The Role of Craving, Executive Cognitive Functioning, and Hunger in Gambling

by

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Abstract

Disordered gamblers often persist in the face of loss, and report an inability to stop gambling despite repeated efforts. One possible reason for this continued gambling is poor executive cognitive functioning (ECF). Specifically, gamblers may lack the ability to control and regulate their behaviour. This paper examines the role of craving to gamble and hunger in producing ECF deficits and increased problem gambling behaviour. In Study 1 ($N = 26$), participants were allowed to gamble on a virtual slot machine until voluntary cessation, after which craving to gamble was assessed, and ECF was assessed using the Iowa Gambling Task (IGT). A proxy measure of hunger was used based on the temporal distance between the experiment start time, and noon (typical lunchtime). Results revealed that craving and hunger interacted to predict ECF deficits. Specifically, those with high levels of craving and hunger preformed the worst on the IGT. In order to determine causation, Study 2 ($N = 49$) manipulated craving using a cue reactivity paradigm. Craving was then assessed, as well as hunger and ECF using the Wisconsin Card Sorting Task (WCST). Results revealed that those cued with gambling related stimuli had higher levels of craving, and that those with high levels of craving and hunger preformed the worst on the WCST. Study 3 ($N = 49$), exposed all participants to gambling related stimuli, and used a fasting paradigm to manipulate hunger. Craving to gamble, hunger and ECF using the WCST were assessed, and participants were given the opportunity to gamble on a multi-line slot machine. Craving to gamble and hunger interacted to predict persistence at play on the slot machine in the face of continued loss. Specifically, participants high in craving to gamble and hunger engaged the longest in

play. Implications for feeding prior to play are discussed as a possible, easy to implement, responsible gambling strategy.

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Many addicts understand that their behaviour is unhealthy (e.g., Oncken, McKee, Krishnan-Sarin, O'Malley, & Mazure, 2005), yet they are seemingly compelled to continue engaging in the addictive behaviour. A large body of literature (e.g., Addolorato, Leggio, Abenavoli, & Gasbarrini, 2005; Franken, 2003; Volkow et al., 2006) suggests that this compulsion among addicts is due in part to cravings – the conscious experience of an urge or desire to engage in an addictive behaviour among addicted persons (Drummond, 2001). Airplane passengers who smoke, for example, typically experience heightened craving for nicotine just before the airplane lands (Dar, Rosen-Korakin, Shapira, Gottlieb, & Frenk, 2010). Because craving increases just prior to using the addictive substance or engaging in the addictive behaviour (see Dols, van den Hout, Kint, & Willems, 2002), it is often considered to play a pivotal role in the development, progression and maintenance of array of addictive behaviours (e.g., May, Andrade, Panabokke, & Kavanagh, 2004; Robinson & Berridge, 1993; Sharpe, 2002; Tiffany, 1999), including gambling (see Raylu & Oei, 2004). Indeed, akin to substance-based addictions, disordered gamblers (compared to those who only play recreationally) report heightened levels of craving both in anticipation of play, as well as a desire to continue playing once engaged in the activity (Young & Wohl, 2009).

Although there is general agreement that craving is an important antecedent of engagement with an addictive substance or behaviour, there is a distinct lack of understanding about *why* those who crave find it difficult to resist their temptations (see Ashrafioun & Rosenberg, 2011; Drummond, 2001). To address this gap in knowledge, my dissertation research puts forth a novel understanding of the link between craving and

addiction engagement that takes into account disruptions in normal cognitive processing among gamblers. Specifically, I will examine the downgrading of executive cognitive functioning as an important mechanism by which craving undermines gamblers' ability to refrain from engaging in play.

Similar to other addicts, disordered gamblers report trouble with executive cognitive function. Specifically, disordered gamblers often report difficulty controlling their behaviour even in the face of mounting financial, familial, and social problems. This loss of control is the hallmark feature of addictions in general (see Crews & Boettiger, 2009; Dackis & O'Brien 2001, 2005) and disordered gambling in specific (National Opinion Research Center, 1999). Importantly, deficits in goal-directed behaviour often accompany self-control problems (see Beaver, Wright, & Delisi, 2007; Hofmann, Schmeichel, & Baddeley, 2012). For example, gamblers who are not able to control their play also show deficits in planning, abstract reasoning, anticipation of consequences, cognitive flexibility, working memory, and response modulation and inhibition (e.g., Brand et al., 2005; Cavedini, Riboldi, Keller, D'Annucci, & Bellodi, 2002; Goudriaan, Oosterlaan, de Beurs, & Van den Brink, 2005, 2008; Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009). Theories of addiction and craving have increasingly incorporated aspects of cognitive functioning to explain the progression and maintenance of addictive behaviours (see Goldstein & Volkow, 2002; Tiffany, 1999). Unfortunately, the reason for the inability of some gamblers to control their behaviour has received very little empirical attention. Herein, I test a heretofore-unexamined notion that craving leads to play among some gamblers to the extent that their cognitive functioning and control is hampered.

Specifically, I test a mediation model in which cognitive functioning is the mediator of the relationship between craving and gambling.

The Role of Craving in Addiction

When an addicted person is asked why he or she engages with their addictive substance, they often reply, "I needed to." In psychological terms, what the addict is expressing is that they had a strong urge or craving that they were unable to resist. Addiction researchers have long known that craving plays a role in addiction. For example, Kerr (1889) stated craving for alcohol was a 'pathological depravity of the appetite centre' (p. 221). Of the array of antecedents for engaging in addictive behaviour, craving has traditionally been viewed as a central component of addiction. This is not to say that all researchers share this conviction. Mello (1972), for example, suggested that discussing craving as an antecedent of addiction was tautological because craving is defined by subsequent engagement in the addictive behaviour. Tiffany (1990) challenged this notion by arguing that craving does not always lead to engagement. In this way, craving is the conscious experience of a desire to engage in an addictive behaviour, but subsequent engagement is not necessary. With this understanding, interest in craving among researchers enjoyed a renascence (see Drummond, 2001). However, the nature of craving and its consequences are still a matter of debate in the addictions literature (e.g., Tiffany, 1992).

What is craving?

There are many different theoretical models that attempt to explain craving and its relation to addiction (see Drummond, 2001). While it is beyond the scope of this thesis to examine these theoretical models, Drummond (2001) has argued that theories of craving

grounded in general theories of human behaviour offer the most promise. These theories, such as those based on principles of conditioning and cognition, allow for a more specific examination of the consequences and antecedents of craving. Specifically, research and theory typically use a classical conditioning framework to explain craving (see Tiffany, 1995; 1999). Within this framework, craving is the product of the repeated pairing of environmental stimuli with the effects of a drug. Due to this repeated pairing, specific external cues become associated with the effects of the addiction (Drummond, Cooper, & Glautier, 1990). Specifically, a neutral stimulus becomes a conditioned stimulus by continually pairing it with an unconditioned response, which then elicits a conditioned response. For example, a person who injects heroin is in need of a syringe to administer the drug. The drug user will experience a euphoric state upon administration of the drug. After repeated administrations, a link between the syringe and the derived euphoric state from the drug is established. The consequence of this pairing is that, eventually, the syringe itself will elicit the desire for the drug and the euphoric state it delivers. In effect, the syringe becomes a cue that instigates a need or craving for the substance. Thus, to assess craving, researchers typically expose the addict to addiction-relevant cues (i.e., the cue reactivity paradigm; Drummond, 2001; Drummond, Tiffany, Glautier, & Remington, 1995). In doing so, subjective craving for an addictive substance typically increases (see Wilsons et al., 2004).

