purposes; on the other hand, sensitivity to motivational conflict may make those high in the BIS indecisive about drinking and may draw attention to threat (i.e., alcohol's negative outcomes) (Keough & O'Connor, 2014). This may deter drinking. Thus, as a standalone predictor of alcohol misuse, it is difficult to assess whether the BIS is a low or a high risk factor. The revised RST provides a conceptual framework to clarify this complexity. The revised RST predicts that BIS-risk for alcohol misuse depends on the relative strength of the BAS (Corr, 2002). The current findings support this prediction; they advance personality models of anxiety-related drinking.

Study 1. The main objective of Study 1 was to examine how the BIS and the BAS jointly influence alcohol-related cognitions (implicit and explicit) through the use of an experimental design. A better understanding of cognitive processes – which are malleable and proximal mechanisms of alcohol misuse – has the potential to inform clinical interventions for anxiety-related drinking in young adulthood (Cooper, 1994; Goldman, 1999). Contrary to hypotheses, results showed that anxiety-prone individuals (i.e., high in the BIS) activated a weak implicit negative-alcohol cognition, but only if they also had low levels of the BAS (not at high levels of BAS as theory would predict). Unexpectedly, anxiety-prone individuals brought to mind expectations of reward (but not of relief) in response to an alcohol cue when they were feeling anxious. That is, those high in the BIS expected elevations in positive mood (rather than reductions in negative mood) when exposed to an alcohol cue when anxious. While this result

was not hypothesized, it aligns with theoretical models of craving (Marlatt, 1985; Tiffany & Conklin, 2000) and also with the Acquired Preparedness Model (Anderson et al., 2003; McCarthy et al., 2001). Moreover, it was found that explicit reward and relief expectancies (but not implicit cognition) positively correlated with retrospective alcohol use, hazardous drinking, and alcohol-related problems. As a whole, the findings of Study 1 indicated that reward expectancies might be a key mechanism of alcohol misuse among those high in both the BIS and the BAS.

Results of Study 1 are consistent with some work on anxiety and drinking motives. While some extant work links anxiety to negative reinforcement motives for drinking (e.g., Stewart et al., 2001), other work demonstrates that anxiety is often associated with positive reinforcement motives for drinking (Buckner, Eggleston, & Schmidt, 2006; Lewis et al., 2008). Also, the null implicit cognition-alcohol misuse association is inconsistent with some work (e.g., Ostafin & Palfai, 2006). However, there is high variability in the associations between implicit processes and alcohol use across studies (see Reich et al., 2010 and Rooke, Hine, & Thorsteinsson for meta-analyses), suggesting that the effect of implicit cognition on drinking depends on other factors, like inhibitory control and working memory (Wiers et al., 2007).

Study 2. The purpose of Study 2 was to examine trajectories of anxiety-related alcohol use during a stressful, but critical transition period in young adulthood – graduating from university. Specifically, based on the revised RST, the interactive effects of the BIS and the BAS were examined to distinguish between young adults who continued to misuse alcohol after leaving university versus those who normatively reduced alcohol use. Consistent with the extant literature on maturing out, it was found that young adults reduced alcohol misuse during the one-year following university studies (O'Malley, 2005; Littlefield et al., 2009). The main finding was that the impulsivity facet of the BAS moderated the prospective association between the BIS and changes in alcohol misuse post-university. As hypothesized, it was found that anxiety-prone individuals showed impeded maturing out if they were also strong in BAS impulsivity. Conversely, also as expected, young adults with a strong BIS rapidly reduced alcohol misuse if they were concurrently low in BAS impulsivity. No clear support was found for the moderating role of other facets of BAS on BIS-related trajectories of alcohol misuse post-university. Although this study had some notable limitations (e.g., attrition), results provide initial support

that the BIS and the BAS, as individual difference factors, are important for predicting trajectories of young adults drinking post-university.

The results of Study 2 are consistent with prospective research on anxiety-related drinking in young adulthood. In particular, published studies identify anxiety as prospective predictor of alcohol misuse among young adults (Kushner et al., 1999; Zimmermann et al., 2003). The findings of Study 2 fit with this literature. Moreover, these findings are also consistent with emerging research showing that reductions in neuroticism and in impulsivity are important predictors of maturing out of alcohol misuse throughout young adulthood (Littlefield et al., 2009; Littlefield et al., 2010).

