2019-08-29

The Effect of Alcohol Cue Exposure on Gambling-Related Attentional Biases and Cravings among Poker Players who Drink

Ritchie, Emma Victoria

UNIVERSITY OF CALGARY

The Effect of Alcohol Cue Exposure on Gambling-Related Attentional Biases and Cravings among Poker Players who Drink

by

Emma Victoria Ritchie

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

GRADUATE PROGRAM IN PSYCHOLOGY

CALGARY, ALBERTA

AUGUST, 2019

Abstract

Alcohol is one of the most common substances used in conjunction with gambling, but the impact it has on gambling cravings and behaviours is poorly understood. The present study sought to determine whether exposure to an alcohol cue increased gambling cravings and preferential attention to gambling images in an eye-tracking task. Male poker players (n = 59) and non-gamblers (n = 59) were randomly assigned to an alcohol or neutral cue condition. All participants completed the same eye-tracking task, which featured pairs of gambling, alcohol, and neutral images. Alcohol and gambling cravings were measured before and after cue expose and after the eye-tracking task. Contrary to hypotheses, gamblers in the alcohol cue condition did not experience an increase in gambling cravings compared to gamblers in the neutral cue condition. Additionally, there were no differences in the way that gambling images were viewed by gamblers based on condition. However, participants in the alcohol cue condition preferentially attended to alcohol images more than participants in the neutral cue condition. Limitations and future directions are discussed.

Key Words: Gambling, Alcohol, Cue Reactivity, Cross-Cue Reactivity

Preface

This thesis is original, unpublished, independent work by the author, E. Ritchie. The experiment reported was covered by REB 17-1420, approved by the University of Calgary Conjoint Faculties Research Ethics Board on November 8, 2018.

Acknowledgements

Thank you to my supervisor, Dr. Dan McGrath, for guiding me through these past few years and providing me with yet another opportunity to do research in this area. I will always be very grateful to you for taking me on in the first place over four years ago. Thank you to my committee, Dr. David Hodgins and Dr. Kristin von Ranson, for your help with the study design and suggestions on my proposal seminar document, and to my internal examiner, Dr. Daniel Kopala-Sibley. A huge thanks to my lab mates Nicole Romanow for her assistance in the study development, and to Chelsea Fitzpatrick for her moral support and comradery during the past two years. Finally, thank you to my parents for their unwavering support, especially since I decided that completing a Master's degree was a fantastic time to also plan a wedding. Finally, thanks to my husband(!), Brent. Two degrees down, hopefully at least one more to go.

Table of Contents

List of Abbreviations

AUD.......................................Alcohol Use Disorder

AUDIT ....Alcohol Use Disorders Identification Test

AUQ.......................................Alcohol Urge Questionnaire

DG..Disordered Gambler/Disordered Gambling

GACS.....................................Gambling Craving Scale

GD..Gambling Disorder

ms...milliseconds

NIAA......................................National Institute on Alcohol Abuse and Alcoholism

PGSI.......................................Problem Gambling Severity Index

SRS ....Subjective Rating Scale

T1 ....Time 1 (pre-cue exposure in the present experiment)

T2 ....Time 2 (post-cue exposure in the present experiment)

T3 ....Time 3 (post eye-tracking task in the present experiment)

VLT..Video Lottery Terminal

List of Tables

List of Figures

List of Appendices

The Effect of Alcohol Cue Exposure on Gambling-Related Attentional Biases and Cravings among Poker Players who Drink

In April 2019, the provincial government of Ontario introduced legislation that considerably changed how gambling venues can legally serve alcohol. This legislation allows licensed establishments to offer and advertise free alcohol and changed the time that alcohol can be served to 9 AM, ostensibly to "allow operators to better compete with their American counterparts" (The Canadian Press, 2019, para. 5). The new laws were proposed in the provincial government's latest budget to increase revenue from gambling ventures in the province (Powers, 2019, "Booze at 9 AM in PC Budget"), as gambling revenues are a lucrative source of income for the provincial and federal governments (Canadian Partnership for Responsible Gambling, 2015). For instance, the Ontario government alone reportedly earned nearly $2.5 billion CAD from gambling revenues in the fiscal period of 2017-2018 (Ontario Lottery and Gaming Corporation, 2018), a figure that the current provincial government is evidently aiming to increase with the new legislation.

This raises the question of how alcohol consumption affects gambling behaviours. Gambling is a risk-taking activity; it involves risking the loss of something valuable (typically money) in the hopes of gaining something of more value (more money). Alcohol is typically characterized as having a disinhibitory effect on consumers, and there is a wealth of research to support the assertion that this disinhibitory effect translates to increased risk-taking behaviours (Lane, Cherek, Pietras, & Tcheremissine, 2004). Evidence from epidemiological studies indicates that problematic gambling and alcohol behaviours frequently co-occur (Brewer, Potenza, & Desai, 2010; Rush, Bassani, Urbanoski, & Castel, 2008); however, research from laboratory-based experiments is inconclusive. Some research suggests that alcohol worsens risk-taking while gambling (e.g., Phillips & Ogiel, 2007), but others have found that it does not necessarily make people gamble in a more impulsive way (Sagoe et al., 2017; Wagner, Sevincer, Keim, Fähnrich, & Oettingen, 2018). Hence, the relationship between drinking and gambling appears to be complex and likely involves several underlying mechanisms.

This thesis is focused on one mechanism that might be implicated in the drinking-gambling relationship: the cognitive processes involved in cue reactivity. The aim of this thesis was to further examine the relationship between alcohol and gambling through the lens of three interrelated concepts: cue reactivity, cross-cue reactivity, and attentional biases. The study was designed to test the applicability of these concepts to alcohol and gambling co-use.

I will begin by summarizing research on the prevalence, clinical concerns, and underlying mechanisms of comorbid alcohol and gambling problems. Second, I will review research from experimental studies that administered alcohol to participants and examined its influence on gambling-related cognitive distortions, cravings, and behaviours. I will conclude by reviewing literature on cue reactivity and cross-cue reactivity specifically in relation to alcohol and/or gambling and explain how they can be used to better understand the gambling-alcohol relationship.

Prevalence of Problematic Alcohol and Gambling Co-Occurrence

Alcohol use disorder (AUD) and gambling disorder (GD) are mental disorders characterized by difficulty controlling one’s alcohol use or gambling such that it causes significant distress or impairment to the individual (American Psychiatric Association, 2013). AUD and GD have been found to co-occur at a greater than chance rate. A systematic review and meta-analysis of disordered gamblers[1] (DGs) found a mean weighted prevalence rate of 28.1%

[1] The term DG (disordered gambling/disordered gamblers) refers to both individuals with GD as well as subsyndromal gamblers who are experiencing problems with their gambling.

for co-occurring AUD across 8 studies (Lorains, Cowlishaw, & Thomas, 2011). In comparison, one epidemiological study in the United States reported that their sample of individuals with AUD had an 8.3% prevalence rate of either GD or at-risk GD (Brewer et al., 2010). A survey conducted in Britain also found several associations between heavy drinking and DG (Griffiths, Wardle, Orford, Sproston, & Erens, 2010). In particular, this study found that rates of DG increased proportionally with alcohol consumption, with the highest prevalence rate of DG reported in men who drank more than 16 units of alcohol on their heaviest drinking day. Further, respondents in this group were significantly more likely to report having gambled in the past 12 months. Rates of AUD also appear to be especially elevated in treatment-seeking samples of DGs, with one study reporting that 72% of their sample of recently abstinent DGs had been diagnosed with an AUD in their lifetime (Hodgins, Peden, & Cassidy, 2005).

High rates of gambling and alcohol problems are also commonly reported in samples of university students. This population experiences high levels of harmful or hazardous drinking[2]; one study found that nearly a third (32.0%) of a random sample of Canadian undergraduates reported harmful or hazardous drinking in the past year (Adlaf, Demers, & Gliksman, 2005). Gambling-related problems are also frequently reported amongst university samples, with one study reporting a prevalence rate of DG of 8.5% for males and 1.9% for females (Engwall, Hunter, & Steinberg, 2004).

In terms of co-occurring alcohol and gambling problems amongst university students, research has found that male students who frequently or always drink when they gamble are more likely to wager more money per bet, to run out of money during a gambling session, and to bet more than they could afford to lose, all of which are potential symptoms of a problematic

[2] Defined as a score ≥ 8 on the World Health Organization’s Alcohol Use Disorders Identification Test (AUDIT)

relationship with gambling (Giacopassi, Stitt, & Vandiver, 1998). A more recent study reported that students who drink in a harmful or hazardous way also gambled more frequently and lost more money gambling than non-drinkers and moderate drinkers (Marten et al., 2009). Taken together, these data indicate that problematic gambling and alcohol use are tightly linked.

Clinical Concerns in Comorbid AUD and DG

Comorbid AUD and DG are of particular importance to clinicians, as research suggests that the incidence of other psychopathology increases with worsening gambling severity (Brewer et al., 2010). For example, one study found that individuals with comorbid AUD and GD were more likely to experience other psychological disorders, particularly personality disorders, compared to individuals with a sole diagnosis of GD (Abdollahnejad, Delfabbro, & Denson, 2014a). DG on its own can negatively impact nearly all aspects of a person's life, from personal relationship issues to potential problems with the legal system (Petry & Kiluk, 2002). Furthermore, DGs often experience devastating financial losses since gambling demands risking the loss of money in order to play. Some researchers have speculated that these losses are so overwhelming that suicide may seem like the only viable option (Abdollahnejad et al., 2014a).

With respect to individuals with comorbid AUD and DG, current research suggests that this group may be at an even higher risk of suicide. Analysis of data from a gambling self-help line found that DGs who self-reported struggling with alcohol abuse had a higher rate of attempted suicide than those without an alcohol problem (Potenza, Steinberg, & Wu, 2005). Epidemiological data from Canadian gamblers examined rates of suicidal ideation and found an interaction effect between gambling severity and alcohol consumption (Kim, Salmon, Wohl, & Young, 2016). Specifically, the odds of a non-DG reporting suicidal ideation did not change depending on their alcohol consumption, but the odds of a DG reporting suicidal ideation increased with greater alcohol consumption. These results highlight that individuals with both DG and AUD may experience greater psychological distress and worse outcomes compared to either disorder alone.

Underlying Mechanisms of Comorbid AUD and DG

While it is important to establish the extent to which problematic drinking and gambling co-occur, other research has been devoted to understanding *why* this is the case. There are several theories proposed by researchers, of which I will review two: (1) AUD and GD represent a unique subtype, and (2) AUD and GD are linked by common underlying mechanisms.

First, it is conceivable that individuals with comorbid AUD and DG represent a unique subtype of these disorders. DGs with comorbid AUD are significantly more likely to display gambling-related cognitive distortions (Abdollahnejad, Delfabbro, & Denson, 2014b), gamble more often and are more impulsive (Ledgerwood, Alessi, Phoneix, & Petry, 2009), begin gambling problematically at a significantly later age (Zois et al., 2014), perform worse on tasks that assess risky decision-making and irrational choices (Zois et al., 2014), and score higher on measures of gambling severity (Lister, Milosevic, & Ledgerwood, 2015), compared to individuals with a sole diagnosis of GD. Furthermore, the personality profile of this group has been shown to be distinct from individuals presenting with either disorder alone. One cross-sectional study compared personality traits in a sample of DGs with and without AUD. The former group had significantly lower scores on the personality sub-traits “control” (the ability to plan for the future with caution), “well-being” (happiness), and “traditionalism” (respecting and adhering to societal values) (Lister et al., 2015).

The second theory proposes that AUD and GD do not causally influence each other *per se* but are instead influenced by similar underlying factors and predispositions (Stewart &

Kushner, 2005). This idea has been empirically tested using a bifactor model, which allows for examining the commonalities between AUD and GD while also examining the unique mechanisms of each disorder separately (Tackett et al., 2017). The bifactor model was applied to undergraduate students who gamble and consume alcohol and was found to fit the data well. The general factor (which explains the shared commonalities between gambling and drinking) was mainly comprised of chasing losses and gambling frequency. Interestingly, nearly all measures of gambling and drinking behaviours and motivations were positively related to the general factor for men, but not for women. The authors suggested that gambling and drinking may be more closely associated for men compared to women. Relatedly, a large study of male twins only found significant evidence that GD and AUD share the same genetic vulnerability, with at least half of the correlation between AUD and GD being attributed to a shared genetic vulnerability (Slutske, Ellingson, Richmond-Rakerd, Zhu, & Martin, 2013).

Enhanced knowledge of the underlying mechanisms of comorbid GD and AUD contributes to our understanding of how the gambling-drinking relationship develops and is maintained. It is also important to examine what this relationship looks like at the event level. Next, I will discuss some key findings of laboratory research in which either drinking or gambling was manipulated experimentally to assess subsequent effects on the other addictive behaviour.

Alcohol and Gambling Laboratory Research

As with most human behaviours, the “why” behind someone’s choice to drink and gamble concurrently likely varies depending on individual factors, such as personality, and situational factors, such as the gambling venue (e.g., playing a casual game of poker at home with friends versus gambling in a casino). Theories of drinking motivations suggest that people drink for three primary reasons: coping, enhancement, and social (Cooper, Russell, Skinner, & Windle, 1992). Gamblers may drink alcohol to cope with losses incurred while gambling (coping), because it makes gambling more fun (enhancement), or because the people they are gambling with are also drinking (social). However, research examining the effects of alcohol on gambling has thus far yielded conflicting results. The methodology adopted by many of these studies have focused on providing participants with measured doses of alcohol and asking them to gamble in controlled, laboratory environment. The results of these studies are summarized below.

The effect of alcohol on gambling among disordered gamblers. Two studies by the same research group specifically examined whether the effect of alcohol on gambling differs between DGs and non-DGs. Both studies administered alcohol and placebo beverages and asked participants to gamble on a Video Lottery Terminal (VLT). The first study by Ellery, Stewart, and Loba (2005) found that participants in the alcohol condition spent more time gambling, an effect that was enhanced in the DGs. However, the other measures of gambling behaviour, total amount of money wagered and average bet, did not differ by condition or DG status. The second study by Ellery and Stewart (2014) found that DGs in the alcohol condition made more double up bets, the researchers' chosen variable to assess risky betting. However, they did not replicate the first study's findings as there was no significant effect of alcohol on the amount of time spent gambling.