Gambling, and other impulse control disorders (e.g., shopping addiction), provide a unique opportunity to examine craving and its relationship to addiction. Whereas the euphoric state in substance-use addictions is derived from an ingested substance, this is not the case amongst gamblers. Thus, the process of addiction in gambling is unimpeded

by any negative effects of substances on health and brain functioning of the addict. In this way, gambling seems to stand apart from substance-related addictions. Notwithstanding, there are a great deal of similarities between the addiction that results from substance misuse and the addiction that results from excessive gambling (i.e., disordered gambling).

When diagnosing gamblers for disordered gambling using the DSM, five of the seven criteria have parallels in substance abuse (see Petry, 2006). For example, one criterion is that the gambler needs to gamble with increasing amounts of money in order to achieve the desired excitement, which describes a phenomenon known as tolerance. This criterion is similar to the tolerance criterion in substance abuse, in which the user needs markedly increased amounts of substance to achieve intoxication or the desired effect of the drug. Indeed, the similarities between substance-related addictions and gambling are striking. For example, in a meta-analysis of cue reactivity research, Carter and Tiffany (1999) concluded that a significant increase in self-reported craving occurs among people who are exposed to addiction-related stimuli. Specifically, addiction relevant cues are triggers that act as catalysts for promoting craving and addictive behaviours. Similarly, gamblers who are exposed to gambling-relevant cues are likely to report a heightened craving to play (Kushner et al., 2007 2008; Young, Wohl, Matheson, Baumann, & Anisman, 2008).

Gamblers also share many clinical, phenomenological and neurological similarities to substance abusers (e.g., Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009; Odlaug, Chamberlain, Kim, Schreiber, & Grant, 2011; van Holst, van den Brink, Veltman, & Goudriaan, 2010). Similar to substance abusers, disordered gamblers report persistent engagement in behaviour despite serious negative consequences, and a loss of

control and self-regulation (Blanco, Moreyra, Nunes, Saiz-Ruiz, & Ibanez, 2001; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2008; Holden, 2001, Potenza, 2008). Disordered gamblers also report withdrawal symptoms similar in severity to that of alcoholics, and gamblers may experience symptoms of tolerance similar to that of substance abusers (Blaszczynski, Walker, Sharpe, & Nower, 2008). The similarities between gambling and substance abuse are so great, that the newest version of the DSM has recognized gambling as an addiction, and has placed gambling alongside substance-based addiction with the creation of a new category labeled "substance related and addictive disorders" (American Psychiatric Association, 2013).

Interestingly, disordered gamblers often report higher levels of craving than substance abusers. For example, gamblers report significantly higher levels of impulsivity and inability to resist craving than cocaine addicts (Castellani & Rugle, 1995) and report higher levels of craving than those who are alcohol-dependent (de Castroa, Fong, Rosenthalb, & Tavaresa, 2007; Tavares, Zilberman, Hodgins, & el-Guebaly, 2005). At present, the reason why craving might be more intense for gamblers than for substance abusers is unknown. However, this state of affairs suggests that more research is needed on why craving leads to addictive behaviour in general, and how it acts as a motivator for gambling specifically.

Craving as a motivator for gambling.

While gambling is an enjoyable form of entertainment for most, it can become problematic in a small, but significant proportion of the population (Shaffer & Hall, 2001). That is, some people become addicted to wagering money on chance outcomes – the odds of which are not in their favour. In this light, gambling researchers have sought

to incorporate the notion of craving into their theories of disordered gambling (Rousseau, Vallerand, Ratelle, Mageau, & Provencher, 2002; Sharpe, 2002; Vallerand, Blanchard, Koestner, & Gagne, 2003; Young et al., 2008). From a classical conditioning and motivational standpoint, craving is a primary antecedent of gambling engagement (see Abrams & Kushner, 2004). That is, gambling should result from the urge to engage in play. For example, if a gambler is passing by a casino and feels a craving to gamble, one would assume that this craving is the primary motivating factor propelling the gambler to enter the casino and insert a coin into a slot machine or lay a bet on a Blackjack table. In other words, the motivation to gamble and subsequent engagement stems from the desire or craving to play (see Raylu & Oei, 2004; Sharpe, 2002; Stoeber, Harvey, Ward, & Childs, 2011; Young & Wohl, 2009). Thus, based on extant theory, a direct relationship should exist between craving and gambling.

Suggestive of a direct relationship between craving and gambling, Sharpe (2002) argued that craving is elicited among disordered gamblers when they are exposed to certain environmental and interceptive cues (e.g., advertisement for gambling or being in an emotional state) that then leads them to engage in gambling. In line with this supposition, Kushner and colleagues (2007) found that when disordered gamblers were exposed to a real casino environment, two-thirds experienced high to moderate levels of craving to gamble. Similarly, exposing frequent gamblers to a simulated casino environment resulted in higher cravings to gamble then when exposed to a neutral environment (Kushner et al., 2008). Providing more direct evidence for a relationship between craving to gamble and gambling behaviour, Young and Wohl (2009) showed that craving to gamble is positively associated with behaviours associated with disordered

gambling. In this study, gamblers bet on the outcomes of a virtual reality slot machine. Importantly, after their 50th spin all subsequent spins were losses. The more the gambler craved to gamble, the longer they persisted in the face of this repeated loss. This result suggests that craving may be a central motivating factor for continued gambling.

In fact, current conceptualizations of craving to gamble assume craving to be motivational state. For example, the gambling urge questionnaire (Raylu & Oei, 2004) assumes craving to be a motivation to seek out gambling or feelings associated with gambling. The gambling-related craving scale (GACS; Young & Wohl, 2009) expands on this notion by showing that craving to gamble is multidimensional. Specifically, gamblers crave in anticipation of play, desire to continue play whilst already engaged, and crave to gamble in order to relieve themselves of negative affect. These conceptualizations of craving to gamble, however, fail to address *why* craving leads to problematic play. One explanation is that that craving leads the gambler to become obsessed with play (Rousseau et al., 2002; Vallerand et al., 2003). For example, Rousseau and colleges (2002) define gambling as an obsessive passion, which is an internal pressure to perform a particular activity. This internal pressure is difficult to resist and is experienced as craving. This claim of gambling as an obsession, however, falls victim to the same tautological issue that plagued the craving literature in the 1970's when researchers like Mello (1972) argued that craving was an irrelevant construct because it necessarily leads to behaviour. Here, understanding gambling as an obsession entails the experience of craving to gamble as an antecedent of play.

Craving, however, may be but one of many factors influencing engagement in disordered gambling (Blaszczynski & Nower, 2002; Ledgerwood & Petry, 2006; Sharpe,

2002). Indeed, gamblers report numerous reasons for play in addition to craving (Neighbors, Lostutter, Cronce, & Larimer, 2002). For example, gamblers engage in play due to the belief that they have control over the objectively uncontrollable (i.e., the outcome of games of chance; Langer, 1975; Wohl & Enzle, 2002). Thus, although craving might initiate movement toward gambling, it might not be the factor that directly causes play. Suggestive of an indirect relationship between craving and gambling, Ashrafioun and Rosenberg (2011) argue that craving is not a necessary antecedent of gambling.

In this light, I contend that a more nuanced understanding of craving to gamble is required. Specifically, traditional motivational and classical conditioning theories do not properly account for the link between craving and gambling. Rationally, people should try to balance between a desire to gamble and a realization that excessive play may be financially (or otherwise) harmful. However, even though disordered gamblers are aware that their behaviour may be harmful they still have difficulty quitting or cutting back their gambling behaviour (Hodgins & el-Guebaly, 2004; Rosenthal & Lesieur, 1992). Why is the balance between approach (desire) and avoidance (knowledge of negative outcomes) not present among disordered gamblers? Although I, as well as others (Rousseau, Vallerand, Ratelle, Mageau, & Provencher, 2002; Sharpe, 2002; Vallerand et al., 2003; Young, et al., 2007), argue that craving plays a key role in driving people toward gambling, this is not the full story. A full story must include why craving influences gambling behaviour – a story not yet established in the extant empirical or theoretical literature. Uncovering why there is a link between craving and gambling (i.e., the mechanism) should go some way in clarifying the concept of craving generally and

craving among gamblers specifically. Moreover, if a mechanism can be found, a means to assist gamblers in weakening the link between craving and engagement might be possible.