Theoretical Contributions

The current work makes several novel theoretical contributions. First, the presented studies are among the first in the literature to provide strong tests of the revised BIS as a risk factor for alcohol misuse. One fundamental issue in most existing work is the continued use of measures that assess the BIS as a punishment sensitivity system (e.g., Sensitivity to Punishment and Sensitivity to Reward Questionnaire [Torrubia et al., 2001]). In contrast, the revised RST identifies the BIS as a motivational conflict system. This has key implications for our understanding of the anxiety-related alcohol misuse. Hence, the primary strength of the current work is that individual differences in the BIS were assessed using newly developed methods that capture motivational conflict sensitivity (Corr & Cooper, 2015; Keough & O'Connor, 2014). By using these theoretically-improved measures of the BIS, the present work was able to test the central prediction that the BAS moderates the effect of the BIS on drinking. There have been relatively few tests of this hypothesis in the literature (i.e., Keough & O'Connor, 2014; Wardell et al., 2011) and this may be attributed to both the BIS-related measurement issue noted above, but also to the continued out-dated notion that BIS and BAS exert orthogonal effects on behaviour (as in Gray's [1972] original model). The results of the current research show that the BIS and the BAS interact to promote drinking among young adults. The moderating role of the BAS in the BIS-pathway provides some clarity on this highly mixed literature.

Second, the present work advances our knowledge of the relevant cognitive mechanisms of the BIS-pathway to alcohol misuse. Motivational and cognitive models posit that cognitions – which are shaped through experience – serve as proximal predictors drinking behaviour (Goldman, 1999; Wiers et al., 2007). In the current work, it was posited that the BAS would be

particularly relevant for shaping cognitive mechanisms or alcohol-related learning processes among anxious individuals. This is because an elevated BIS (independently) may lead to the formation of either positive or negative associations with alcohol. Accordingly, the joint subsystems hypothesis (Corr, 2008; 2002) and the Acquired Preparedness Model (Anderson et al., 2003; McCarthy et al., 2001) indicate that traits related to disinhibition, like the BAS, bias attention to the rewarding aspects of alcohol use and away from its negative effects. Through repeated drinking experience, this is believed to result in the formation of positive alcohol associations. While a strong BAS has been linked with positive alcohol associations (e.g., Wardell, Read, Colder, & Merrill, 2012), very little work has been done to understand how an elevated BAS affects drinking among anxious individuals. This is surprising, given the proposed role of the BAS in anxiety-related drinking according to the revised RST. There is also data implicating the BAS in negative reinforcement urges to drink (e.g., Franken, 2002). Based on the revised RST (Corr, 2002), the current results suggest that the BAS shapes reward expectancies among anxious persons, which may subsequently increase their risk for alcohol misuse.

Finally, results from Study 2 further our understanding of the role of personality in maturing out of alcohol misuse among young adults. Developmental perspectives suggest that young adults reduce alcohol misuse after university (Arnett, 2005; O'Malley, 2005) because they come to believe that alcohol misuse is incompatible with new adult roles (e.g., starting a family) (Gotham, Sher, & Wood, 2003; Yamaguchi & Kandel, 1985). One (perhaps unintended) issue with the concept of maturing out is an assumption that it applies to all young adults. However, mainstream and research reports clearly demonstrate that an appreciable minority of young adults continue to misuse alcohol after leaving university – habits that presage the development of alcohol use disorders in later adulthood (Adlaf et al., 2005; WHO, 2014). There has been very little work examining the predictors of continued alcohol misuse risk post-university. The current work is a first step in filling this gap in the literature. In particular, results identify the BIS and the BAS as individual differences that predict alcohol misuse risk as young adults transition out of university. This pivotal, but stressful transition may provide a developmental context for anxiety and impulsivity to interact to solidify alcohol misuse habits.