The effect of alcohol on gambling among non-disordered gamblers. Some research has suggested that alcohol may influence gambling cravings in non-DGs. For instance, one study found that scores on the "desire to gamble" subscale of the Gambling Craving Scale (Young & Wohl, 2009) increased significantly after consumption of alcohol compared to placebo (Barrett et al., 2015). There is also evidence to suggest that non-DGs who consume alcohol are more persistent in their gambling, despite continued losses. An early study manipulated a gambling task so that the player lost more money the longer that they played (Kyngdon & Dickerson, 1999). In this study, participants who were given alcohol played significantly more trials, were more likely to gamble until they ran out of money (50% in alcohol condition compared to 15% in placebo), and bet significantly more on average after a loss. Another study that controlled payouts on a VLT did not find a main effect of beverage condition on gambling persistence, although they did find that participants in the alcohol condition who gambled until they had lost all their money had done so in fewer trials than participants who had been given the placebo, which is suggestive of a riskier style of betting (Cronce & Corbin, 2010).

The effect of alcohol on skill-based gambling. While VLT players are a popular target demographic for experimental research, alcohol may affect skill-based gambling (e.g., poker) differently than chance-based gambling (e.g., VLTs). One study that measured gambling behaviour using a computer blackjack game reported that participants who consumed alcohol were significantly faster at placing bets and making decisions compared to when they had not consumed alcohol (Phillips & Ogiel, 2007). This effect has not been reported amongst VLT play, although it is still thought to reflect a riskier style of gambling since the tendency to place bets more quickly is associated with running out of money more quickly and losing more often (Phillips & Ogiel, 2007). However, another study which used a video poker task did not find a main effect of beverage on any gambling variables and pointed to the strategic nature of poker as a reason for their null findings (Corbin & Cronce, 2017). In sum, the evidence for how alcohol consumption affects gambling is mixed, and this is seen no matter the sample (DGs vs. non-DGs) or the type of gambling measured (chance vs. strategic).

The effect of gambling on alcohol consumption. There is comparatively little research that has examined how gambling influences alcohol consumption. One study randomly assigned VLT players to either gamble on a VLT or to watch an action movie for 90 minutes and allowed them to purchase either alcoholic or non-alcoholic beverages (Stewart, McWilliams, Blackburn, & Klein, 2002). They found that significantly more participants in the VLT condition (73%) purchased and drank at least one alcoholic beverage, compared to the movie condition (40%), suggesting that gambling may trigger a desire to consume alcohol. Other research found that undergraduates who gambled on a slot machine scored significantly higher on all of the researchers' measures of alcohol consumption, including total milliliters of alcohol consumed, number of drinks ordered from the bar, speed of drinking, and intention to drink (Tobias-Webb, Griggs, Kaufman, & Clark, 2018). However, a follow-up study by the same group of researchers which used the same design but disguised alcohol consumption as a taste test[3] did not find any significant differences in the amount of alcohol consumed (Tobias-Webb et al., 2018).

Overall, research has found that the impact of alcohol on gambling behaviours and cravings is inconsistently supported. Some researchers have found that consuming alcohol makes DGs and gamblers in general more prone to gambling in a risky way (Ellery & Stewart, 2014; Kyngdon & Dickerson, 1999), particularly if engaging in chance-based gambling. However, other research has not found support that alcohol influences the way that people gamble, particularly in skill-based gambling (Corbin & Cronce, 2017). Finally, although there are few studies examining how gambling impacts alcohol consumption, the existing literature suggests that losing while gambling may lead to increased alcohol consumption (Stewart et al., 2002), although this is not a consistent finding (Tobias-Webb et al., 2018).

[3] The taste test was incorporated in order to account for demand characteristics that may have contributed to their earlier findings.

Cue Reactivity

The primary aim of the studies described above was to assess the pharmacological effects of alcohol on gambling behaviours. It is well-known that alcohol can enhance disinhibition and exacerbate risk-taking behaviour (Lane et al., 2004). Yet, psychological components are also critical to a complete understanding of the development and maintenance of addictive behaviour. One factor that is central to the current thesis is cue reactivity. In the addictions literature, cue reactivity refers to an individual's psychological (e.g., craving), physiological (e.g., change in heart rate), and/or behavioural (e.g., drug-seeking) reaction to a stimulus related to their addiction (Carter & Tiffany, 1999; Drummond, Tiffany, Glautier, & Remington, 1995).

Cue reactivity is most often explained by classical conditioning principles, although other learning and cognitive theories have been proposed (Rose, Field, Franken, & Munafò, 2013). In terms of a classical conditioning model, substances of abuse and stimuli related to them become closely associated with the rewarding effects of the substance, resulting in a conditioned response (e.g., craving or a desire to use the substance) when presented with the substance or its related stimuli. Psychologically conditioned responses, such as craving, have been identified as a key feature of cue reactivity paradigms. For example, Carter and Tiffany (1999) found a large effect size for addiction cues on psychological reactions, particularly cravings, in contrast to a small effect size for physiological reactions.

The importance of cue reactivity in the development and maintenance of addictive behaviours has mostly been linked to its elicitation of drug craving, as craving is an important construct in understanding and predicting relapse (Drummond, 2000). Moreover, cue reactivity has been identified as a potential target for therapeutic interventions in addictions treatment since extinction of reactions to drug-related cues is thought to be an important process for recovery and abstinence from an addiction (Conklin & Tiffany, 2002).

Alcohol cue reactivity. Cue reactivity in relation to alcohol has been extensively studied over the past thirty years. For example, a 2015 systematic review identified 19 empirical studies that used a cue reactivity paradigm with alcohol cues (Veilleux & Skinner, 2015). Most research conducted has operationalized alcohol cues using an *in vivo* protocol whereby alcohol is presented to the participant and they are asked to look at it and/or smell it[4]. Exposure to alcohol cues has been found to initiate behavioural reactions, such as choosing to drink alcohol over other non-alcoholic beverages (MacKillop & Lisman, 2007; Engels, Hermans, van Baaren, Hollenstein, & Bot, 2009; Koordeman, Anschutz, van Baaren, & Engels, 2011). Furthermore, exposure to alcohol cues consistently elicits psychological reactions, including poor decision-making in individuals with AUD (Waters & Green, 2003), increased responsiveness to rewards (Kambouropoulous & Staiger, 2001), heightened craving or urges for alcohol (Witteman et al., 2015), and failure to inhibit responses (Muraven & Shmueli, 2006).

Gambling cue reactivity. While not as well-studied as alcohol cue reactivity, several investigations in recent years have examined the effect of gambling-related cue reactivity. A recent meta-analysis identified eight studies that looked at cue reactivity in DGs compared to healthy controls (Starcke, Antons, Trotzke, & Brand, 2018). The study concluded that DGs consistently displayed stronger cue reactivity towards gambling cues compared to controls. The studies included in this meta-analysis used a variety of techniques to assess cue reactivity, including physiological methods (e.g., heart rate, blood pressure, skin conductance level), neurological imaging (fMRIs), and subjective craving measures (e.g., self-report scales). The

[4] See Appendix A for a full description of the original alcohol cue exposure protocols by Monti et al. (1987) and Monti et al. (1993)

effect size was large for all included studies, medium for physiological measures and interestingly, was small and non-significant for subjective measures (Starcke et al., 2018).

Cross-cue reactivity. The mechanisms underlying cue reactivity have been extended to cross-addicted individuals. That is, cross-cue reactivity occurs when the cue for one addiction comes to elicit a response for another. Theoretically, if alcohol and gambling are repeatedly paired together, one may learn to associate alcohol with gambling, and gambling with alcohol, such that alcohol by itself can elicit thoughts, behaviours, cravings for gambling (and vice versa). Cross-cue reactivity has been studied in relation to co-morbid substance addictions, particularly concurrent alcohol and tobacco use, such that exposure to smoking cues can lead to stronger urges to drink while exposure to alcohol cues results in enhanced cigarette cravings (e.g., Gulliver et al., 1995; Rohsenow et al., 1997; Carpenter et al., 2014). Unfortunately, there is a very limited literature examining similar phenomenon among gamblers.

To my knowledge, only two studies have examined cross-cue reactivity in relation to gambling and other substances. The first examined gambling and smoking cross-cue reactivity, and found that poker players who smoke reported greater urges to smoke when exposed to gambling cues in comparison to a group of poker players who did not smoke and smokers who did not gamble (Wulfert, Harris, & Broussard, 2016). They also found that poker players who smoke had a greater physiological response, as measured by greater skin conductance, in response to gambling and smoking cues.

The second study is from an unpublished doctoral dissertation and examined gambling and alcohol cross-cue reactivity (Lipinski, 2010). Participants were randomly assigned to gamble on a slot machine, watch a boring or an exciting basketball game, or watch a movie. They were then asked to report their cravings for alcohol. Individuals who had gambled on a slot machine reported significantly higher cravings for alcohol compared to those who watched the boring basketball game and the movie. The second part of the study manipulated the slot machine payouts so that there were three conditions: break-even, winning, and losing. Participants were randomly assigned to either of the three conditions, or to watch a movie. Afterward, alcohol cravings were assessed. Participants who had played the slot machines reported higher alcohol cravings than those who watched the movie, and furthermore, participants in the losing condition reported the highest alcohol cravings. The results from this study suggest that cross-cue reactivity between alcohol and gambling may manifest as increased alcohol cravings in response to gambling losses.

Attentional Biases

A related cognitive process frequently seen in addictions populations are attentional biases. Attentional biases are the irrepressible tendency to preferentially attend to certain stimuli over others (Ciccarelli, Nigro, Griffiths, Cosenza, & D'Olimpio, 2016). They can be thought of as the cognitive component of cue reactivity and are related to how these addiction-related cues are processed (Field & Cox, 2008). Research has demonstrated that attentional biases exist across a wide range of psychopathologies, from eating disorders (Faunce, 2002), anxiety disorders (Bradley, Mogg, Millar, & White, 1995), and most pertinent to this proposal, addictions (Field & Cox, 2008).

The extant literature has shown that individuals with substance use disorders consistently demonstrate attentional biases towards their drug of choice. Classical conditioning principles, as outlined in the cue reactivity section, can partially explain why this occurs. However, these principles do not fully explain the mechanisms underlying attentional biases in substance users. In a comprehensive review of attentional biases in addictions, Field and Cox (2008) refer to the importance of incentive-sensitization theory (Robinson & Berridge, 1993) in more fully describing how attentional biases develop. Although the exact mechanisms of psychoactive drugs vary substantially, all drugs of addiction influence dopaminergic pathways in the brain's reward circuitry (Diana, 2011). Incentive-sensitization theory posits that the brain becomes sensitized to subsequent drug administration, releasing more dopamine and causing the substance and stimuli related to it to acquire salience to an individual (Robinson & Berridge, 1993). Particularly, it affects motivational states such that an individual will become driven to use the substance again (i.e., cravings).

Attentional biases are an important cognitive process in the development and maintenance of addictive behaviour. Given the close relationship between cue reactivity and attentional biases, much interest has also been paid to the relationship between attentional biases and craving. The current evidence reported in the research literature supports the assertion that attentional biases are related to craving, and that stronger attentional biases are related to stronger cravings (Field, Marhe, & Franken, 2014). Furthermore, early research showed that attentional biases may be a useful predictor of relapse, such that individuals who display stronger attentional biases, particularly early in treatment for their addiction, are more likely to relapse (Cox, Pothos, & Hosier, 2007). However, the relationship between attentional biases and maintenance of abstinence has been inconsistently supported in subsequent research, with some studies indicating that attentional biases predict relapse (Cox, Hogan, Kristian, & Race, 2002), and others failing to find this relationship (Field, Mogg, Mann, Bennett, & Bradley, 2013).

Attentional biases in gamblers. Although not as well-studied as in substance use disorders, there is evidence that attentional biases exist in gambling. A systematic review on attentional biases in GD reported 11 studies in total that had examined this phenomenon (Hønsi, Mentzoni, Molde, & Pallesen, 2013). In aggregate, the findings of this review suggest that DGs do display attentional biases related to gambling stimuli, although this effect is moderated by the type of measurement tool used. Researchers have used a variety of methods to study attentional biases in addictions, including Stroop tasks and visual probe tasks, but the internal reliability of some of these methods is reported to be quite poor (Field et al., 2014). In contrast, eye-tracking paradigms are one of the most direct methods to assess attentional biases and have shown superior internal reliability compared to other methods (Field et al., 2014). Eye-tracking measures have been shown to complement direct measures of human cognition, such as neuroimaging, and are thought to be an ideal way to examine the relationship between what is happening in the brain with observable behaviour (Luna, Velanova, & Geier, 2008)[5].

Unfortunately, there is still a considerable gap in research on attentional biases in gamblers, particularly as eye-tracking research is practically non-existent in relation to gambling. One of the only studies to date that has used eye-tracking to assess attentional biases in gamblers examined differences in attentional biases amongst different types of gamblers (McGrath, Meitner, & Sears, 2018). The results of this study indicate that poker players and VLT players spent more time attending to images related to their preferred form of gambling compared to neutral stimuli (board games). This echoes research from the alcohol literature that found individuals who drink alcohol display attentional biases towards their preferred type of alcoholic beverage (Christiansen, Mansfield, Duckworth, Field, & Jones, 2015).

The existence of attentional biases for both gambling and alcohol have been established, yet, to our knowledge, no known study has explored the possible influence of cue exposure on subsequent measures of attentional biases. Further to this, cross-cue exposure among dually

---

[5] See Eckstein, Guerra-Carrillo, Singley, and Bunge (2017) for an excellent review how eye-tracking has been used to study human cognition and attention

addicted individuals has been ostensibly ignored in the gambling area. This is somewhat surprising given the frequent real-world pairing of alcohol and gambling in gambling venues and suggests a need for research into this area.

Rationale and Hypotheses

The purpose of this study was two-fold. First, to examine whether cue reactivity, measured by alcohol cravings and attentional biases for alcohol images, occurs after exposure to an alcohol cue compared to a neutral cue (in other words, to validate the existence of alcohol-specific cue reactivity using an *in vivo* paradigm). Second, to examine whether cross-cue reactivity, measured by gambling cravings and attentional biases for gambling images, occurs after alcohol cue exposure in a sample of gamblers who drink when they gamble.