My dissertation research will assess the mechanism by which craving to gambling facilitates problematic gambling behaviour. Specifically, I test the idea that craving impairs the gambler's cognitive capacity to control their play. That is, I ague that craving leads to cognitive impairments that in turn, cause gamblers to have poor control. This lack of cognitive control or executive cognitive functioning hinders the gambler's ability to stop play.

Executive Cognitive Functioning

Executive cognitive functioning (also known as executive function, executive control, or cognitive functioning) is a general umbrella term used to describe various complex cognitive processes (Elliott, 2003). These complex cognitive processes also involve sub-processes implicated in successful goal-directed behaviour, co-ordination and/or control of behaviour. Some of the sub-processes involved in ECF include planning, abstract reasoning, anticipation of consequences, cognitive flexibility, working memory, and response modulation and inhibition (Stuss & Benson, 1984). ECF coordinates these sub-processes, and if ECF fails, behaviour can become disjointed, disinhibited and uncontrolled.

To assess executive cognitive functioning, researchers have used a variety of cognitive tasks. For example, the Wisconsin Card Sorting Task (WCST; Berg, 1948) measures a person's ability to shift cognitive strategies in response to changing environmental conditions – an ability that has also been labeled as set-shifting or

cognitive flexibility. In this task, participants are presented with a series of cards. Each card has a coloured shape or a few coloured shapes printed on one side. For example, one card has two yellow triangles and another has one red square. Participants must place the card in one of four different cards piles according to an abstract rule. Specifically, the participant must pair their card with the different card piles according to the colour, shape, or the number of stimuli reproduced on the card. The goal of the task is for the participant to discover the rule that allows for correct pairing, which is discovered via feedback given to the participant when he or she places a card in its correct or incorrect pile. Importantly, the rules change after 10 correct pairings – the player must then figure out the new rule.

Another task commonly used to assess ECF is the Iowa Gambling Task (IGT). In this task, participants must pick a card from one of four decks of cards. Every time a person selects a card, he or she receives a reward of virtual money. The object of the IGT is to gain as much virtual money as possible (thus more closely mimicking a gambling experience than the WCST). However, on occasion, the reward is paired with a monetary penalty. Importantly, unbeknownst to the participant, two of the decks are 'good decks' and two of the decks are 'bad decks.' In the good decks, the participant receives moderate financial reward and low financial penalties. In the bad desks, the participant receives high financial reward, but even higher financial penalties. Because the IGT involves uncertainty in terms of reward and punishment, it is similar to real world situations and thus is an ecologically valid measure of the decision-making process (Bechara, Dolan, Denburg, Hindes, Anderson, & Nathan, 1994; Bowman & Tumbull, 2003). Individuals whom perform poorly on the IGT have poor ECF – they lack the executive control to

delay instant gratification (i.e., the prospects of large wins) to ensure long-term financial success.

Successful performance on ECF tasks rely heavily on intact function of the frontal cortex (see Banfield, Wyland, Macrae, & Heatherton, 2004; Duncan, 1986; Koechlin, Ody, & Kouneiher, 2003; Miller & Cohen, 2001). That is, individuals with damage to the frontal cortex demonstrate impulsivity, as well as poor judgment, organization, planning, and decision making (Luria, 1966; Shallice, 1982; Stuss & Benson, 1984). As such, they do poorly on ECF tasks (e.g., Minler, 1963). Pre-frontal cortex damage can occur in a multitude of ways from (among other ways) physical damage, drug induced impairments, or developmental deficiencies. For example, some people are born with poor ECF, and these ECF deficits may manifest in behavioural disorders such as attention deficit disorder (e.g., Aytaclar, Tarter, Kirisci, & Lu, 1999; Romer, et al., 2009; Sergeant, Geurts, & Oosterlaan, 2002), antisocial personality disorder (Stevens, Kaplan, & Hesselbrock, 2003) and other disorders where self-control is key (e.g., Bohne et al., 2006). Recently, ECF has been implicated in the initiation and progression of addictive behaviours.

The role of executive cognitive functioning in addiction.

Common to all addictions is an increasing lack of control, even in the face of serious negative consequences (see Crews & Boettiger, 2009; Dackis & O'Brien 2001, 2005). This loss of control often accompanies general deficits in ECF and deficits in ECF frequently accompany addictive behaviours (e.g. Barry & Petry, 2008; Bechara & Martin, 2004; Dolan, Bechara, & Nathan, 2008; Ernst et al., 2003; Giancola & Moss, 1998). According to Goldstein and Volkow (2002), addicted people may show ECF deficits due

to structural changes in brain areas caused by addictive substances. Specifically, deficits in frontal cortex functioning results from the consumption of a neurotoxic substance (Goldstein & Volkow 2002), which then have a detrimental impact in ECF performance. However, gambling does not involve ingesting neurotoxic substances, therefore one would expect gamblers to not have such ECF deficits. Yet, there is a growing literature that suggests that disordered gamblers do show decrements in ECF (e.g., Brand et al., 2005; Cavedini et al., 2002; Goudriaan et al., 2005, 2008; Lawrence et al. 2009; Linnet et al., 2006; Kertzman et al., 2011) – a fact that should not be surprising since, until recently, gambling was categorized an impulse control disorder by the American Psychiatric Association (see APA, 1994).

Although addiction researchers like Goldstein and Volkow (2002) argue that the addictive substance is responsible for decrements in ECF, a reverse causal model is also possible. That is, people who have pre-existing ECF deficits might be less likely to refrain or control themselves from engaging in an addictive behaviour such as gambling (see Von Hipple et al., 2009). This would explain why gamblers show decrements in ECF even though they do not ingest neurotoxic substance. For this reason, gambling is an ideal model of addiction that may shed light on the addiction process and underlying neurobiology of addiction including craving and ECF (see Bechara, 2003; Goodman, 2008; Potenza, 2006; Tamminga & Nestler, 2006).

Executive cognitive functioning as an antecedent of disordered gambling.

A key feature of disordered gambling is persistence in the face of loss (National Opinion Research Center, 1999). Researchers have suggested this persistence in the face of loss may be due to (a) impaired decision-making processes, (b) problems in inhibition

when making choices, and/or (c) poor problem-solving skills (see Clark, 2010; Kertzman, Lidogoster, Aizer, Kotler, & Dannon, 2006; Sharpe, 2002; van Holst., van den Brink, Veltman & Goudriaan, 2010). All of these explanations may be reflective of deficits in ECF (see Barkley, 2001; Bechara, Damasio, Damasio, & Anderson, 1994). It is possible that disordered gamblers have deficits in ECF and underlying frontal cortex dysfunction similar to substance-based addictions (e.g. Clark, 2010; Grant, Potenza, Weinstein, & Gorelick, 2010), as both gamblers and substance abusers share a number of characteristics with patients who have had damage to the ventromedial prefrontal cortex. One of these shared characteristics includes a general 'myopia for the future' where addicted individuals are insensitive to future consequences and often choose immediate rewards, even though there are long-term negative consequences (see Bechara, 2003; Bechara et al., 2001, 2004; Bechara, Tranel, & Damasio, 2000; Cavedini, Riboldi, Keller, D'Annucci, & Bellodi, 2002). This may explain why disordered gamblers choose to gamble, even in the face of growing negative consequences. Accompanying this 'myopia for the future', disordered gamblers also demonstrate poor ECF similar to that of substance abusers, which may help explain the progression and maintenance of maladaptive gambling behaviour (Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009).