Future Directions

There are several future directions that emerge from the results of the current studies. It would be interesting to extend the predictions of the revised RST to examine anxiety-related risk

for other types of addictive behaviours. Theoretical models of addiction identify anxiety as a risk factor for addictive behaviour in general (e.g., cannabis use [Agosti, Nunes, & Levin, 2002; Bonn-miller, Zvolensky, Bernstein, & Stickle, 2008], problem gambling [Blaszczynski & Nower, 2001; Stewart & Zack, 2008], and nicotine dependence [Breslau, Kilbey, & Andreski, 1991]). Similar to alcohol misuse, drug use and behavioural addictions are associated with conflicting motivational outcomes. For example, problem gambling is associated with potential reward (e.g., reductions in anxiety) and punishment (e.g., loss of money). An anxiety-prone person (i.e., high in the BIS) may engage in problem gambling to cope with negative affect, but at the same time, they may also avoid gambling due to potential negative outcomes (Smillie et al., 2006). The revised RST predicts that a concurrently elevated BAS should bring those high in the BIS towards addictive behaviours (in general) for coping-related purposes (Corr, 2002). Testing the further utility of the revised RST would help improve etiological models of personality-risk for addictive behaviour.

A second future direction is to incorporate the Fight/Flight/Freeze system (FFFS) into models of alcohol misuse in young adults. In contrast to the original RST (Gray, 1972), the revised theory predicts that motivational systems interact meaningful to influence behaviour (Corr, 2002; Gray & McNaughton, 2000; Smillie et al., 2006). The present work has focused mainly on understanding how the BAS moderated the cross-sectional and prospective associations between BIS and alcohol misuse in young adult undergraduates. However, it would be useful for future research to extend the joint subsystems hypothesis (Corr, 2002) to examine how the FFFS may moderate the BIS-alcohol misuse association. Consistent with theory (Gray & McNaughton, 2000), a strong FFFS should draw even more attention to the potentially punishing outcomes of alcohol use. Therefore, a concurrently strong FFFS may help to resolve BIS-conflict in favour of alcohol avoidance by increasing the salience of negative outcomes. While we provided an initial test of this interaction in prior work (Keough & O'Connor, 2014), results were limited by the use of a weak self-report composite of FFFS strength. Now that a better measure of the FFFS exists (Corr & Cooper, 2015), we intend to examine the interactive effects of the BIS and the FFFS in future work on alcohol misuse.

Third, it may be important for future work to examine personality-risk pathways for anxiety-related drinking over a longer period of time in young adulthood. Studies of this kind would allow us to better understand personality factors relate to the onset of alcohol use

disorders in adulthood. Study 2 explored how the interactive effects of the BIS and the BAS predicted alcohol misuse during the initial stages of the transition into adulthood. Due to this, there are important longer-term aspects of the post-university transition that were not integrated into models of alcohol use. Most notably, we were unable to control for role transitions (e.g., starting a family, getting married, finding meaningful employment) explicitly in our model. Consistent with previous work (e.g., O'Malley, 2005; Littlefield et al., 2009; Littlefield et al., 2010), it is important to control for these role transitions (which are known predictors of maturing out) in order to draw firm conclusions about the unique effects of personality factors on young adult trajectories of alcohol misuse after university.

On a related note, while traditional personality theory posits that traits (like the BIS and the BAS) are relatively stable over time (Caspi, Roberts, & Shiner, 2005), emerging work suggests that personality factors may change during the formative years of young adulthood and that this may have implications for alcohol misuse risk (Littlefield et al., 2009). For example, it has been shown that reductions in neuroticism and impulsivity from ages 18 – 35 predicted reductions in alcohol use during this same period (Littlefield et al., 2009). Moreover, follow up studies indicate that changes in coping motives for drinking mediate the effects of personality change on alcohol misuse throughout young adulthood (Littlefield et al., 2010). Extrapolating this to the current work, it is possible that individuals may experience shifts in the sensitivity of the BIS and the BAS as they navigate the new and stressful experiences of adulthood. Given that we were looking at only a short period of time, we did not observe changes in the BIS or the BAS as individuals transitioned out of university. However, over a longer period in young adulthood, it is possible that upward shifts in BIS and BAS sensitivity may relate to risk for the development of AUDs later in life. The potential role of personality change during young adulthood may further inform our understanding of how BIS and BAS relate to maturing out.

Fourth, future work should continue to explore the mechanisms underlying risk for young adult drinking. Specifically, future work should expand on a key limitation of Study 1, which was the temporal disconnect between in-lab alcohol-related cognitions and retrospective drinking outcomes. Future work should incorporate in-lab drinking following an anxious mood induction procedure. This may be particularly useful for clarifying the link between implicit alcohol cognition and alcohol use. We observed that implicit alcohol cognition was uncorrelated with retrospective reports of alcohol misuse. This is problematic because theory predicts that implicit

processes are most central to *in-the-moment* decisions to drink when anxious (Goldman, 1999; Strack & Deutsch, 2004). In future work, the use of an anxious mood manipulation followed by an in-lab drinking procedure would provide a stronger test of the role of implicit cognition in BIS-related drinking. Given the tighter temporal coupling of anxiety and drinking, it would also permit a direct test of mediation from personality to alcohol use via cognition.