This study adds to the literature in a few important ways. First, examining attentional biases using an eye-tracking methodology in gamblers has been a vastly under-utilized paradigm. Given the superior internal reliability and the usefulness of this methodology in measuring unconscious and implicit processes (Eckstein et al., 2017), additional research is needed in this area in order to more thoroughly understand gambling-specific attentional biases. Second, no studies to my knowledge have examined the feasibility of using an eye-tracking task as a measure of cue reactivity following cue exposure. Using a control group of non-gamblers provides a sound methodological basis on which to establish the existence of cue and cross-cue reactivity in gamblers who drink. Third, exploring the effect of exposure to alcohol cues on gambling-specific attentional biases and gambling cravings would help determine whether cross-cue reactivity between alcohol and gambling does exist for individuals who drink and gamble concurrently.

Hypotheses

(H1) Participants in the alcohol cue condition will experience higher subjective cravings for alcohol compared to participants in the neutral cue condition following exposure to alcohol cues.

(H2) Participants in the alcohol cue condition will preferentially attend to alcohol images to a significantly greater extent compared to participants in the neutral cue condition.

(H3) Gamblers will preferentially attend to gambling images to a significantly greater extent compared to non-gamblers.

(H4) Gamblers in the alcohol cue condition will preferentially attend to gambling images to a greater extent compared to gamblers in the neutral cue condition.

(H5) Gamblers in the alcohol cue condition will experience higher subjective cravings for gambling compared to the neutral cue condition.

Method

Participants

Participants were recruited using the University of Calgary's research participation system, which allows students to sign up for research studies in compensation for course credits; posters on campus; and online advertisements on Kijiji and Facebook. Those interested in participating were directed to a short online screening form to determine their eligibility for the study. A total of 404 potential participants completed the online screening form. Of those, 192 were deemed eligible, and 125 completed the study.

All participants were required to (1) identify as male (chosen due to a greater proportion of pokers players being male) (Gainsbury, Suhonen, & Saastamoinen, 2014) (2) be between the ages of 18 and 35, and (3) regularly consume alcohol, defined as drinking at least 1 drink per week on average. Participants were excluded if they (1) experienced any problems with colour blindness, (2) were trying to quit alcohol or gambling or intended to quit either within the next 30 days, or (3) did not drink beer. Gamblers had the additional exclusion requirements of stating that they never drank when they gambled. The beer requirement was included as more than half (65%) of the alcohol images in the eye-tracking task were images of beer.

Individuals were classified as non-gamblers if they had not bet or spent money on any gambling activity in the 12 months. Gamblers were classified as such if they (1) had played poker once per month for the past three months, or (2) spent the most money on poker out of all types of gambling over the past three months, or (3) selected poker as their favourite form of gambling to play from all types of gambling over the past three months.

Eye-tracking data was missing for seven participants, as they were wearing glasses with anti-reflective coating or gas permeable contacts, both of which are incompatible with the eye-tracker. As such, these participants were excluded from all analyses. The final included sample size for this study consisted of 118 males who regularly consumed alcohol, n = 59 in each the non-gambler and gambler groups.

Apparatus and Materials

Problem gambling severity index (PGSI). The PGSI (Ferris & Wynne, 2001) consists of nine questions that each reflect a potentially problematic relationship with gambling. There are four set answers to each question: “never”, “sometimes, “most of the time”, or “almost always”. Examples of questions in the PGSI include, “Do you feel guilty about the way that you gamble or what happens when you gamble?” and “Have you bet more than you could really afford to lose?” Each answer is associated with a score, anchored at 0 for “never” and 3 for “almost always”, and all responses are summed to yield a total score. The interpretive categories of the PGSI were originally broken down into non-DGs, low-risk gamblers, moderate-risk gamblers, and DGs. I followed the recommendations of Currie et al. (2013) and categorized potential DGs as those scoring 5 or higher on the PGSI.

Alcohol use disorders identification test (AUDIT). The AUDIT is a 10-item self-report questionnaire used to categorize individuals who drink as low-risk, moderate-risk (risky or hazardous drinking), or high-risk. The AUDIT has three subscales that measure different aspects of problematic drinking: consumption (*amount* of alcohol typically consumed), dependence (indicative of *physical dependency* on alcohol), and harms (*practical consequences* of problematic drinking, such as its impact on close relationships). A recent review of the psychometric properties of the AUDIT concluded that it demonstrates strong test-retest reliability in general samples, strong construct and criterion validity, and is suitable for use amongst diverse ethnic and age groups (Reinert & Allen, 2007).

Subjective rating scale (SRS). The SRS is an 11-item questionnaire that consists mainly of one-word mood states such as “relaxed”, “pleasant”, and “irritable”. There are also two questions that ask the degree of “wanting” and “liking” to drink/gamble. Participants are asked to select a number that corresponds with how much of that particular mood state they are feeling at that moment, from 1 (“not at all”) to 10 (“extremely”). The SRS has been used in previous alcohol cue reactivity related experiments that use repeated measures (e.g. Barrett et al., 2015).

Alcohol urge questionnaire (AUQ). The AUQ is composed of eight statements related to urges to drink alcohol such as: “Having a drink now would make things seem just perfect” and “I crave a drink right now”. Responses are anchored from 1 (“strongly disagree”) to 7 (“strongly agree”). Scores from each statement are summed and then averaged to provide a total score. The total score measures a single factor (urge to drink) which in turn is thought to partially represent craving (Bohn, Krahn, & Staehler, 1995). Higher scores represent greater urges to drink. The AUQ is particularly well-suited to measure drinking urges in dependent drinkers (Drummond & Phillips, 2002) and heavy drinkers (MacKillop, 2006), as it is significantly correlated with measures of alcohol dependency (Bohn et al., 1995; Drummond & Phillips, 2002; MacKillop, 2006). The AUQ has demonstrated excellent internal consistency, as well as good construct validity and discriminant validity (Bohn et al., 1995).

Gambling craving scale (GACS). The GACS is a 9-question self-report measure that assesses gambling cravings based on three related factors: (i) anticipation [that gambling will be enjoyable] (ii) desire [to gamble], and (iii) relief [of negative mood symptoms by gambling] (Young & Wohl, 2009). Participants are asked to rate how much they agree with statements such as “Gambling would be fun right now”, “I need to gamble right now”, and “Gambling would make me less depressed”, on a scale from 1 (“strongly disagree”) to 7 (“strongly agree”). The three subscales of the GACS have shown to have strong concurrent validity in convenience and community samples (Young & Wohl, 2009). They have also demonstrated high predictive validity; the three subscales have shown to significantly predict lengthier gambling sessions and continued engagement in gambling despite persistent losses (Young & Wohl, 2009). Higher scores on each subscale collectively represent stronger gambling cravings, and each subscale is usually interpreted on their own rather than collectively.

Eye-tracking task. An Eyelink 1000 eye-gaze tracking system (SR Research Ltd., Ottawa, Ontario) was used for the eye-tracking task. The eye-tracking system has a sampling rate of 1000 Hz, or 1000 samples, per second; a temporal resolution of less than 2.5 milliseconds (ms); and the reported eye-gaze at any given point is accurate to within less than 0.5 degrees of visual angle. Each image was 4.5 x 6 inches and was displayed with its matched pair on a 21 x 12 inch monitor, which was situated 40 inches from the participant.

There were four types of image pairings: alcohol vs. neutral (water), gambling vs. neutral (board games), alcohol vs. gambling, and neutral (water) vs. neutral (board games). Each image type (alcohol, gambling, neutral) appeared in the left quadrant and right quadrant equal amounts of times within each image pairing (i.e., 10 times on the left and 10 times on the right). The neutral vs. neutral image pairing acted as a filler and was not the focus of any hypotheses, so was not included in any analyses.

There were a total of 80 trials with 20 trials for each category. Each trial was displayed for a total of 4000 milliseconds and each trial was randomized for each participant. However, each image pair remained the same. Image pairings were carefully selected to ensure congruency between the images. That is, each image and its pair would share similar structural features, colours, presence (or lack of) people in the image, etc. See Appendix B for examples of each image pairing. The eye-tracking task took approximately 10 minutes to complete, including time for calibration and validation.

Demographics and alcohol and gambling history. This author-compiled questionnaire was used to gather information on age, education, employment, income, marital status, and ethnicity. The alcohol and gambling history contained questions about parental gambling and alcohol treatment, age of first alcoholic beverage, type of preferred alcoholic beverage, and questions about last time alcohol and caffeine had been consumed.

National Institute on Alcohol Abuse and Alcoholism (NIAA) recommended alcohol use questions. The NIAA Task Force on Recommended Alcohol Questions released four sets of questionnaires designed for researchers with limited time or interaction with a participant to assess drinking patterns over the past 12 months (NIAA, n.d.). I used the four-question set, which contains two questions related to frequency of drinking sessions and number of alcoholic drinks typically consumed per session, and two questions related to binge drinking.

UPPS-P impulsive behaviour scale. The UPPS-P consists of 59 questions related to one of five domains of impulsivity: urgency, perseverance, premeditation, sensation-seeking, and positive urgency (Lynam, Smith, Whiteside, & Cyder, 2006). Each question is a statement where participants are asked to what extent they agree or disagree with the statement. Responses are anchored on a scale of 1 (“strongly agree”) to 4 (“strongly disagree”). Higher scores reflect stronger impulsive tendencies.

Procedure

Participants were randomly assigned to the alcohol cue or neutral cue condition using GraphPad QuickCals random number calculator (https://www.graphpad.com/quickcalcs/randomize1/) prior to arriving at the lab for their testing session. They were asked not to consume any alcohol or cannabis 12 hours prior to their testing time, as well as caffeine for 3 hours prior to their testing time, in order to control for any potential effects of these substances on alcohol and gambling cravings. Study sessions were scheduled to start between 11 AM and 7 PM and were all tested by the same researcher (ER).

Participants were first brought to a neutral testing room (designed to be absent of any cues) and were asked to read through the informed consent. All questionnaires were delivered via Qualtrics, an online survey platform often used to administer questionnaires and surveys in research studies. The SRS, AUQ, and GACS (filled out in that order) were completed by the participant at three times during the study session. Time 1 (T1) measures were filled out after signing the informed consent form. Time 2 (T2) measures were completed after the cue exposure (described below). Time 3 (T3) measures were completed after the eye-tracking task and before the demographics and alcohol and gambling history questionnaires.

While the participant was filling out the T1 measures, the researcher left the room to organize the drinks for the *in vivo* cue exposure task. For the neutral cue condition, six different brands of bottled water (Dasani, Aquafina, Evian, Fiji, Perrier, and San Pellegrino) were placed in a row on a bar cart, along with a single glass. For the alcohol cue condition, there were a variety of spirits, mixers, wine, and beer assembled on the cart. For liquor, there were 750 mL bottles of rum (Captain Morgan's), vodka (Smirnoff), gin (Bombay Sapphire), and whiskey (Jack Daniel's). The rest of the bar cart contained white wine and red wine, one type of cider (Strongbow), and four types of beer (Canadian, Budweiser, and two types of craft beer from a local brewery). Four mixers were available: Coke, Sprite, tonic water, and club soda. Beside the bottles and cans there were three glasses (a tall glass, a short glass, and a pint), as well as a dual-sided shot glass that could measure 1.0 oz or 1.5 oz shots. The alcohol was displayed in a way such that the large bottles of spirits were in the back row, the beer and cider cans were in the front row, and the smaller mixers were in the middle row. This way, the participant could view all types of alcohol without needing to move anything.

When T1 measures were completed, the researcher brought the bar cart into the neutral testing room. Participants were told that the next part of the study was to complete a focus task, where they would be asked to focus on different aspects of a drink for 30 seconds at a time (see Appendix C for a full description for the script). They were asked to select their favourite beverage from the ones on the cart. The cue exposure consisted of three parts, each 30 seconds in duration: (1) looking at the drink and paying close attention to its physical appearance, (2) pouring the drink into a glass and thinking carefully about what they were doing (they were told to “be mindful”), (3) smelling the drink. The cue exposure protocol was the same for both conditions.

When the cue exposure task was completed, the researcher put the selected drink back on the cart, asked the participant to begin filling out T2 measures, and put the bar cart in a different room where the participant could no longer see it. The participant was then escorted to the eye-tracking room to complete the eye-tracking task. Afterwards, they completed T3 measures, demographics and alcohol and gambling histories, and the UPPS-P in the original neutral testing room. All participants were then compensated with either one course credit or a $20 gift card and were fully debriefed about the purpose of the study.

Statistical Analyses

With respect to the eye-tracking data, there were three trial pairings of interest: gambling vs. alcohol, gambling vs. neutral, and alcohol vs. neutral. The Eyelink software that generates output for the eye-tracking sessions allows for the selection of multiple dependent variables, each of which can be produced for either image in the trial pairing. I selected three dependent variables to focus all analyses that involved eye-tracking data, specifically: the mean dwell time percent, first run dwell time, and second run dwell time. See Table 1 for a more detailed explanation of each of these variables. These variables were selected as they represent different aspects of attentional biases and have been used in previous research (i.e., McGrath et al., 2018; Skinner et al., 2018). The eye-tracking data were reviewed for outliers by examining the total trial dwell time for each participant, as total trial dwell times less than 75% of the total trial time (3000 ms for a 4000 ms trial) are thought to indicate low attention (C. Sears, personal communication, May 15, 2019). No participants had a trial dwell time of less than 3000 ms, nor were any indicated by assessing boxplots for outliers; as such, all data was kept for further analyses.

For each of the dependent variables analyzed (i.e., all craving measures and eye-tracking data), the Shapiro-Wilk test for normality was consistently significant for most measures, indicating that normality was violated. Given that ANOVA is robust to violations of normality given a sufficiently large sample size (Maxwell & Delaney, 2004), the ANOVAs were conducted without transforming data. Further assumptions of each analysis are discussed in their respective sections below. For post-hoc comparisons of the repeated measures data only, Fisher's LSD for multiple comparisons was applied as it is recommended for use with data that has three means (Hayter, 1986; Levin et al., 1994).