Akin to addiction research in general, two of the most common ECF tasks used to assess cognitive functioning among gamblers include the IGT and WCST. Compared to non- disordered, healthy controls, disordered gamblers tend to perform worse on the IGT and similar tasks measuring decision making (Brand et al., 2005; Cavedini et al., 2002; Goudriaan, Oosterlaan, dr Beurs, & van den Brink, 2005; Kertzman et al., 2011; Lakey, Goodie, & Campbell, 2007; Lawrence et al., 2009; Linnet, Rojskjaer, Nygaard, & Maher,

2006; Ledgerwood et al., 2011; Petry, 2001). Disordered gamblers also perform poorly on the WCST and similar tasks that measure cognitive shifting and flexible responding (Forbush et al., 2008; Goudriaan et al., 2006; Kalechstein et al., 2007; Marazziti et al., 2008; Rugle & Melamed, 1993; Odlaug et al., 2011). Thus, research on ECF among gamblers suggests that disordered gamblers have deficits in a number of cognitive areas.

Poor ECF may result in disjointed, disinhibited, and uncontrolled behaviour, thus poor ECF may contribute to the development and progression of disordered gambling. Indeed, poor ECF may explain the development and progression of disordered gambling among both older adults (von Hippel, Ng, Abbot, Caldwell, Gill, & Powell, 2009) and youth (Betancourt et al., 2012; Romer, Betancourt, Giannetta, Brodsky, Farah, & Hurt, 2009). What has yet to determined is how gamblers come to have ECF deficits. What is known is that stress can negatively affect ECF (e.g., de Kloet, Joëls, & Holsboer, 2005; McEwen & Sapolsky, 1995; Preston, Buchanan, Schoofs, Preuss, & Wolf, 2008) – a factor that can lead to problematic gambling behaviours (e.g., Bergevin, Gupta, Derevensky, & Kaufman, 2006; Coman, Burrows, & Evans, 1997), but no study to-date has specifically examined factors that affect ECF among gamblers. Herein I suggest that craving is a possible antecedent of poor ECF. Specifically, the intense urge or desire to engage in an addictive behaviour may impair a person's ability to control their executive functions.

Craving as an antecedent of poor executive cognitive functioning.

Addicts commonly report intense cravings that consume their thoughts and undermine their ability to control their behaviour (e.g., Goldstein, 2001; Loewenstein, 1999). Research conducted by Potenza and colleagues (2003) provided an empirical

substance behind this claim. They used a fMRI to assess the neural activity of gamblers whilst craving to gamble. To induce craving they exposed disordered gamblers and non-disordered controls to a videotaped gambling scenario in an fMRI machine. Disordered gamblers reported increased subjective craving, and decreased activation in brain regions associated with self-control and response conflict processing. Thus, gamblers who crave appear to have difficulty with their executive control. Of course, fMRI experiments are very time consuming and costly. A more convenient, less intrusive and less expensive way to assess functioning in cortical areas of the frontal cortex is through assessing ECF (Banfield, Wyland, Macrae, & Heatherton, 2004; Duncan, 1986; Koechlin, Ody, & Kouneiher, 2003; Miller & Cohen, 2001). Specifically, researchers can assess ECF via tasks like the previously described WCT or the IGT.

Disordered gamblers perform worse on measures of ECF than healthy controls (e.g., Cavedini et al., 2002; Goudriaan, Oosterlaan, de Beurs, & Van den Brink, 2004; Roca, Torralva, López, Cetkovich, Clark, & Manes, 2008). Ashrafioun and Rosenberg (2011) suggest that one reason gamblers may do worse on certain ECF tasks is due to cravings. Specifically, they suggest that gambling-related cues within ECF tasks may elicit craving to gamble. Indeed, it has been suggested that performance on the IGT may be influenced by craving. Specifically, the IGT contains aspects of gambling implicit in the task (i.e., winning and losing money bested on uncertain outcomes). Thus, thus a gamblers craving, arousal, and/or past gambling experience may affect performance on the IGT (Goudriaan et al., 2004). Unfortunately, no data has yet to be collected to substantiate this claim. That is, at present, the link between craving and poor performance on ECF tasks remains theoretical. However, Von Hipple and colleagues (2009) have

argued that craving should undermine ECF. They suggest that gamblers with poor ECF should be unable to inhibit the motivation that craving elicits. This is because ECF works as a counterbalance to control behaviour – in this case gambling – in the face of cravings to engage in play.

In the current research, I make a bolder claim than that proposed by Von Hipple and colleagues (2009). Whereas Von Hipple and colleagues (2009) suggest that craving will lead to disordered gambling when gamblers have poor ECF, I take this one-step further by suggesting that craving is the *cause* of poor ECF. Put another way, I suggest that craving is the driving force *behind* decreases in a person's ability to control their behaviour, which will then lead to problematic gambling behaviour. Given the links between (a) craving and gambling, (b) craving and ECF, and (c) ECF and gambling, I argue that a mediated model explains these links. Specifically, I argue that ECF mediates the relationship between craving and disordered gambling. The hypothesis I aim to test in this program of research is that increases in craving to gamble will result in decreased ECF, which in turn will lead to disordered gambling. However, there may also be mechanisms at play that strengthen the link between craving, ECF and disordered gambling behaviour. Specifically, there likely exist factors that exacerbate the role that craving has on disordered gambling behaviour. I proposed one such exacerbating factor is hunger (i.e., the desire to eat).

Hunger

It has long been known that people are more likely to make risky decisions when they are hungry (Symmonds, Emmanuel, Drew, Batterham, & Dolan, 2010). From an evolutionary framework, this makes sense– as food becomes scarce there is a need to

hunt more “risky” prey (Damsgard & Dill, 1998). Importantly, hungry people may engage in an array of risky behaviours. That is, risk-taking as a result of hunger extends beyond behaviours that facilitate feeding, possibly because it lowers self-control. Indeed, a series of studies by Gailliot (2007) found that performance on a number of self-control tasks was deteriorated by hunger - the authors suggest that hunger ‘flues’ willpower. Another study examining self-control and hunger found that hungry participants were more likely to stick pins into a voodoo doll representing their spouse, and blasted their spouse with louder and longer noise blasts when they were angry with them (Bushman, DeWall, Pond, & Hanus, 2014). These results suggest that those who are hungry are less able to control their aggressive impulses, and thus hunger undermines self-control. This lack of self-control may be the result of low ECF that stems from hunger.

I argue that hunger may negatively impact ECF by redirecting attentional resources on ways to satisfy the hunger pangs and, in doing so, hunger undermines self-control. Indeed, it has long been postulated that breakfast is an important meal for school-aged children and it assists in concentration and learning (see Hoyland, Dye, & Lawton, 2009). Approximately 60% of US high-school teachers say that hungry student lack concentration and struggle with academic learning (Share Our Strength, 2012). Providing empirical substance behind this supposition, Gajre, Fernandez, Balakrishna and Vazir (2008) found that hungry students tend to demonstrate lower attention and concentration than their not-hungry peers. Hunger has also been shown to direct spatial attentional resources towards food related cues (e.g., Mogg, Bradley, Hyare, & Lee, 1998; Mohanty et al., 2008). Lastly, hungry people demonstrate significant deficits in self-regulation (Stucke & Baumeister, 2006), which may be the result of deficits in ECF. Indeed, in an

ECF-like financial task, participants who were not fed prior to the experiment made more risky economic decisions than individuals who had eaten (Symmonds, Emmanuel, Drew, Batterham, & Dolan, 2010).