Moreover, one other future direction that may clarify the findings of Study 1 would be to examine if other factors moderate the association between implicit cognition and alcohol misuse. As noted earlier, contemporary dual-process models (Bickel et al., 2015; Wiers et al., 2007) posit that the effects of implicit cognitive processes depend on more explicit processes. To illustrate, emerging research illustrates that strong implicit alcohol cognition positively predicts alcohol use only when executive function (e.g., Wiers et al., 2007) and self-regulation abilities (e.g., O'Connor & Colder, 2016) are low. When executive control and/or self-regulation are high, explicit processes are believed to better predict alcohol use behaviour than implicit processes. It is possible that when anxious, a concurrently high BAS would be associated with increased alcohol consumption via an impulsive process among those high in BIS. In contrast, when BAS is low, self-regulatory processes (e.g., motives for drinking) would need to come into play to promote alcohol misuse among anxious individuals. Future work should test the speculations using an anxious mood manipulation followed by in-lab free drinking procedures. Thus, our understanding of implicit and explicit cognitive processes in the anxiety pathway would benefit from more sophisticated models that examine interactions between implicit and explicit processes.

Future work should also explicitly examine the mechanisms of risk underlying the effects observed in study 2. Based on previous work (Littlefield et al., 2010; Perkins, 1999), it was speculated that increases in coping motives might explain why those high in both the BIS and BAS impulsivity show impeded maturing out following university graduation. We were unable to test coping motives as mediators explicitly in our statistical models; therefore, future work should test mediation directly using longitudinal methods.

Clinical Implications

There are clinical implications of the proposed work. There is an emerging body of literature indicating that reward-related personality constructs are key contributing factors that promote alcohol misuse among anxious individuals (broadly defined). For example, it has been

shown that socially anxious undergraduates are at high risk for experiencing alcohol-related problems, but only if they were also impulsive (Keough, Badawi, Nitka, O'Connor, & Stewart, 2016; Nicholls et al., 2014). Similarly, in another study, it was observed that men (but not women) who were high in anxiety sensitivity (which is conceptually linked to the BIS in terms of attention to treat and avoidance) experienced alcohol-related problems, but only when they had an elevated tendency to act rashly under emotional distress (Keough, Hines, Winslade, & O'Connor, 2015). Collectively, studies to date (including the results of this dissertation) in the area of personality risk show that anxious, impulsive people are most at risk for self-medication drinking and associated negative consequences. This work implies that it would likely be beneficial to target elevated BAS sensitivity and impulsivity in trans-diagnostic interventions for co-morbid anxiety and alcohol use disorders. One potentially effective strategy would be to target reward expectancies among anxious, impulsive individuals via Cognitive Behavioural Therapy and perhaps cue-exposure.

Results from Study 2 also suggest that there are intervention strategies that may be useful for reducing continued misuse in young adults as they transition out of university. First, counsellors at post-secondary institutions could provide psychoeducation (e.g., via pamphlets, brochures, and workshops) about how alcohol misuse changes throughout young adulthood. Based on the present results, it may be useful to focus efforts on the educating students about the risks of anxiety-related drinking in young adulthood (and beyond). Second, one other potentially effective tool would be to use early screening methods to identify those most at risk for anxiety-related drinking and associated consequences. Ideally, this should be done early in undergraduate studies to mitigate the escalation of alcohol misuse during university and also lessen the likelihood of continued drinking once anxious, impulsive individuals graduate.

Conclusion

In sum, the presented studies clarify the risk factors and mechanisms of anxiety-related drinking in young adulthood. Using Gray's revised RST as a framework, experimental and prospective findings demonstrated that BIS-risk for alcohol misuse depended on one's concurrent level of the BAS. This is a prediction that stems directly from the revised RST, but that remains scantly tested due to the continued use of Gray's original model. Findings shed light on the cognitive mechanisms underlying BIS-related drinking and provide a first look at how the BIS and the BAS interact to set the stage for long-term alcohol problems in young adulthood.

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