Results

Participant Characteristics

Demographic characteristics of the participants are summarized in Table 2. The mean age of the participants was 23.98 (*SD* = 4.87), and most of the sample identified as white (61.50%) and were single (83.89%). Of the gamblers, 20 were categorized as DGs and 39 as non-DGs. As shown in Table 2, gamblers and non-gamblers did not differ significantly in age, marital status, ethnicity, or highest level of education completed, *p*s > .05. The percentage of non-gamblers who were students did differ significantly from the percentage of gamblers who were students, $\chi^2(1) = 5.59$, $p = .018$; this could be due to the fact that we recruited more non-gamblers from the research participation system ($n = 20$) compared to gamblers ($n = 7$).

As shown in Table 3, gamblers and non-gamblers differed significantly on AUDIT scores, AUDIT categorizations (as a low risk, moderate risk, or high risk drinker), on one measure of binge drinking using the NIAA Recommended Alcohol Questions, and two subscales of the UPPS-P (sensation seeking and positive urgency). They did not differ significantly in smoking status, frequency of drinking sessions, average drinks consumed per session, or on the other four measures of alcohol consumption from the NIAA, *p*s > .05.

Alcohol Variable Analyses: H1

Alcohol cravings & urges. A one-way repeated measures ANOVA was conducted to assess the impact of cue exposure on alcohol cravings and urges for each of the alcohol craving measures. Boxplots were examined for outliers, and none were detected for AUQ scores or SRS "Like To Drink" scores. Three outliers were detected for SRS "Want To Drink" scores, and analyses were conducted with and without the outliers; however, the results did not change significantly, so the outliers were kept in the analyses. Mauchly's test of sphericity was significant for all three ANOVAs, $p < .001$, indicating that sphericity had been violated. As such, the Greenhouse-Geisser correction was used.

AUQ. There was a significant main effect of time on average AUQ scores, $F(1.65, 186.64) = 45.76$, $p < .001$, $\eta^2_p = .29$. Pairwise comparisons revealed that average scores on the AUQ increased after the cue exposure, such that there was a significant difference between T1 ($M = 2.38$, $SD = 1.04$) and T2 ($M = 3.01$, $SD = 1.59$), $p < .001$, but not T2 and T3 ($M = 3.03$, $SD = 1.62$), $p = .808$. Measures of effect size indicate that the increase in alcohol urges was larger for the alcohol cue condition, $\eta^2_p = .30$, than the water cue condition, $\eta^2_p = .17$.

SRS "Want to Drink". There was a significant two-way interaction between time and condition, $F(1.69, 191.48) = 5.74$, $p = .006$, $\eta^2_p = .05$. Pairwise comparisons revealed that on average, "Want to Drink" scores for both conditions increased after cue exposure but did not continue to increase post eye-tracking. For the water cue condition, there was a significant difference between T1 ($M = 2.10$, $SD = 1.51$) and T2 ($M = 3.24$, $SD = 2.78$), $p < .001$, and T1 and T3 (M = 3.17, SD = 2.73), p < .001, but not T2 and T3, p = .931. Similarly, there were significant differences in "Want to Drink" scores for the alcohol condition between T1 (M = 1.93, SD = 1.15) and T2 (M = 4.10, SD = 2.64), p < .001, and T1 and T3 (M = 4.12, SD = 2.62), p = .001, but not T2 and T3, p = .931. Measures of effect size indicate that the increase in alcohol urges was larger for the alcohol cue condition, η^2_p = .38, than the water cue condition, η^2_p = .14.

SRS "Like to Drink". The results for the two-way interaction between time and condition are displayed in Figure 1. The two-way interaction was significant, F(1.87, 211.20) = 3.17, p = .047, η^2_p = .03. Follow-up pairwise comparisons revealed that there were no significant differences in "Like to Drink" scores for the water cue condition between any of the time points, p > .05. However, there was a significant difference in "Like to Drink" scores for the alcohol cue condition between T1 (M = 3.62, SD = 2.16) and T2 (M = 4.88, SD = 2.65), p < .001, and T1 and T3 (M = 4.79, SD = 2.61), p < .001, but not T2 and T3, p = .652, indicating that participants in the alcohol cue condition experienced an increase in "liking to drink" following exposure to alcohol cues. This increase in alcohol craving did not continue to increase after the eye-tracking task.

Alcohol Variable Analyses: H2

Attentional biases for alcohol. A 2 (trial pairing: gambling vs. alcohol, alcohol vs. neutral) x 2 (condition: alcohol, neutral) mixed ANOVA was conducted to examine the effect of cue exposure on alcohol-specific attentional biases. There were no outliers, as detected by inspection of boxplots for each of the dependent variables. Box's M was significant for dwell time percent and first run dwell time, p < .05, but not for second run dwell time, p > .05. Levene's test was not significant for any of the eye-tracking variables, indicating that the assumption of homogeneity of variances was met, p > .05.

Mean dwell time percent for alcohol images. As shown in Figure 2, there was a statistically significant main effect of condition on average dwell time percent scores, $F(1,116) = 4.73$, $p = .032$, , $\eta^2_p = .04$. Pairwise comparisons revealed that participants in the alcohol cue condition spent significantly more percent of the trial time looking at the alcohol images, $M = .56$, $SD = .01$, compared to participants in the neutral cue condition, $M = .52$, $SD = .10$.

Mean first run dwell time for alcohol images. The two-way interaction between trial pairing and condition was not statistically significant, $F(1,116) = 0.003$, $p = .955$. There was no significant main effect of condition, $F(1,116) = 3.68$, $p = .057$, nor a significant main effect of trial pairing, $F(1,116) = 1.52$, $p = .22$. Overall, this indicates that there were no differences in how long participants spent looking at alcohol images upon their first fixation between conditions or trial pairings.

Mean second run dwell time for alcohol images. There was a significant main effect of condition on average second run dwell time, $F(1,116) = 4.71$, $p = .032$, $\eta^2_p = .04$. Participants in the alcohol condition had significantly longer second run dwell times on average, ($M = 1121.96$, $SE = 41.36$) compared to participants in the neutral cue condition, ($M = 955.06$, $SD = 41.36$). This indicates that participants in the alcohol cue condition spent significantly longer looking at the alcohol images upon their second fixation compared to participants in the neutral cue condition.

Gambling Variable Analyses: H3

Attentional biases for gambling between gamblers and non-gamblers. A 2 (trial pairing: gambling vs. alcohol, gambling vs. neutral) x 2 (group: gambler, non-gambler) mixed-methods ANOVA was conducted for each of the eye-tracking variables to assess differences between gamblers and non-gamblers in gambling-specific attentional biases. Five outliers were detected by inspection of boxplots for mean dwell time percent. As such, analyses were conducted with and without the outliers and the results did not change between analyses, so the outliers were included. Box's M was not significant for any of the eye-tracking measures, $p >$ .05. There was homogeneity of variances, as indicated by Levene's test, $p > .05$.

As shown in Figure 4, there was a significant main effect of group for mean dwell time percent, $F(1,116) = 99.96$, $p < .001$, $\eta^2_p = .46$. Gamblers spent significantly longer gazing at gambling images across trial pairings, $M = .53$, $SE = .01$, compared to non-gamblers, $M = .36$, $SE = .01$. There was also a significant main effect of group for first run dwell time, $F(1,116) = 33.84$, $p < .001$, $\eta^2_p = .23$, and second run dwell time, $F(1,116) = 34.08$, $p < .001$, $\eta^2_p = .23$. This indicates that gamblers spent significantly longer gazing at gambling images during their first and second fixations compared to non-gamblers. Overall, these results suggest that gamblers preferentially attended to gambling images significantly more than non-gamblers.

Gambling Variable Analyses: H4

Attentional biases for gambling amongst gamblers only. A 2 (trial pairing: gambling vs. alcohol, gambling vs. neutral) x 2 (condition: alcohol, neutral) mixed-methods ANOVA was conducted for each of the eye-tracking variables to assess differences between the alcohol and neutral cue conditions amongst gamblers only. There were no outliers for first or second run dwell time, as detected by inspection of boxplots for each of the dependent variables. There were three outliers detected for mean dwell time percent; analyses were conducted with and without the outliers in the data, and the results did not change significantly, so the outliers were included in the analysis. Box's M was not significant for any of the eye-tracking measures, $p > .05$. There was homogeneity of variances, as indicated by Levene's test, $p > .05$.

Mean dwell time percent for gambling images. The two-way interaction between trial pairing and condition was not statistically significant, $F(1,57) = 0.35$, $p = .556$. There was no significant main effect of trial pairing, $F(1,57) = 0.81$, $p = .373$, or condition, $F(1,57) = 0.47$, $p = .497$. This indicates that there were no significant differences in the average time gamblers spent looking at gambling images based on the trial pairing or the condition.

Mean first run dwell time for gambling images. The two-way interaction between trial pairing and condition was not statistically significant, $F(1,57) = 0.55$, $p = .46$. There was no significant main effect of trial pairing, $F(1,57) = 2.55$, $p = .116$, nor a significant main effect of condition, $F(1,57) = 0.07$, $p = .798$. These results indicate that on average, gamblers spent similar lengths of time gazing at gambling images when they first looked at them, regardless of the trial pairing or the condition.

Mean second run dwell time for gambling images. The two-way interaction between trial pairing and condition was not statistically significant, $F(1,57) = 0.48$, $p = .489$. The main effect of trial pairing type was not significant, $F(1,57) = 2.04$, $p = .159$, nor was condition, $F(1,57) = 0.47$, $p = .494$. This indicates that on average, gamblers spent similar lengths of time gazing at the gambling images in both trial pairings during their second fixation, and this did not differ by the cue exposure they experienced.

Gambling Variable Analyses: H5

Gambling cravings and urges. A one-way repeated measures ANOVA was conducted for each gambling craving measure in order to assess the impact of cue exposure for gamblers only. There were no outliers for the SRS scores or the “Relief” and “Anticipation” scales of the GACS, as detected by inspection of boxplots for each of the dependent variables. However, five outliers were identified for the “Desire” subscale of the GACS, all in the water cue condition.

Analyses were conducted with and without the outliers, but the results were the same regardless, so the outliers were ultimately kept in the analyses. The assumption of sphericity was not met for "Want to Gamble" and all subscales of the GACS, as indicated by a significant Mauchly's test, and so the Greenhouse-Geisser correction was applied.

GACS. There were no statistically significant two-way interactions between time and condition for any of the GACS subscales, *p*s > .05. The effect of condition was not significant for any of the GACS subscales, $p > .05$. However, there was a main effect of time for the Desire subscale, $F(1.51, 84.57) = 20.81$, $p < .001$, $\eta^2_p = .27$, and the Relief subscale, $F(1.61, 90.17) = 4.56$, $p = .012$, $\eta^2_p = .08$, but not the Anticipation subscale, $F(1.73, 96.71) = 2.77$, $p = .075$. Post-hoc pairwise comparisons revealed a statistically significant difference between T1 ($M = 2.18$, $SD = 1.28$) and T3 ($M = 2.83$, $SD = 1.64$), $p < .001$, and T2 ($M = 2.24$, $SD = 1.27$) and T3, $p < .001$, for the Desire subscale only (shown in Figure 3). This indicates that desire to gamble significantly increased for all gamblers after the eye-tracking task, but not after cue exposure. None of the follow-up pairwise comparisons for the Relief subscale were significant.

SRS "Want to Gamble". The two-way interaction between time and condition was not significant, $F(1.73, 96.71) = 2.77$, $p = .075$. There was no main effect of time on "Want to Gamble" scores, $F(1.67,93.58) = 2.62$, $p = .077$, nor a main effect of condition on "Want to Gamble" scores, $F(1,56) = 0.08$, $p = .781$.

SRS "Like to Gamble". The two-way interaction between time and condition was not significant, $F(2,112) = 1.24$, $p = .294$. There was no main effect of time on "Want to Gamble" scores, $F(2,112) = 0.32$, $p = .725$, nor a main effect of condition on "Want to Gamble" scores, $F(1,56) = 0.89$, $p = .351$.

Discussion

This thesis represents the first known study to directly examine gambling and alcohol cross-cue reactivity using eye-tracking technology. Cross-cue reactivity was measured subjectively by assessing gambling cravings pre- and post- cue exposure and objectively by capturing indices of attention through eye-tracking. First, the existence of gambling-specific attentional biases was assessed using eye-tracking and comparing preferential attention toward gambling stimuli in gamblers vs. non-gamblers. As expected, the gamblers did attend to gambling imagery to a greater extent compared to non-gamblers. This finding indicates that an attentional bias towards gambling was present among the gamblers in the sample.

Next, I tested whether exposure to *in vivo* alcohol cues vs. neutral (water) cues would result in cross-cue reactivity, as measured by subjective cravings for gambling and greater attention to gambling stimuli. Research in addictive behaviors has indicated that substance-use craving is an important correlate of attentional biases (Field, Munafò, & Franken, 2009). Given this, the craving measures were assessed at several time points over the course of the experimental session. These included baseline measurements (T1), post cue exposure (T2), and post eye-tracking stimuli presentation (T3). And while both gamblers and non-gamblers were recruited, the gamblers in this case were of primary interest. That is, there is theoretical justification for possible cross-cue reactivity among gamblers who pair their gambling with alcohol; however, similar processes likely do not occur among non-gamblers who drink given that they have no first-hand experience with gambling. Therefore, the focus of the cross-cue reactivity analyses were directed toward comparing alcohol vs. neutral cue exposure among the gambler group only. Contrary to my hypotheses, the overall results indicated that alcohol cue exposure did not result in cross-cue reactivity as there was no effect of condition on gambling cravings or gambling-specific attentional biases.

For the craving measures, gamblers in the alcohol cue condition did not report higher cravings for gambling from T1 to T2, nor did they report higher cravings for gambling compared to gamblers in the neutral cue condition at any of the time points. Gambling cravings significantly increased following the eye-tracking task, but this was demonstrated in all gamblers regardless of the cue exposure condition they were assigned to. This increase in gambling cravings post eye-tracking could be attributed to cue reactivity, as they viewed gambling images in the eye-tracking task. Since both gambling and alcohol images were presented in the eye-tracking task, however, it is difficult to determine if viewing gambling images, alcohol images, or both images contributed to this increase in gambling cravings.