Low self-control and risk-taking that results from hunger may extend to the risk-taking inherent in betting on unknown, random outcomes (i.e., gambling). Preliminary evidence for this supposition comes from Biner, Huffman, Curran and Long (1998) who found that hungry gamblers are more likely to believe they can control the outcome of gambling (i.e., increased illusions of control) and also expect to win more money gambling (i.e., increased positive outcome expectancies). One reason that hungry participants have these beliefs and expectations is that they are experiencing a control heuristic (Thompson et al., 1998). Specifically, the control heuristic states that individuals will over-estimate the amount of control they have over a situation when they are personally involved in a task and have a strong desire for an outcome. Gamblers often have a strong desire to win, especially when they are craving. Thus, I propose that the reason hunger inflates illusions of control and outcome expectancies is that it interacts with craving to gamble, which has been shown to influence such variables (Ashrafioun, McCarthy, & Rosenberg, 2012). Indeed, research suggests that hunger may exacerbate craving to gamble.

Hunger and gambling share neurological substrates - eating food and gambling are typically pleasurable activities and thus they both tend to stimulate reward pathways in the brain (Cagniard, Balsam, Brunner, & Zhuang, 2006; Joutsa, Johansson, Jarkko, Niemela, Ollikainen, & Hirvonen, 2012). Craving for this ‘rush of pleasure’ from one activity may heighten engagement in another activity given a similar ‘rush of pleasure’

(Mahler & Kent, 2012). It is possible that hunger may exacerbate the effects of craving to gamble. That is to say, gamblers who crave to play *and* are hungry may be at an increased risk for problem gambling behaviour. This is because both hunger and craving may negatively influence ECF. If so, craving to gamble whilst hungry might be a particularly dangerous cocktail for gamblers – a cocktail that might lead to problem gambling behaviour.

Although the effect of hunger on the relationship between craving and gambling might be additive (i.e., people who are hungry and crave to gamble will be especially likely to show deficits in ECF and thus problematic gambling behaviours), there is also the possibility that the two variables will interact in other ways. For example, ECF deficits might not be observed among hungry people who are not craving to gamble. This is because some research has argued that hunger has no effect on ECF (see Widenhorn-Müller, Hille, Klenk, & Weiland, 2008), while other research suggests that a full (not empty) stomach negatively impacts ECF (see Michaud, et al., 1991). Indeed, Michaud and colleagues (1991) found that a high caloric breakfast had a negative effect on the concentration of adolescents. Moreover, Dhurandhar, Allison, van Groen and Kadish (2013) suggested that hunger might help preventing declines ECF by triggering neuropeptide patterns in the brain, which may increase ECF. Thus, hunger alone may not produce deficits in ECF. The current program of research will assess hunger to determine if it interacts with craving to gamble to influence ECF and thus gambling behaviour.

Overview of the Current Research

This program of research consists of three studies. Study 1 was an initial test of the relationship between craving and ECF among gamblers. To my knowledge, no study

to-date has demonstrated such a link. Thus, it was important to establish an association between these variables at the onset of this program of research. Specifically, craving was assessed using the GACS (Young & Wohl, 2009), which is a multidimensional measure of craving to gamble. ECF was assessed using the IGT, which measures sensitivity to reward and punishment as well as decision making under uncertainty. Hunger was also assessed as a potential moderator in the craving, ECF association. It was hypothesized that that increases in each subscale of the GACS (anticipation of positive affect, immediate desire to gamble, and relief from negative affect) would predict lower performance on the IGT, and that this relationship would be moderated by hunger.

In Study 2, the causal direction of the relationship between craving, ECF and hunger was examined by manipulating craving to gamble. To this end, a cue reactivity paradigm was used to induce craving to gamble – anticipation, desire, as well as relief related cravings - among some participants (i.e., some participants were exposed to gambling-related stimuli prior to engaging in gambling, whereas other participants were not exposed to such stimuli). It was hypothesized that craving (regardless of the subscale) would negatively affect ECF, which was assessed with the WCST. It was also predicted that hunger would moderate the effect of craving on ECF.

Study 3 expanded and extended Study 2 by exposing all participants to a gambling related cue (to induce craving in all participants), but manipulate hunger. Specifically, all participants were asked to come into the study hungry, but half were fed prior to start of the experiment. Craving was then assessed using the GACS, and ECF was assessed using the WCST. Importantly, in this study participants were given the chance to play on slot machines, and hence gambling behaviour was assessed.

Unbeknownst to participants, the slot machines were pre-programmed to provide a series of continual losses. The amount of time that participants gambled in the face of these continual losses was used as a measure of problematic gambling behaviour. It was hypothesized that craving would interact with the hunger manipulation to predict ECF deficits, which would, in turn, increase problematic gambling behaviour (i.e., continued gambling in the face of loss).

Study 1

The purpose of Study 1 was to establish relations between craving to gamble, hunger and ECF among gamblers. To do so, gamblers' naturally occurring levels of craving to gamble was assessed using the GACS, along with their ECF. To assess ECF, participants completed the IGT, as disordered gamblers consistently perform poorly on this task (Brand et al., 2005; Cavedini et al., 2002; Goudriaan, Oosterlaan, dr Beurs, & van den Brink, 2005; Kertzman et al., 2011; Lakey, Goodie, & Campbell, 2007; Lawrence et al., 2009; Linnet, Rojskjaer, Nygaard, & Maher, 2006; Ledgerwood et al., 2011; Petry, 2001). In addition, the IGT shares overlap with performance on other measures of executive cognitive functioning (Bechara, Damasio, Tranel, & Anderson, 1998; Bechara & Martin, 2004; Clark, Cools, & Robbins, 2004; Dolan, Bechara, & Nathan, 2008; Dunn, Dalgleish, & Lawrence, 2006). To measure the participant's hunger, a proxy measure was used. Specifically, 'temporal distance from lunchtime`, or more simply `time from lunch', was coded in minutes since the noon hour. It was hypothesized that increases in craving would predict poor ECF. Moreover, it was hypothesized that hunger would moderate this relationship. Specifically, hunger was expected to exacerbate the effect of craving to gamble on ECF.

Methods

Participants.

As part of a larger study, 26 gamblers were recruited from a catalogue of student gamblers compiled by the Carleton University Gambling Laboratory (*n* = 2261), who had previously indicated that they would be willing to participate in research pertaining to gambling at Carleton University. Potential participants were contacted via phone (see Appendix A). Gambling pathology was assessed when participants came into the lab using the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001). According to the PGSI, the sample consisted of 14 recreational gamblers, 10 low-risk gamblers, 1 moderate-risk gambler and 1 problem gambler. The sample consisted of 10 males and 16 females, and the age of the sample ranged from 18 to 40 years old (*M* = 20.31, *SD* = 4.32).

Procedure.

Upon arrival at the laboratory, the experimenter greeted participants and informed them that the purpose of the study was to investigate gambling attitudes and behaviour within a virtual reality casino. Participants were then asked to read and sign an informed consent (see Appendix B). Following the informed consent, participants were shown the virtual reality equipment and given instructions on how to use it. The headset was connected to a computer that runs *VR Worlds 2.0* software constructed by Psychology Software Tools. The experimenter demonstrated how to put on the head mounted display (Z800 3D Visor, eMagin Corporation, Fishkill, New York), and assisted participants if requested. Participants then navigated throughout a virtual downtown environment, and casino until they felt comfortable with the controls. This acclimatization period also

assisted in identifying any participants who may experience nausea or motion sickness (cybersickness) during the experiment, although no participants reported such symptoms.