Additionally, there were no significant differences between conditions amongst the gamblers for the chosen eye-tracking variables: mean dwell time percent, first run dwell time, and second run dwell time. That is, it did not matter which cue exposure the gamblers experienced, they all preferentially attended to gambling images in both the gambling vs. alcohol and gambling vs. neutral trials. In fact, this preference for gambling images was observed in the gambling vs. alcohol trials when gamblers and non-gamblers were compared such that gamblers still preferred the gambling images over the alcohol images. Given that the gamblers in this sample were also drinkers, one might expect that their attention would be more equally divided between the gambling and alcohol images in this trial pairing. This itself is an interesting result, as it suggests that there may be an underlying mechanism in which gamblers preferentially attend to gambling stimuli in the face of other competing stimuli which should still be appealing to them. One suggestion is that this could be the result of gambling being a primarily visual activity, in contrast to drinking, where individuals can engage in other activities while they are drinking (i.e., when one is drinking, they typically do not spend the entire time staring at their drink). This warrants future investigation into gambling attentional biases as measured by eye-tracking paradigms.

The null findings with respect to cross-cue reactivity could be attributed to several factors. First, the inclusion criteria for alcohol and gambling co-use allowed individuals who responded that they only *sometimes* drink when they gamble. Additionally, given that we recruited poker players, it is likely that the association between drinking and gambling was weaker for them, as individuals who are serious about poker may avoid drinking while playing, due to potential effects of alcohol on their decision-making (Petry, 2002). Finally, I suspect that there may have been some evidence of cross-cue reactivity if a gambling cue had been presented rather than an alcohol cue. The two studies that have been conducted previously on gambling cross-cue reactivity had significant findings only in the gambling cue condition (Wulfert et al., 2016; Lipinski, 2010). It is feasible that many of the gamblers in the study do not drink *only* when they gamble, so they have many experiences of consuming alcohol without also gambling. As such, they may not immediately connect alcohol to gambling. However, even if they only sometimes drink when they gamble, a gambling cue may have elicited urges for alcohol because they have more experiences of gambling while drinking than experiences of gambling while not drinking. Thus, a gambling cue may have elicited urges for alcohol. A similar train of thought can be seen in the cross-cue reactivity literature for alcohol and smoking co-use. It is far more common for researchers to use alcohol cue exposure rather than tobacco cue exposure, as many individuals only smoke while they are drinking alcohol, and thus have no experiences of smoking without also drinking (Bobo & Husten, 2000).

Although I did not find anything to support that cross-cue reactivity occurs in gamblers who drink, there were other significant findings of note with respect to alcohol related cue reactivity. There was a significant difference between conditions for two of the eye-tracking variables, mean dwell time percent and second run dwell time. Participants who were exposed to an alcohol cue prior to eye-tracking spent significantly longer gazing at alcohol images for both trial pairings, and they also spent longer looking at alcohol images upon their second fixation. Both findings suggest that the cue exposure manipulation was successful, as increased attention to alcohol image indicates heightened cue reactivity towards alcohol in the alcohol cue condition only.

Interestingly, the differences in alcohol cravings between the alcohol and neutral cue conditions were not as clear. Alcohol cravings as assessed by the AUQ and two items on the SRS ("Want to Drink" and "Like to Drink") indicated that participants in the alcohol cue condition only increased in "Like to Drink" scores and not the other measures of alcohol craving following cue exposure. However, participants in both conditions reported significantly higher scores for "Want to Drink" following cue exposure. Although the observed effect size was much larger for the alcohol cue condition, this increase in alcohol urges for the neutral cue condition was unexpected.

One potential explanation for this finding is demand characteristics. Although participants did not know the true purpose of the study until they were debriefed at the end, they were likely aware that it had something to do with alcohol since many of our study advertisements had titles such as "Are you a male who drinks alcohol?" Furthermore, it is possible that simply asking participants about their alcohol urges acted as a cue itself. In addition, exposure to water cues could have feasibly resulted in increased thirst or desire to drink liquids. Unfortunately, participants were not directly queried for this possibility. If water cues increased thirst, then it is possible that participants would indicate increased desire to drinking beverages in general (including alcoholic beverages). Future research on this topic should address this possibility by establishing a baseline measure of thirst.

Strengths

This study had several strengths worth noting. First, the sample consisted of both members recruited from the community (*n* = 91, 77.12%) as well as undergraduate students (*n* = 27, 22.88%). Using primarily undergraduate samples is common practice in psychological research. However, these studies are limited in their generalizability as students differ from the general public in significant ways (Hanel & Vione, 2016). That said, this study did select for primarily poker players, a form of gambling that is particularly prevalent among male young adults (Gainsbury et al., 2010). Using a mix of community-recruited gamblers in addition to a convenience sample helps to enhance the external validity of the study's findings.

Another strength of this study was the use of *in vivo* cues. Previous research suggests that *in vivo* cues, as opposed to simply pictorial cues, are more effective for inducing acute craving (Cooney, Cooney, Pilkey, Kranzler, & Oncken, 2003). *In vivo* exposure permits use of multiple sensory modalities. For instance, participants were able to extensively interact with the cues by first choosing their favourite alcoholic drink, then pouring the drink, and then smelling it. This provides for a much more enhanced interaction than simply viewing images. Furthermore, offering participants in the alcohol cue condition a wide variety of alcoholic beverages tailors the cue exposure to each individual's preferences (Christiansen et al., 2015).

Finally, including an eye-tracking component adds an additional measure of cue and cross-cue reactivity that is more objective than self-report measures. Eye-tracking may circumvent issues that measures reliant on self-report are privy to, such as demand characteristics and social desirability biases. Using eye-tracking as an objective way to measure cue and cross-cue reactivity is an effective way of measuring unconscious processes (i.e., attentional biases).

Limitations

There are several limitations of this study that should be discussed. For one, although I used an *in vivo* cue exposure, which is consistently used in the cue reactivity literature, I also used a neutral testing room for the cue exposure protocol. As such, the cue exposure may have felt particularly artificial or contrived to the participants compared to if it had been done in a bar lab. There is no standardized cue exposure protocol for alcohol cue reactivity, although many are adaptations from the original protocol presented in Monti et al. (1993) (see Appendix A). Cue exposure protocols range from *in vivo* presentations, pictorial presentations, and guided narrative scripts; even within these categories, there are multiple methods of delivery. For instance, some studies employ the cue exposure in a neutral testing room, as in Monti et al. (1993), but other research has employed the cue exposure while the participant is in a bar lab (Jones, Rose, Cole, & Field, 2013) or in conjunction with an audio tape (Gauggel et al., 2010). The cue exposure is the present study could have been enhanced if I had chosen another cue exposure type to supplement the *in vivo* protocol.

Similar to differences in cue exposure protocols, measures of craving differ widely between studies. Self-report measures are commonly used, but there is no single scale that is repeatedly used by researchers for this purpose. Additionally, other research has used in-person semi-structured interviews as a way of assessing alcohol cravings (Gauggel et al., 2010). I used the AUQ and two items on the SRS, which have been previously used in studies that administer alcohol to participants (e.g., Barrett et al., 2015). However, the AUQ was developed for use in individuals with AUD and has been validated in samples of individuals who are dependent on alcohol. As such, it may not have been the best measure to use in my sample as I did not specifically recruit individuals with an AUD, and in fact excluded individuals who may have had an AUD if they indicated that they were trying to quit drinking during the screening process. This may have contributed to the null findings with respect to the AUQ and alcohol cravings between conditions, since the AUQ is better suited to assessing craving in individuals who are dependent on alcohol rather than those who use it recreationally.

Although our sample represents the population which it intended to study (i.e., poker players and healthy controls), it was limited in that I only recruited young adult (aged 18-35) males. Hence, it is not representative of gamblers nor of non-gamblers. As discussed earlier, gamblers are a heterogenous group, and focusing on strategic gamblers who were males does limit the generalizability of the results to gamblers as a larger group. There is a wealth of research suggesting important differences amongst gamblers by preferred gambling activity (Petry, 2002; Challét-Bouju et al., 2016), gender (Echeburúa et al., 2011), and age (Petry, 2002). For instance, DG rates tend to be highest amongst chance gambling (i.e., VLTs or slot machines) when compared to more strategic forms of gambling (Challét-Bouju et al., 2016). Similarly, there are important differences between males and females who gamble. Females tend to report being motivated to gamble in order to “escape” or to cope (Walker, Hinch, & Weighill, 2005). Additionally, female DGs tend to start gambling at an older age compare to males and develop a problematic relationship with gambling relatively more quickly than males (LaPlante, Nelson, LaBrie, & Shaffer, 2006). As such, it is important to include females in studies on gambling, particularly if the research is focused on DG and/or gambling in older adults.

There were also some issues with our gambling and alcohol co-use inclusion criteria. I used the question "How often do you drink when you gamble?" and potential participants could select from four options: never, sometimes, most of the time, or almost always. It was decided to include gamblers who only sometimes drink when they gamble. This ended up constituting just about half of the sample of gamblers (*n* = 30) and may have impacted gambling cravings and attentional biases following cue exposure.

Future Directions

The existing literature on gambling cross-cue reactivity is still sparse. Although I found largely null results in relation to cross-cue reactivity, future research can improve upon the present study in several ways. First, inclusion criteria should focus less on the type of gambling and more on the frequency of gambling and alcohol co-use. If using an eye-tracking procedure, gambling stimuli can be more generalized (i.e., include a variety of gambling images rather than solely poker images) while ensuring that participants pair their gambling with alcohol frequently enough to indicate that classical conditioning between the two activities has occurred. Specifically, participants who answer that they almost always or always drink when they gamble should only be recruited if studying cross-cue reactivity between gambling and alcohol. Including participants who gamble in venues where alcohol is served (i.e., bars for VLTs and casinos for VLTs, slots, and table games) is also warranted.

Second, the cue exposure could be improved upon in several ways. A study design that implements both alcohol and gambling cue exposures as separate conditions may help to further clarify whether the type of cue exposure is important in studying cross-cue reactivity in this population. Using a gambling cue instead or to supplement an alcohol cue may make more sense in practice, as it would be relatively easy to ask a participant to engage in a gambling task versus the potential safety and health risks that come with asking a participant to consume alcohol in a laboratory setting. Additionally, in terms of better understand gambling cue reactivity, no other studies to date have used eye-tracking as a measure of gambling cue reactivity following exposure to a gambling cue. Further research using an eye-tracking paradigm would be beneficial in understanding the mechanisms of cue reactivity in gambling. Furthermore, studies that use an alcohol cue exposure protocol could improve upon *in vivo* presentation in a neutral room by implementing it in a bar lab or in conjunction with audio tapes to enhance the experience of the cues.

Finally, a variety of gamblers, such as gamblers who prefer VLTs, slot machines, and/or table games, such as blackjack and roulette, should be included in future designs of this nature. These types of gambling are almost ubiquitously found in venues that also serve alcohol (casinos and bars) and thus may be a more representative population of gamblers who drink when they gamble. There should also be an effort to recruit females (to investigate potential gender differences), gamblers who are older adults, and DGs (to compare to non-DGs), in order to more thoroughly investigate cross-cue reactivity in gamblers.

References

Abdollahnejad, R., Delfabbro, P., & Denson, L. (2014a). Psychiatric co-morbidity in problem and pathological gamblers: Investigating the confounding influence of alcohol use disorder. *Addictive Behaviors, 39*, 566-572. doi: 10.1016/j.addbeh.2013.11.004

Abdollahnejad, R., Delfabbro, P., & Denson, L. (2014b). Understanding the relationship between pathological gambling and gambling-related cognition scores: The role of alcohol use disorder and delusion proneness. *International Gambling Studies*, *14*(2), 183-195. doi: 10.1080/14459795.2014.886711

Adlaf, E. M., Demers, A., & Gliksman, L. (2005). *Canadian campus survey 2004*. Toronto, Ontario, Canada: Centre for Addiction and Mental Health. Retrieved from http://www.ontla.on.ca/library/repository/mon/25005/309709.pdf on October 9, 2018

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Barrett, S. P., Collins, P., & Stewart, S. H. (2015). The acute effects of tobacco smoking and alcohol consumption on video-lottery terminal gambling. *Pharmacology, Biochemistry, and Behavior, 130*, 34-39. doi: 10.1016/j.pbb.2014.12.015

Bobo, J. K., & Husten, C. (2000). Sociocultural influences on smoking and drinking. *Alcohol Research & Health, 24*(4), 225-232.

Bohn, M. J., Krahn, D. D., & Staehler, B. A. (1995). Development and initial validation of drinking urges in abstinent alcoholics. *Alcoholism: Clinical and Experimental Research, 19*(3), 600-606.

Bradley, B. P., Mogg, K., Millar, N., & White, J. (1995). Selective processing of negative information: Effects of clinical anxiety, concurrent depression, and awareness. *Journal of Abnormal Psychology, 104*(3), 532–536.

Brewer, J. A., Potenza, M. N., & Desai, R. A. (2010). Differential associations between problem and pathological gambling and psychiatric disorders in individuals with and without alcohol abuse or dependence. *CNS Spectrums, 15*(1), 33-44. doi: 10.1017/S10928529 00000286

Canadian Partnership for Problem Gambling (2015, August). *Canadian Gambling Digest 2013 2014*. Retrieved from https://www.responsiblegambling.org/docs/default-source/default-document-library/cprg_canadian-gambling-digest_2013-14.pdf

Carpenter, M. J., Saladin, M. E., LaRowe, S. D., McClure, E. A., Simonian, S., Upadhyaya, H. P. & Gray, K. M. (2014). Craving, cue reactivity, and stimulus control among early-stage young smokers: Effects of smoking intensity and gender. *Nicotine & Tobacco Research, 16(*2), 208-215. doi: 10.1093/ntr/ntt147

Carter, B. L., & Tiffany, S. T. (1999). Meta-analysis of cue-reactivity in addiction research. *Addiction, 94*(3), 327-340.

Challét-Bouju, G., Hardouin, J., Lagadec, M., Burlacu, S., Valleur, M., Magalon, D., … & Grall Bronnec, M. (2016). Profiles of problem and non-problem gamblers, depending on their preferred gambling activity. *Addiction Research & Theory, 24*(3), 209-222. doi: 10.3109/16066359.2015.1102895

Christiansen, P., Mansfield, R., Duckworth, J., Field, M., & Jones, A. (2015). Internal reliability of the alcohol-related visual probe task is increased by utilizing personalized stimuli and eye-tracking. *Drug and Alcohol Dependence, 155*, 170-174. doi:10.1016/j.drugalcdep. 2015.07.672

Ciccarelli, M., Nigro, G., Griffiths, M. D., Cosenza, M., & D'Olimpio, F. (2016). Attentional biases in problem and non-problem gamblers. *Journal of Affective Disorders*, *198*, 135 141. doi: 10.1016/j.jad.2016.03.009

Conklin, C. A., & Tiffany, S. T. (2002). Applying extinction research and theory to cue-exposure addiction treatments. *Addiction*, *97*(2), 155-167.

Cooney, J. L., Cooney, N. L., Pilkey, D. T., Kranzler, H. R., & Oncken, C. A. (2003). Effects of nicotine deprivation on urges to drink and smoke in alcoholic smokers. *Addiction, 98*(7), 913-921.

Cooper, M. L., Russell, M., Skinner, J. B., & Windle, M. (1992). Development and validation of a three-dimensional measure of drinking motives. *Psychological Assessment*, *4*(2), 123-132. doi: 10.1037/1040-3590.4.2.123

Corbin, W. R., & Cronce, J. M. (2017). Effects of alcohol, initial gambling outcomes, impulsivity, and gambling cognitions on gambling behavior using a video poker task. *Experimental and Clinical Psychopharmacology, 25*(3), 175-185. doi: 10.1037/pha 0000125

Cox, W. M., Hogan, L. M., Kristian, M. R., & Race, J. H. (2002). Alcohol attentional bias as a predictor of alcohol abusers' treatment outcome. *Drug and Alcohol Dependence, 68*(3), 237-243.

Cox, W. M., Pothos, E. M., & Hosier, S. G. (2007). Cognitive motivational predictors of excessive drinkers' success in changing. *Psychopharmacology, 192*(4): 499–510. doi: 10.1007/s00213-007-0736-9

Cronce, J. M., & Corbin, W. A. (2010). Effects of alcohol and initial gambling outcomes on within-session gambling behavior. *Experimental Clinical Psychopharmacology*, *18*(2), 145-157. doi:10.1037/a0019114.

Currie, S. R., Hodgins, D. C., & Casey, D. M. (2013). Validity of Problem Gambling Severity Index interpretive categories. *Journal of Gambling Studies, 29*(2), 311-327. doi: 10.1007/ s10899-012-9300-6

Diana, M. (2011). The dopamine hypothesis of drug addiction and its potential therapeutic value. *Frontiers in Psychiatry*, *2*(64). doi: 10.3389/fpsyt.2011.00064

Drummond, D. C. (2000). What does cue-reactivity have to offer clinical research? *Addiction*, *95*(2), S129-S144.

Drummond, D. C., & Phillips, T. S. (2002). Alcohol urges in alcohol-dependent drinkers: Further validation of the Alcohol Urge Questionnaire in an untreated community clinical population. *Addiction*, *97*(11), 1465-1472. doi: 10.1046/j.1360-0443.2002.00252.x

Drummond, S., Tiffany, S. T., Glautier, S. & Remington, B. (1995) Cue exposure in understanding and treating addictive behaviour. In D. C. Drummond, S. T. Tiffany, S. Glautier, & B. Remington (Eds.), *The Wiley series in clinical psychology. Addictive behaviour: Cue exposure theory and practice* (pp. 1-17). Oxford, England: John Wiley & Sons.

Echeburúa, E., González-Ortega, I., de Corral., & Polo-López, R. (2011). Clinical gender differences among adult pathological gamblers seeking treatment. *Journal of Gambling Studies, 27*(2), 215-227. doi: 10.1007/s10899-010-9205-1.

Eckstein, M. K., Buerra-Carrillo, B., Singley, A. T., & Bunge, S. A. (2017). Beyond eye gaze: What else can eyetracking reveal about cognition and cognitive development? *Developmental Cognitive Neuroscience, 25*, 69-91. doi: 10.1016/j.dcn.2016.11.001

Ellery, M., & Stewart, S. H. (2014). Alcohol affects video lottery terminal (VLT) gambling behaviors and cognitions differently. *Psychology of Addictive Behaviors, 28*(1), 206-216. doi: 10.1037/a0035235

Ellery, M., & Stewart, S. H., & Loba, P. (2005). Alcohol's effects on Video Lottery Terminal (VLT) play among probably pathological and non-pathological gamblers. *Journal of Gambling Studies, 21(*3), 299-324. doi: 10.1007/s10899-005-3101-0

Engels, R. C. M. E., Hermans, R., van Baaren, R. B., Hollenstein, T., & Bot, S. M. (2009). Alcohol portrayal on television affects actual drinking behaviour. *Alcohol and Alcoholism, 44*, 244–249. doi: 10.1093/alcalc/agp003

Engwall, D., Hunter, R., & Steinberg, M. (2004). Gambling and other risk behaviors on university campuses. *Journal of American College Health, 52*(6), 245-255. doi: 10.3200/JACH.52.6.245-256

Faunce, G. J. (2002). Eating disorders and attentional bias: A review. *Eating Disorders, 10*, 125-139. doi: 10.1080/10640260290081696

Ferris, J., & Wynne, H. J. (2001). *The Canadian Problem Gambling Index final report.* Ottawa, ON: Canadian Centre on Substance Abuse.

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence*, *97*(1–2), 1–20. doi: 10.1016/j.drugalcdep.2008.03.030

Field, M., Marhe, R., & Franken, I. H. A. (2014). The clinical relevance of attentional bias in substance use disorders. *CNS Spectrums, 19,* 225-230. doi: 10.1017/S1092852913000321

Field, M., Mogg, K., Mann, B., Bennett, G. A., & Bradley, B. P. (2013). Attentional biases in abstinent alcoholics and their association with craving. *Psychology of Addictive Behaviors*, *27*(1), 71-80. doi: 10.1037/a0029626

Field, M., Munafò, M. R., & Franken, I. H. A. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin*, *135*(4), 589-607. doi: 10.1037/a0015843

Gainsbury S. M., Suhonen N., & Saastamoinen J. (2014). Chasing losses in online poker and casino games: Characteristics and game play of Internet gamblers at risk of disordered gambling. *Psychiatry Research*, *217*(3), 220–225. doi: 10.1016/j.psychres.2014.03.033

Gauggel, S., Heusinger, A., Forkmann, T., Boecker, M., Lindenmeyer, J., … Staedtgen, M. (2010). Effects of alcohol cue exposure on response inhibition in detoxified alcohol dependent patients. *Alcoholism: Clinical and Experimental Research, 34*(9). doi: 10.1111/j.1530-0277.2010.01243.x

Giacopassi, D., Stitt, B. G., & Vandiver, M. (1998). An analysis of the relationship of alcohol to casino gambling among college students. *Journal of Gambling Studies*, *14*(2), 135-149.

Griffiths, M., Wardle, H., Orford, J., Sproston, K., & Erens, B. (2010). Gambling, alcohol, consumption, cigarette smoking and health: Findings from the 2007 British Gambling Prevalence Survey. *Addiction Research and Theory, 18*(2), 208-223. doi: 10.3109/ 16066350902928569

Gulliver, S. B., Rohsenow, D. J., Colby, S. M., Dey, A. N., Abrams, D. B., Niaura, R. S., & Monti, P. M. (1995). Interrelationship of smoking and alcohol dependence, use and urges to use. *Journal of Studies on Alcohol, 56*(2), 202-206.

Hanel, P. H. P., & Vione, K. C. (2016). Do student samples provide an accurate estimate of the general public? *PLoS ONE, 11*(12), e0168354. doi: 10.1371/journal.pone.0168354

Hayter, A. J. (1986). The maximum familywise error rate of Fisher's least significance difference test. *Journal of the American Statistical Association, 81*(396), 1000-1004.

Hodgins, D. C., Peden, N., & Cassidy, E. (2005). The association between comorbidity and outcome in pathological gambling: A prospective follow-up of recent quitters. *Journal of Gambling Studies, 21*(3), 255-271. doi: 10.1007/s10899-005-3099-3

Hønsi, A., Mentzoni, R. A., Molde, H., Pallesen, S. (2013). Attentional bias in problem gambling: A systematic review. *Journal of Gambling Studies, 29*, 359-375. doi: 10.1007/s10899-012-9315-z

Jones, A., Rose, A. K., Cole, J., & Field, M. (2013). Effects of alcohol cues on craving and ad libitum alcohol consumption in social drinkers: The role of disinhibition. *Journal of Experimental Psychopathology, 4*(3), 239-249. doi: 10.5127/jep.031912

Kambouropoulos, N., & Staiger, P.K. (2001). The influence of sensitivity to reward on reactivity to alcohol-related cues. *Addiction, 96*, 1175–1185. doi: 10.1080/0965214012 0060761.

Kim, H. S., Salmon, M., Wohl, M. J. A., & Young, M. (2016). A dangerous cocktail: Alcohol consumption increases suicidal ideations among problem gamblers in the general population. *Addictive Behaviors, 55,* 50-55. doi: 10.1016/j.addbeh.2015.12.017

Koordeman, R., Anschutz, D.J., van Baaren, R.B., & Engels, R.C.M.E. (2011). Effects of alcohol portrayals in movies on actual alcohol consumption: An observational experimental study. *Addiction, 106*, 547–554. doi: 10.1111/j.1360-0443.2010.03224.x.

Kyngdon, A., & Dickerson, M. (1999). An experimental study of the effect of prior alcohol consumption of a simulated gambling activity. *Addiction, 94*(5), 697-707. doi: 10.1046/ j.1360-0443.1999.9456977.x

Lane, S. D., Cherek, D. R., Pietras, C. J., & Tcheremissine, O. V. (2004). Alcohol effects on human risk taking. *Psychopharmacology, 172*(1), 68-77. doi: 10.1007/s00213-003-1628-2

LaPlante, D. A., Nelson, S. E., LaBrie, R. A., Shaffer, H. J. (2006). Men & women playing games: Gender and the gambling preferences of Iowa gambling treatment program participants. *Journal of Gambling Studies, 22*(1), 65-80. doi: 10.1007/s10899-005-9003-3

Ledgerwood, D. M., Alessi, S. M., Phoenix, N., & Petry, N. M., (2009). Behavioral assessment of impulsivity in pathological gamblers with and without substance use disorder histories versus healthy controls. *Drug and Alcohol Dependence, 105*, 89-96. doi:10.1016/j.drugalc dep.2009.06.011

Levin, J. R., Serlin, R. C., & Seaman, M. A. (1994). A controlled, powerful multiple-comparison strategy for several situations. *Psychological Bulletin, 115*(1), 153-159.

Lipinski, (2010). *Effects of gambling on alcohol cravings and mood* (doctoral dissertation). Retrieved from ProQuest Dissertations & Theses database. (Order No. 3370273).

Lister, J. L., Milosevic, A., & Ledgerwood, D. M. (2015). Personality traits of problem gamblers with and without alcohol dependence. *Addictive Behaviors, 47*, 45-54. doi: 10.1016/ j.addbeh.2015.02.021

Lorains, F. K., Cowlishaw, S., & Thomas, S. A. (2011). Prevalence of comorbid disorders in problem and pathological gambling: A systematic review and meta-analysis of population surveys. *Addiction, 106*(3), 490-498. doi: 10.1111/j.1360-0443.2010.03300.x.

Luna, B., Velanova, K., & Geier, C.F. (2008). Development of eye-movement control. *Brain and Cognition*, *68*(3), 293–308. doi: 10.1016/j.bandc.2008.08.019

Lynam, D. R., Smith, G. T., Whiteside, S. P., & Cyders, M. (2006). The UPPS-P: Assessing five personality pathways to impulsive behavior (Technical Report). West Lafayette.

Mackillop, J. (2006). Factor structure of the Alcohol Urge Questionnaire under neutral conditions and during a cue-elicited urge state. *Alcoholism: Clinical and Experimental Research, 30*(8), 1315-1321. doi: 10.1111/j.1530-0277.2006.00159.x

MacKillop, J., & Lisman, S. A. Examining the effect of perceived availability on craving for alcohol: A quasi-experimental approach. *Addiction Research & Theory, 15*(3), 231-245. doi: 10.1080/16066350701407104

Martens, M. P., Rocha, T. L., Cimini, M. D., Diaz-Myers, A., Rivero, E. M., & Wulfert, E. (2009). The co-occurrence of alcohol use and gambling activities in first-year college students. *Journal of American College Health*, *57*(6), 597-602. doi: 10.3200 JACH.57. 6.597-602

Maxwell, S. E., & Delaney, H. D. (Eds.). (2004). *Designing experiments and analyzing data: A model comparison perspective*. New York, NY: Psychology Press.

McGrath, D. S., Meitner, A., & Sears, C. R. (2018). The specificity of attentional biases by type of gambling: An eye-tracking study. PLoS ONE, 13(1), 1-16. doi: 10.1371/journal.pone. 0190614

Monti, P. M., Binkoff, J. A., Abrams, D. B., Zwick, W. R., Nirenberg, T. D. & Liepman, M. R. (1987). Reactivity of alcoholics and nonalcoholics to drinking cues. *Journal of Abnormal Psychology*, *96*(2), 122-126.

Monti, P. M., Rohsenow, D. J., Rubonis, A. V., Niaura, R. S., Sirota, A. D. Colby, S. M., & Abrams, D. B. (1993). Alcohol cue reactivity: Effects of detoxification and extended exposure. *Journal of Studies on Alcohol, 54*(2), 235-245.

Muraven, M., & Shmueli, D. (2006). The self-control costs of fighting the temptation to drink. *Psychology of Addictive Behaviors, 20*, 154–160. doi: 10.1037/0893-164X. 20.2.154.

National Institute on Alcohol Abuse and Alcoholism. (n.d.) Recommended alcohol questions. Retrieved from https://www.niaaa.nih.gov/research/guidelines-and-resources/recommended-alcohol-questions on June 25, 2019.

Ontario Lottery and Gaming Corporation. (2018, November) *Annual report 2017-2018*. Retrieved from https://about.olg.ca/wp-content/uploads/2018/11/OLGAnnualReport-2017-18-en.pdf

Petry, N. M. (2002). A comparison of treatment-seeking pathological gamblers based on preferred gambling activity. *Addiction, 98*, 645-655.