Following the acclimatization period, participants were instructed on how to play the slot machines:

> Before you begin the virtual gambling there are a few things I would like to explain. First, in this session I would like you to play slots. You will have the opportunity to win money during the game, depending on the outcome of the spins. We will start you off with $20. As in the casino, each credit is worth 25 cents, so you will have a total of 80 credits when you start. In the game you will be playing, I ask that you bet 1 credit (or 25 cents) on each and every spin. Know that whatever amount you have left at the end of this session today you will be allowed to trade in for money you will be allowed to keep. So if you end up with 10 tokens you will keep $2.50. If you end of with 40 tokens you will receive $10 to keep. Do you have any questions?

If participants asked the payout amount, they were told that it was set at 85% - the standard payout rate in Ontario. Participants were instructed that they may play on any slot machine, that they may gamble for as long as they like and that it was up to them when they wanted to quit. Importantly, the outcomes of the slot machine spins were predetmined, such that all participants were down 40 credits (a $10 net loss) after the 60th spin. Thereafter, participants experienced incremental increases and decreases (1-3 credits in either direction) around the 40-credit mark until they decided to quit playing.

Upon voluntary cessation, participants were given a brief questionnaire that included a measure of gambling-related cravings. Participants were then directed to a separate computer where a computer versions of the IGT was administered using the PEBL Psychological Test Battery (Mueller, 2004, 2010). Importantly, the PEBL records the time which participants begin the IGT task. Upon completion, participants were verbally debriefed and given a debriefing form. This debriefing form explained the rationale behind the study, as well as provided additional information about disordered gambling and numbers for the Ontario Problem Gambling Helpline and local distress centers (see Appendix C). Participants were then given $30 as compensation for their time in participating in the study.

Measures.

Craving. Craving to gamble was assessed using the gambling-related craving scale (GACS: Young & Wohl, 2009; See Appendix D). Participants were asked to complete a series of 9 items, indicating how much they agreed with questions assessing different aspects of the craving experience. Responses were given using a 7-point scale, ranging from 1 (strongly disagree) to 7 (strongly agree). The GACS is comprised of three subscales. The first, the anticipation subscale, consists of 3 items ($\alpha = .76$) that assess craving for the anticipation of positive affect from gambling (e.g., "Gambling would be fun right now"). The desire subscale contains 3 items ($\alpha = .71$) that assess craving for the immediate desire to gamble (e.g., "I need to gamble now"). Finally, the relief subscale

contains 3 items ($\alpha = .39$)[1] and measures craving for relief from negative affect from gambling (e.g., "If I were gambling now I could think more clearly"). Higher scores on the subscales reflect increased craving to gamble.

The Iowa Gambling Task (IGT). The IGT is a widely used task designed to assess the decision-making process (Bechara et al., 1994), and it mimics real life decision making in terms of gains, loses, uncertainty, reward, and punishment. The task is set up such that participants are instructed to pick a card from one of four decks of cards. Every time a card is chosen, participants will be rewarded with virtual money. On occasion however, the reward is paired with a monetary penalty. The object of the IGT is to gain as much virtual money as possible. Unbeknownst to participants, the decks differ in the way the rewards and penalties are structured. Specifically, two decks are "good decks" (decks C and D), which have moderate financial reward and low financial penalties and will lead to monetary gains over the long run. The other two decks are "bad decks" (decks A and B) as participants receive high financial reward but even higher financial penalties, leading to losses over the long run. The final composite score of the IGT is calculated by taking the total selection from the good decks and subtracting the total selection from the bad decks (i.e., [Deck C+Deck D]−[Deck A+ Deck B]), lower scores on this task suggest deficits in decision making. Participants completed the IGT for a total of 100 trials.

[1] The last item of the relief subscale "Gambling would make me less depressed" did not correlate with the other two items and was therefore dropped for future analysis. Cronbach's alpha for the remaining two times was .83.

Hunger. Hunger was assessed using a proxy measure. Specifically, the computer recorded the time at which participants began completing the IGT. This time was than subtracted from 12:00 (noon). Noon was used as a representation of the typical lunch time. The temporal distance between 12:00 and the beginning of the IGT was recorded in minutes. Increased time from lunch is therefore used as a proxy measure for increased hunger.

Results

Preliminary analysis.

The normality of the distribution of scores for craving to gamble, hunger and the IGT were examined using frequency histograms, skewness, and kurtosis plots. There were no missing values or significant univariate outliers identified. Previous research, has identified gender and age as potential covariates of craving to gamble (e.g. Elman, Karlsgodt, & Gastfriend, 2001; Willner, Field, Pitts, & Reeve, 1998; Pelchat & Schaefer, 2000), ECF (e.g., Barrett-Connor & Kritz-Silverstein, 1998) and hunger (e.g., De Castro, 1993; Del Parigi et al., 2002). Therefore, in order to ensure that neither gender nor age affected performance on the IGT, hunger or craving to gamble, the following analyses were performed. A one-way ANOVA was conducted on the IGT, hunger, and each subscale of the GACS separately, in order to determine if being male as opposed to female affected scores on these variables. Males (M = 5.60, SD = 17.20) did not have significantly different scores on the IGT compared to females (M = 3.25, SD = 25.84), $F(1,25) = 0.64$, $p = .80$, $\eta_p^2 = .003$. Males (M = 130.10, SD = 107.70) did not significantly differ from females (M = 163.43, SD = 85.17) on the hunger measure, $F(1,25) = .76$, $p = .39$, $\eta_p^2 = .03$. Males (M = 3.93, SD = 1.12) did not significantly differ

from females (M = 4.65, SD = 0.96) on craving for the anticipation of positive affect from gambling, $F(1,25) = 1.58$, $p = .22$, $\eta_p^2 = .06$. Similarly, males (M = 1.87, SD = 0.95) did not significantly differ from females (M = 1.68, SD = 0.79) on craving for the immediate desire to gamble, $F(1,25) = 0.27$, $p = .61$, $\eta_p^2 = .01$. Lastly, males (M = 1.15, SD = 0.34) did not significantly differ from females (M = 1.15, SD = 0.35) on craving for the relief of negative affect from gambling, $F(1,25) = .002$, $p = .96$, $\eta_p^2 < .001$. Since there were no significant differences with respect to gender, gender was collapsed for all subsequent analysis.

In order to determine if age affected craving to gamble, hunger or performance on the IGT, separate regression analysis were conducted on the IGT, hunger and each subscale of the GACS. Age was not a significant predictor of performance on the IGT, $\beta = -.57$, $t(25) = -.536$, $p = .60$, the hunger measure, $\beta = -6.40$, $t(25) = 2.27$, $p = .14$, craving for the immediate desire to gamble, $\beta = -.02$, $t(25) = -.90$, $p = .67$, or craving for the relief of negative affect from gambling, $\beta = -.007$, $t(25) = -.43$, $p = .67$. Surprisingly however, age was significantly related to craving for the anticipation of positive affect from gambling, $\beta = -.15$, $t(25) = -2.50$, $p = .02$, such that increases in age predicted lower craving for the anticipation of positive affect. Therefore, in order to control of the effects of age on craving to gamble, age was used as a covariate in further analysis using this subscale.

Craving and the Iowa Gambling Task.

In order to determine if increased craving to gamble lead to decreased performance on the IGT, a multiple regression analysis was conducted. Specifically, all three subscales of the GACS were entered into a regression equation simultaneously to

predict performance on the IGT. Results of this analysis revealed that craving for the anticipation of positive affect from gambling was not a significant predictor of performance on the IGT, $\beta = 1.60$, $t(25) = .45$, $p = .66$, neither was craving for the relief of negative affect from gambling, $\beta = 14.13$, $t(25) = .97$, $p = .34$. However, desire-related craving was a significant predictor of performance on the IGT, $\beta = -14.03$, $t(25) = -2.29$, $p = .03$, such that increased craving for the immediate desire to gamble predicted decreases performance on the IGT.