Petry, N. M., & Kiluk, B. D. (2002). Suicidal ideation and suicide attempts in treatment-seeking pathological gamblers. *The Journal of Nervous and Mental Disease*, *190*(7), 462-469. doi: 10.1097/01.NMD.0000022447.27689.96.

Phillips, J. G., & Ogeil, R. P. (2007). Alcohol consumption and computer blackjack. *Journal of General Psychology*, *134*(3), 333–353. doi: 10.3200/GENP.134.3.333-354

Potenza, M. N., Steinberg, M. A., & Wu, R. (2005). Characteristics of gambling helpline callers with self-reported gambling and alcohol use problems. *Journal of Gambling Studies, 21*(3), 233-254. doi: 10.1007/s10899-005-3098-4

Powers, L. (2019, April 11). Booze at 9 a.m., online gambling and more combat sports feature heavily in PC budget. *CBC News*. Retrieved from https://www.cbc.ca/news/canada/toronto/ontario-budget-2019-booze-gambling-combat-sports-1.5092742

Reinert, D. F., & Allen, J. P. (2007). The Alcohol Use Disorders Identification Test: An update of research findings. *Alcoholism: Clinical & Experimental Research, 31*(2), 185-199. doi: 10.1111/j.1530-0277.2006.00295.x

Robinson, T. E., Berridge, K. C. (1993). The neural basis of drug craving: an incentive-sensitization theory of addiction. *Brain Research Review, 18,* 247–291.

Rohsenow, D. J., Monti, P. M., Colby, S. M., Gulliver, S. B., Sirota, A. D., Niaura, R. S., & Abrams, D. B. (1997). Effects of alcohol cues on smoking urges and topography among alcoholic men. *Alcoholism: Clinical and Experimental Research, 21*(1), 101-107.

Rose, A. K., Field, M., Franken, I. H. A., & Munafò, M. (2013). Cue reactivity. In P. M. Miller (Ed.), *Principles of Addiction: Comprehensive Addictive Behaviors and Disorders* (pp. 413-423). San Diego, CA: Academic Press. doi: 10.1016/B978-0-12-398336-7.00043-7

Rush, B. R., Bassani, D. G., Urbanoski, K. A., & Castel, S. (2008). Influence of co-occurring mental and substance use disorders on the prevalence of problem gambling in Canada. *Addiction, 103*(11), 1847-1856. doi: 10.1111/j.1360-0443.2008.02338.x

Sagoe, D., Mentzoni, R. A., Leino, T., Molde, H., Haga, S., Fredericson, M., … Pallesen, S. (2017). The effects of alcohol expectancy and intake on slot machine gambling behavior. *Journal of Behavioral Addictions*, *6*(2), 203-211. doi: 10.1556/2006.6.2017.031

Skinner, I. W., Hübscher, M., Moseley, G. L., Lee, H., Wand, B. M., Traeger, A. C., … McAuley, J. H. (2018). The reliability of eyetracking to assess attentional bias to threatening words in healthy individuals. *Behavior Research Methods*, *50*(5), 1778-1792. doi: 10.3758/s13428-017-0946-y

Slutske, W. S., Ellingson, J. M., Richmond-Rakerd, L. S., Zhu, G., & Martin, N. G. (2013). Shared genetic vulnerability for disordered gambling and alcohol use disorder in men and women: Evidence from a national community-based Australian Twin Study. *Twin Research and Human Genetics*, *16*(2), 525-534. doi: 10.1017/thg.2013.11.

Starcke, K., Antons, S., Trotzke, P., & Brand, M. Cue-reactivity in behavioral addictions: A meta-analysis and methodological considerations. *Journal of Behavioral Addictions*, *7*(2), 227-238. doi: 10.1556/2006.7.2018.39

Stewart, S. H., & Kushner, M. G. (2002). Introduction to the special issue on ‘relations between gambling and alcohol use’. *Journal of Gambling Studies*, *21*(3), 223-231. doi: 10.1007/s10899-005-3097-5

Stewart, S. H., McWilliams, L. A., Blackburn, J. R., & Klein, R. M. (2002). A laboratory-based investigation of relations among video lottery terminal (VLT) play, negative mood, and alcohol consumption in regular VLT players. *Addictive Behaviors*, *27*(5), 819-835. doi: 10.1016/S0306-4603(01)00213-1

Tackett, J. L., Krieger, H., Neighbors, C., Rinker, D., Rodriguez, L., Edward, G. (2017). Comorbidity of alcohol and gambling problems in emerging adults: A bifactor model conceptualization. *Journal of Gambling Studies, 33*, 131-147. doi: 10.1007/s10899-016-9618-6

The Canadian Press. (2019, May 4). Ontario stops funding problem gambling research agency, orders closure. *CBC News*. Retrieved from https://www.cbc.ca/news/canada/toronto/ gambling-research-exchange-ontario-cut-1.5123316

Tobias-Webb, J., Griggs, R. L., Kaufman, N., & Clark, L. (2018). Role reversal: The influence of slot machine gambling on subsequent alcohol consumption. *Journal of Gambling Studies*. doi: 10.1007/s10899-018-9787-6

Veilleux, J. C., & Skinner, K. D. (2015). Smoking, food, and alcohol cues on subsequent behavior: A qualitative systematic review. *Clinical Psychology Review, 35*, 13-27. doi: 10.1016/j.cpr.2015.01.001

Wagner, G., Sevincer, A. T., Keim, R., Fähnrich, M., & Oettingen, G. (2018). Alcohol intake can reduce gambling behavior. *Psychology of Addictive Behaviors, 32*(7), 832-845. doi: 10.1037/adb0000396

Walker, G. J., Hinch, T. D., & Weighill, A. J. (2005). Inter- and intra-gender similarities and differences in motivations for casino gambling. *Leisure Sciences, 27*(2), 111-130. doi: 10.1080/01490400590912042

Waters, A.J., Shiffman, S., Bradley, B.P., & Mogg, K. (2003). Attentional shifts to smoking cues in smokers. *Addiction, 98*(10), 1409–1417.

Witteman, J., Post, H., Tarvainen, M., de Bruijn, A., Perna Ede, S., Ramaekers, J. G., & Wiers, R. W. (2015). Cue reactivity and its relation to craving and relapse in alcohol dependence: A combined laboratory and field study. *Psychopharmacology, 232*(20), 3685-3696. doi: 10.1007/s00213-015-4027-6

Wulfert, E., Harris, K., & Broussard, J. (2016). The role of cross-cue reactivity in coexisting smoking and gambling habits. *Journal of Gambling Issues, 32*, 28-43. doi: 10.4309/ jgi.2016.32.3

Young, M. M., & Wohl, M. J. A. (2009). The gambling craving scale: Psychometric validation and behavioral outcomes. *Psychology of Addictive Behaviors, 23*(3), 512-522. doi: 10.1037/a0015043

Zois, E., Kortlang, N., Vollstädt-Klein, S., Lemenager, T., Beutel, M., Mann, K., & Fauth-Bühler, M. (2014). Decision-making deficits in patients diagnosed with disordered gambling using the Cambridge gambling task: The effects of substance use disorder comorbidity. *Brain and Behaviour, 4*(4), 484-494. doi: 10.1002/brb3.231

Table 1

Definitions and Examples of the Eye-Tracking Variables Used for the Present Study

Variable Name*	Definition	Domain of attentional bias assessed‡	Detailed explanation of attentional bias domain	Example	Interpretation
Dwell time percent	The ratio of the total dwell time for the target image within a trial pairing by the total dwell time for the trial pairing	Overall attention to target image	Often called an attentional bias score; for a two-image design, a score > .50 or 50% indicates an attentional bias for the target image†	Participant X has a dwell time percent score of .54 for the alcohol images in the alcohol vs. neutral trials	Participant X spent on average 54% of the total trial dwell time looking at alcohol images for the alcohol vs. neutral trial pairings only
First run dwell time	The length of time the target image is looked at upon first fixation (i.e., when it is first looked at)	Early attention to target image	Automatic, unconscious processes; a low first run dwell time can indicate low interest in an image and/or an avoidance effect (i.e., they look at the image then quickly look away)	Participant X has a first run dwell time of 748.21 for alcohol images in the alcohol vs. neutral trials	Participant X spent 748.21 milliseconds on average gazing at the alcohol image when they first fixated on it during the alcohol vs. neutral trials only
Second run dwell time	The length of time the target image is looked at upon first fixation (i.e., when it is looked at for a second time)	Late attention to target image	More intentional and conscious processes; a longer second run dwell time can indicate greater interest in an image (i.e., indicates that the participant looked at image 1 first, then image 2, then back to image 1)	Participant X has a second run dwell time of 1350.23 for alcohol images in the alcohol vs. neutral trials	Participant X spent 1350.23 milliseconds on average gazing at the alcohol image when they looked at it for the second time in the alcohol vs. neutral trials only

*All eye-tracking variables are calculated from means across trial pairings and thus represent averages, not a total score

ǂ Following from definitions used in Skinner and colleagues (2018)

† C. Sears, personal communication (May 14, 2019)

Table 2

Demographic Characteristics and Comparisons between Gamblers and Non-Gamblers

	Non-Gamblers (n = 59)		Gamblers (n = 59)		Significance test		Effect size
Characteristic	N	% / M (SD)	N	% / M(SD)	χ^2 / t	p	V
Age	59	23.78 (4.70)	59	24.12 (5.05)	0.38	.71	
Student status							
Yes	46	78.00%	34	57.60%	5.59	.02*	0.22†
No	13	22.00%	25	65.80%			
Marital status							
Married/Common law	10	16.90%	9	15.30%	0.06	.80	
Single	49	83.10%	50	84.70%			
Ethnicity							
White	35	59.30%	38	64.40%	1.05	.59	
Aboriginal/Asian/Black/Latin American	11	18.60%	7	11.90%			
Mixed ethnicity	13	22.00%	14	23.70%			
Highest level of education completed							
High school	16	27.10%	12	20.30%	1.07	.59	
Some college/university	24	40.70%	29	49.20%			
College/university degree	19	32.20%	18	30.50%			
Employment status							
Employed part-time	20	33.90%	19	32.20%	7.16	.07	
Employed full-time	11	18.60%	22	37.30%			
Unemployed	19	32.20%	15	25.40%			
Other‡	9	15.30%	3	5.10%			
Annual income							
<$20,000 per year	36	61.00%	27	45.80%	6.12	.19	
$20,000-$40,000 per year	11	18.60%	12	20.30%			
$41,000-$60,000 per year	6	10.20%	8	13.60%			
$61,000-$80,000 per year	5	8.50%	5	8.50%			
>$80,000 per year	1	1.70%	7	11.90%			

‡ Included seasonal employment, self-employment, and one professional poker player

*p < .05 † Denotes a medium effect size for Cramer's V with 1 degree of freedom (Cohen, 1988)

Table 3

Alcohol Use and Impulsivity Measures with Comparisons between Non-Gamblers and Gamblers.

	Non-Gamblers (*n* = 59)		Gamblers (*n* = 59)		Significance test		Effect size
Measure	*N*	% / *M (SD)*	*N*	% / *M(SD)*	χ^2 / *t*	*p*	V/ *d*
Alcoholic drinks per week‡	58	7.95 (9.02)	58	10.23 (8.30)	-1.42	.16	
AUDIT							
Total score	58	8.88 (5.37)	59	11.98 (6.45)	-2.83	.006*	0.52†
Categorization							
Low risk	31	52.50%	17	28.80%	6.89	.03*	0.25††
Moderate risk	15	25.40%	23	39.00%			
High risk	13	22.00%	19	32.20%			
NIAA							
Frequency of drinking sessions							
Monthly	25	42.40%	18	30.50%	2.34	.31	
Weekly	24	40.70%	32	54.20%			
Daily	10	16.90%	9	15.30%			
Quantity (drinks per session)							
1 to 2 drinks	24	40.70%	11	18.60%	6.93	.07	
3 to 4 drinks	15	25.40%	20	33.90%			
5 to 6 drinks	10	16.90%	13	22.00%			
7 or more drinks	10	16.90%	15	25.40%			
Binge drinking							
Most drinks in a single session over past 12 months	59	11.50 (6.67)	59	14.31 (6.03)	-2.39	.02*	0.44†
Days drank > 5 drinks over past 30 days	59	3.11 (5.79)	59	4.37 (5.49)	-1.22	.23	
UPPS-P subscale scores							
Negative urgency	59	2.33 (0.70)	59	2.50 (0.58)	-1.48	.14	
Premeditation	59	2.09 (0.48)	59	2.07 (0.52)	0.17	.87	
Perseverance	59	1.96 (0.48)	59	2.00 (0.52)	-0.39	.70	
Sensation seeking	59	3.01 (0.52)	59	3.31 (0.43)	-3.31	.001*	0.63†
Positive urgency	59	1.85 (0.67)	59	2.20 (0.57)	-2.95	.004*	0.56†
Smoking status							
Daily	3	5.10%	8	13.60%	2.54	.28	
Occasionally	14	23.70%	12	20.30%			
Not at all	42	71.20%	39	66.10%			

‡ Several participants (*n* = 31) specified a range of drinks per week rather than a single number. For these participants, the average of the range was calculated and used in all analyses.
* *p* < .05
† Denotes a medium effect size (Cohen, 1988)
†† Denotes a medium effect size for Cramer's V with 2 degrees of freedom (Cohen, 1988)

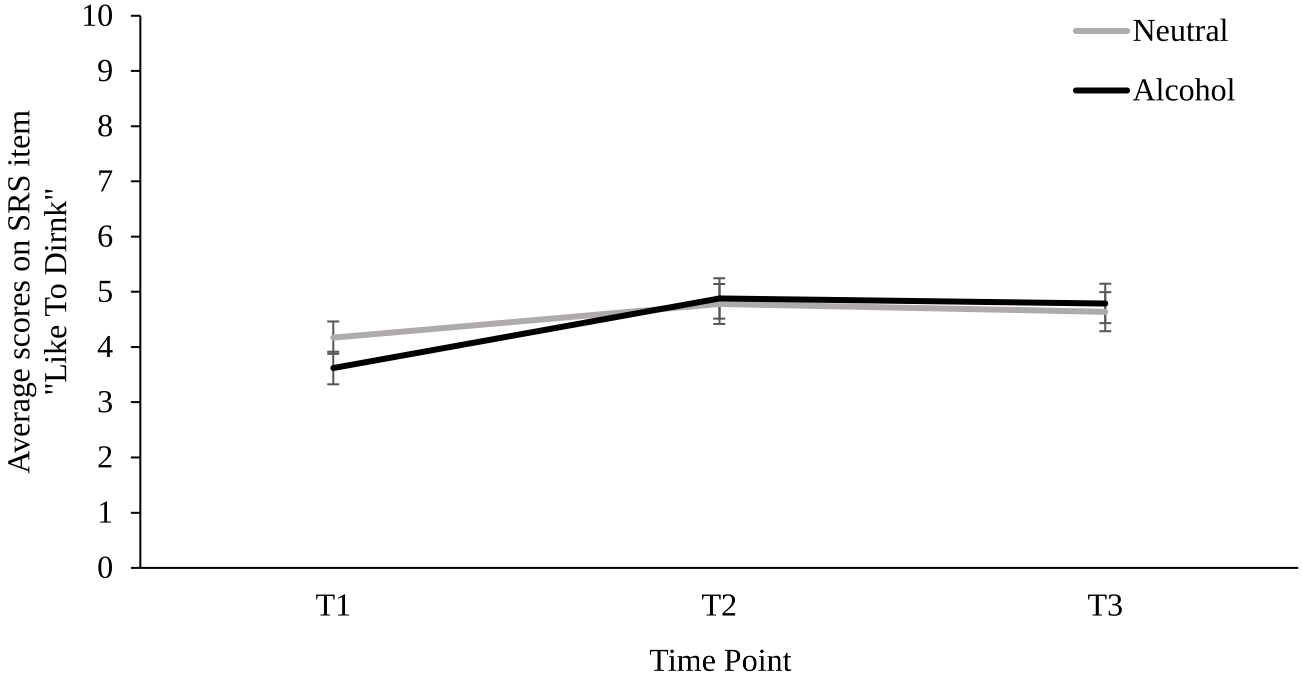

Figure 1. Average scores on "Like to Drink" for the neutral and alcohol cue conditions across all three time points. Error bars represent standard deviation.