Hunger as a Moderator.

Hunger was investigated as a moderator of the relationship between craving to gamble and ECF. This was tested using the PROCESS macro developed by Hayes (2012) for probing interactions in ordinary least squares regression models (Model 1). Thus, each subscale of the GACS and hunger were separately entered as predictors of performance on the IGT, as well an interaction term between the two was created and entered into a simultaneous regression model. Importantly, both the predictors were automatically centered using the PROCESS macro.

GACS Anticipation Subscale. Results indicated that the hunger was not associated with the IGT, $b = .20$, $SE = .21$, $p = .36$, CI [-.24, .64], nor was craving for the anticipation of positive affect from gambling, $b = 4.74$, $SE = 6.46$, $p = .47$, CI [-8.66, 18.13]. Additionally, the interaction between hunger and craving for the immediate desire to gamble was not significant, $b = -.04$, $SE = .05$, $p = .40$, CI [-.13, .06].

GACS Desire Subscale. Results indicated that the hunger was positively associated with performance on the IGT, $b = .22$, $SE = .12$, $p = .07$, CI [-.02, .47], however this effect failed to meet traditional levels of significance. Craving for the

immediate desire to gamble was not associated with performance on the IGT, $b = 10.23$, $SE = 12.13$, $p = .41$, CI [-14.92, 35.40]. However, there was an interaction between hunger and craving for the immediate desire to gambling was significant, $b = -.14$, $SE = .07$, $p = .07$, CI [-.29, .02], suggesting that the effect of an immediate desire to gamble on IGT performance depends on hunger. Although this this effect failed to meet traditional levels of significance, its existence was hypothesized and thus the interaction was examined.

In order to fully examine the interaction, simple slopes were first conducted for the association between hunger and IGT performance and were probed at 1 SD above and below the mean of craving for the immediate desire to gamble. Simple slope tests revealed no relationship between hunger and IGT at 1 SD above or below the mean of desire-related craving, $b = .08$, $SE = .05$, $p = .13$, CI [-.02, .20] and, $b = -.13$, $SE = .10$, $p = .17$, CI [-.33, .06], respectively. Figure 1 plots these simple slopes for the interaction.

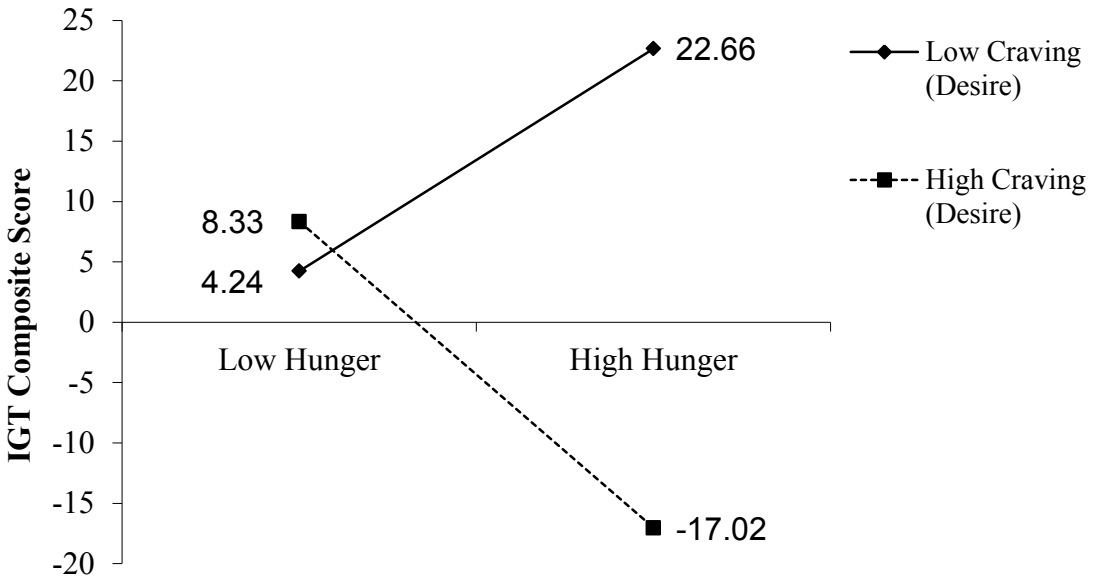

Figure 1. The effect of hunger on IGT performance probed a 1 standard deviation above and below the mean of craving.

Simple slopes were then conducted to test the association between craving for the immediate desire to gamble and IGT performance at 1 SD above and below the mean of hunger. Simple slope tests revealed a no relationship between craving for the immediate desire to gamble and IGT at 1 SD below the mean of hunger, $b = 2.43$, $SE = 8.47$, $p = .78$, CI [-15.13, 20.00]. However, there was a negative association between craving for the immediate desire to gamble and IGT at 1 SD above the mean of hunger, $b = -23.62$, $SE = 8.59$, $p = .01$, CI [-41.45, -5.79]. In other words, as predicted, among hungry participants, increases desire-related craving was associated with decreased performance on the IGT. Figure 2 plots these simple slopes for the interaction.

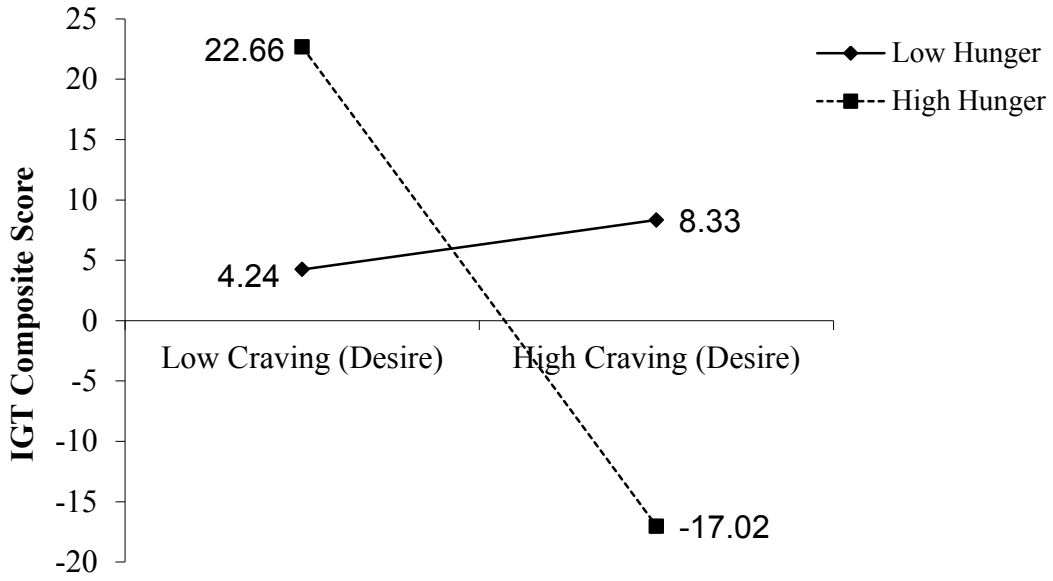

Figure 2. The effect of craving on IGT performance probed a 1 standard deviation above and below the mean of hunger.

GACS Relief Subscale. Results indicated that the hunger was not associated with the IGT, $b = .10$, $SE = .20$, $p = .61$, CI [-.32, .53], nor was craving for the relief of negative affect via gambling, $b = 12.17$, $SE = 32.91$, $p = .72$, CI [-56.08, 80.42]. Additionally, the interaction between hunger and craving for the relief of negative affect was not significant, $b = -.08$ $SE = .17$, $p = .66$, CI [-.43, .28].