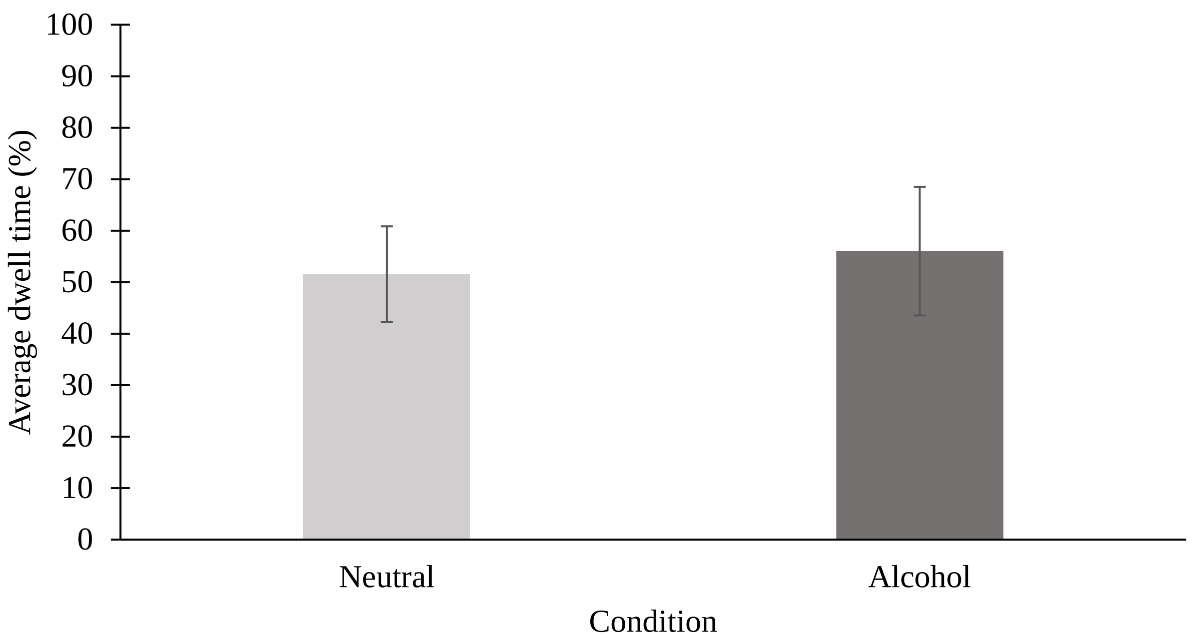

Figure 2. The mean dwell time percent scores for alcohol images in the alcohol vs. neutral trial pairings. Error bars represent standard deviation.

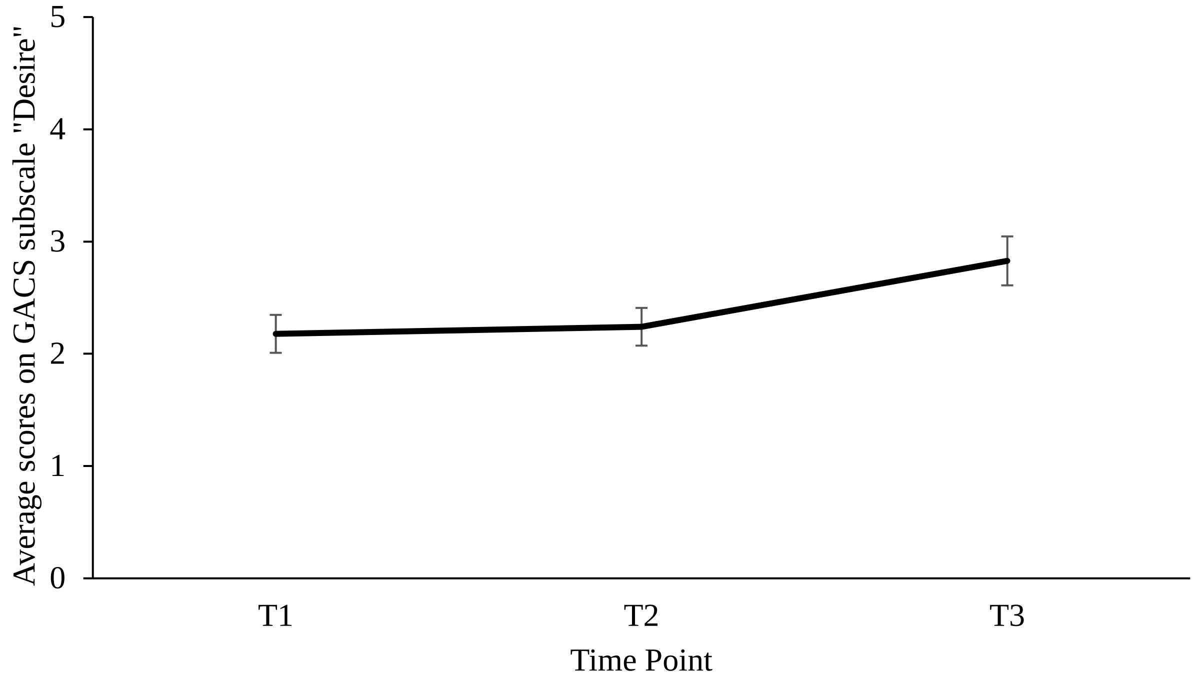

Figure 3. Average scores on the GACS subscale “Desire to Gamble” across all time points for gamblers only. Errors bars represent standard error.

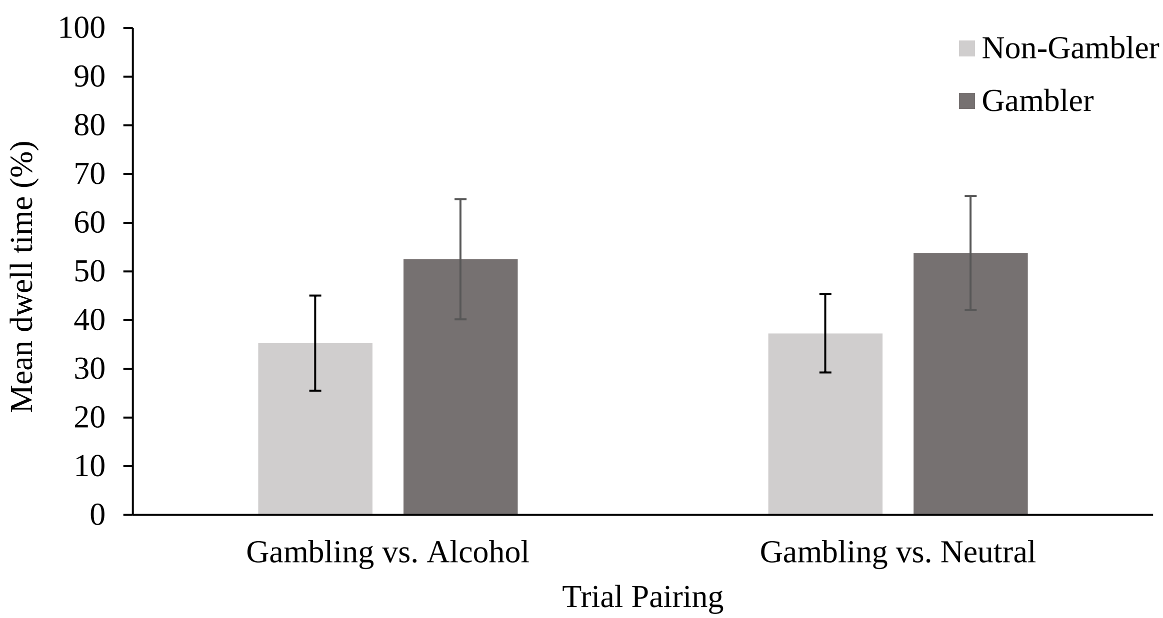

Figure 4. Average dwell time (% of total trial dwell time) for the gambling vs. alcohol and gambling vs. neutral trial pairings amongst gamblers and non-gamblers. Errors bars represent standard deviation.

Appendix A
Description of Original *In Vivo* Protocols

Monti et al. (1987)

Pre-study requirements. No consumption of food, tobacco, or caffeine 1 hour prior to the study session. All sessions started at 1 PM and lasted 45 minutes.

Protocol. Participants were seated in front of two inverted pitchers. Underneath one pitcher was the participant's preferred alcoholic beverage (PAB) with the branded can or bottle next to it. Underneath the other pitcher was a glass of water with a bottle of branded spring water next to it. A vial of dental rolls was located beside the pitchers. Participants were instructed via an audiotape to place the dental rolls in their mouth and to then uncover one of the pitchers. In the original protocol, the order of alcohol versus water was counterbalanced between subjects, so one group received the water exposure first and the other group received the alcohol cue exposure first. This was subsequently found to have carryover effects, so all subsequent studies that used this procedure exposed participants to the water cue first and the alcohol cue second.

In the first cue exposure trial, participants were instructed to pick up, hold, and occasionally sniff the beverage that was under the pitcher for 3 minutes. They were then told to cover the beverage with a pitcher and remove the dental rolls before relaxing for 5 minutes. During the relaxation period, they completed self-report measures that assessed urge to smoke and urge to drink on a Likert scale. When the relaxation period was over, participants put in a fresh set of cotton rolls before the second cue exposure trial commenced. This trial was identical to the second except that participants uncovered the other pitcher. After the second cue exposure trial, participants again removed their dental rolls, filled out the same self-report measures on urges to drink and smoke, and relaxed for another 5 minutes before being debriefed.

Monti et al. (1993)

Pre-study requirements. No consumption of food, tobacco, or caffeine 1 hour prior to the study session. All sessions started at 1 PM and lasted 45 minutes.

Protocol. The protocol was the same as described in Monti et al. (1987) save for two modifications. First, instead of being instructed to sniff the beverage occasionally (i.e. at random) during each cue exposure trial, participants were signaled to sniff for a duration of 5 seconds on 13 occasions in the 3-minute trial. This was done to standardize exposure to olfactory cues across trials. The signal was a tone played via an audiotape. Second, all participants completed the trials in the same order: (1) 3-minute relaxation period (2) 3-minute water cue exposure trial (3) 3-minute relaxation period (4) 3-minute alcohol cue exposure trial (5) 15-minute period where the relaxation period was alternated with the alcohol cue exposure trial, each for 3 minutes. The extended alcohol cue exposure period was tested here in order to assess how long it takes for participants to become habituated to the alcohol cue. They reported that urge to drink was highest after initial exposure and decreased with each subsequent exposure and concluded that a 3-minute alcohol cue exposure trial is best to assess cue reactivity.

Appendix B
Cue Exposure Protocol Script

Cue Exposure Procedure	**Check/ Notes**
Tell participant: "Okay, wait here for a minute while I bring in the materials for the next task, which is a focus task where you'll be asked to concentrate on different aspects of a drink for 30 seconds at a time."	
STEP 1: SELECTION OF DRINK & LOOK #1 (30 seconds) Wheel bar cart into neutral testing room. Tell participant: "So I have a selection of drinks here on this cart. For the first part of the task, I want you select one of them, whichever is your favourite or closest to your favourite. Then, for the next 30 seconds, I want you to look at the drink bottle. Think about the colour of the bottle, its shape and texture, and other physical features of the bottle. I'll tell you when the 30 seconds is finished."	
STEP 2: POURING DRINK INTO GLASS (30 seconds) Tell participant: "For the second part of the focus task, I want you to open the bottle/can, pour the drink into the glass, and then look at the poured drink for another 30 seconds. Again, I want you to carefully think about the colour of the drink and other physical features. I'll tell you when the 30 seconds is finished."	
STEP 3: SMELLING DRINK (30 seconds) Tell participant: "For the final part of this task, I want you to bring the drink to your nose and smell it for 30 seconds. Please breathe normally but ensure that you are smelling the drink. I'll tell you when the 30 seconds is finished."	
Tell participant: "Great, you're finished this part of the task. I'll take the drink from you and take the cart out of the room. In the meantime, please complete the next set of questionnaires on the laptop, and I'll be back in a second."	
Return to neutral testing room. When the participant is finished the questionnaires, take them into the eye-tracking room.	

Appendix C
Examples of Trial Pairings for the Eye-Tracking Task

Gambling vs. Alcohol Trial Example

Gambling vs. Neutral Trial Example

Alcohol vs. Neutral Trial Example