Discussion

Results of this study supported my general hypothesis that increases in a gambler's level of craving to gamble result in ECF deficits. Specifically, desire to gamble significantly predicted decreased performance on the IGT. However, anticipation to gamble and desired relief from negative affect via gambling did not influence ECF. The reason for this result may be due to the design of Study 1. Specifically, craving to gamble

was assessed after gambling engagement. That is to say, the craving to gamble scale was administered after participants decided that they were finished gambling in the virtual reality casino. As such, questions that assessed anticipation- as well as relief-related craving likely did not factor because participants had already gambled when the measure was completed. Only desire to continue gambling is relevant immediately after a gambling session, which may explain why desire was the only craving factor that predicted ECF deficits.

Hunger was examined as a possible moderator of the relationship between craving to gamble and ECF. Results revealed that among participants who participated in the study well after lunch, craving to gamble predicted poor ECF. Interestingly, people who participated in the study well after lunch (and were thus seemingly hungry), but were not craving to gamble performed well on the ECF task. Thus, it seems that hunger alone (without craving) may enhance ECF. This result is in line with past research that has shown hunger may improve ECF (e.g., Michaud, et al., 1991), however the mechanisms responsible for this improvement in ECF are unknown and debated (see Dhurandhar, Allison, van Groen, & Kadish, 2013).

There are three major limitations to the current study. First, Study 1 was correlational in nature and thus the causal direction of the associations between variable cannot be determined. Although increases in craving to gamble predicted decreased ECF, and hunger moderated this relationship, it was not possible to determine the direction of this relationship. For example, it is possible that those with preexisting low ECF report stronger cravings to gamble, as they are unable to control such urges. Therefore, Study 2 was designed to assess the causal relations among variables by manipulating craving to

gamble. The second major limitation is that a proxy measure of hunger was used. Although 'time from lunch' was measured with respect to when participants completed the ECF task, there is no way to determine when participants last ate. That is to say, although we used 12:00 (noon) as a reference point for eating, it is possible that participants ate earlier or later in the day, and hence closer or father away from when the study took place. In this way, the proxy measure of hunger is crude. It would be much better to actually assess participants' hunger using a self-report questionnaire, which I did in Study 2.

The third limitation is that participants' craving to gamble was assessed after gambling in a VR casino. It could be argued that a VR casino removes participants from their natural gambling environment; thereby compromising external validity. However, the use of a VR casino was necessary to achieve proper methodology. Specifically, because I had full control over the VR environment, it remained static and each participant had same experience with the slot machine, regardless of which machine participants chose. Additionally, while it may be argued that using a virtual casino may not trigger the same cues as in a real casino, previous research suggests that craving to gamble can be successfully elicited within a virtual casino (Young, Wohl, Matheson, & Anisman, 2007). Regardless, Studies 2 and 3 did not use a virtual reality casino; instead, participants were placed into a physical environment modeled after a typical casino, with slot machines, a poker table, dim lighting, busy carpet, and neon signs in order to better replicate the experience of a real-world casino.

Study 2

The purpose of Study 2 was to test the hypothesized causal path (i.e., craving to gamble leads to ECF deficits). To this ends, craving to gamble was manipulated using a cue reactivity paradigm wherein half of participants were exposed to a simulated casino environment and half were exposed to a neutral, laboratory environment. It was hypothesized that participants cued with gambling-related stimuli would experience craving to gamble (compared to a control group who was not exposed to such stimuli). Once again, hunger was examined as a moderator of the hypothesized craving-ECF link. To get a more accurate assessment of hunger, participants completed a multidimensional measure of subjective hunger. It was hypothesized that hunger would moderate the effects of craving on ECF. Specifically, I hypothesized that those who were craving to gamble and hungry would have increased deficits in ECF.

Methods

Participants.

Sixty-two participants were recruited from a catalogue of student gamblers compiled by the Carleton University Gambling Laboratory (n = 2261), who had previously indicated that they would be willing to participate in research pertaining to gambling at Carleton University. Potential participants were contacted via phone (see Appendix E). Thirteen of these 62 were removed from analysis: three participants for single responding on the ECF task (i.e., not paying attention), four due to experimenter or computer error, and six participants for failing attention checks (such as consistently answering reverse coded items, or median responding on multiple scales). Gambling pathology was assessed when participants came into the lab using the Problem Gambling

Severity Index (PGSI; Ferris & Wynne, 2001). According to the PGSI, the sample consisted of 14 recreational gamblers, 15 low-risk gamblers, 17 moderate-risk gamblers and 3 problem gamblers. The sample consisted of 33 males and 16 females, and the age of the sample ranged from 18 to 40 years old (M = 21.33, SD = 4.16).

Procedure.

Upon arrival at the laboratory, participants were told that the study was an investigation of gambling-related attitudes and beliefs. After signing an informed consent (see Appendix F), participants were then randomly assigned to a condition. Specifically, half of the participants were exposed to a simulated casino environment, and half of the participants were placed in a neutral laboratory environment. Thus, two groups were created: a control group (n = 24; 9 females) and a craving condition (n = 25; 7 females). After acclimatizing to their particular environment (casino or neutral) for 2 minutes, participants were given a questionnaire that assessed their craving to gamble and hunger. Following, ECF was assessed using a computer-automated task (The PEBL Psychological Test Battery; Mueller, 2004, 2010). Specifically, participants completed the WCST on an adjacent computer. Upon completion, participants were verbally debriefed, as well as provided with a debriefing form (see Appendix G). The debriefing form explained the rationale behind the study, as well as provided additional information about disordered gambling and numbers for the Ontario Problem Gambling Helpline and local distress centers. Participants were then granted partial credit towards an introductory psychology class as compensation for their time.

Measures.

Gambling Craving. The Gambling and Craving Scale (GACS; Young & Wohl, 2009). Please see Study 1 for a more complete description of this measure. The GACS is comprised of three subscales: craving for the anticipation of positive affect from gambling (α = .77), craving for the immediate desire to gamble (α = .91), and craving for relief from negative affect from gambling (α = .90).

Hunger. Hunger was assessed using the State Food-Craving Questionnaire (SFCQ; Cepeda-Benito, Gleaves, Williams, & Erath, 2001; See Appendix H). Participants were asked to complete a series of 15 items, indicating how much they agreed with questions assessing different aspects of the food-craving experience. Responses were given using a 6-point scale, ranging from 1 (strongly disagree) to 6 (strongly agree). The SFCQ is comprised of five subscales. The desire subscale consists of 3 items (α = .91) and assesses the intense desire to eat (e.g., "I have an urge for tasty food"). The anticipation subscale consists of 3 items (α = .85) and assesses the anticipation of positive affect from eating (e.g., "Eating something tasty would make things just perfect"). The relief subscale consists of 3 items (α = .77) and assesses the relief from negative states and feelings that result from eating (e.g., "If I ate something, I wouldn't feel so sluggish and lethargic"). The control subscale consists of 3 items (α = .65) and assesses a lack of control over eating (e.g., "If I had something tasty to eat, I could not stop eating it"). Finally, the hunger subscale consists of 3 items (α = .78) that assess hunger for food as a physiological state (e.g., "If I ate right now, my stomach wouldn't feel as empty"). Higher scores on the subscales reflect increased craving for food.

The Wisconsin Card Sorting Task (WCST). This task assesses the ability to shift cognitive strategies in response to changing environmental conditions, also called set-shifting and/or cognitive flexibility. In this task, participants are presented with a series of cards, each containing stimuli that may differ in colour, shape, or number. For example, one card may contain two yellow triangles, and the next may contain one red square. The participant is asked to place the card in one of four different cards piles according to an abstract rule. Specifically, the participant must pair off their card with the different card piles according to the colour, shape, or number of stimuli reproduced on the card. The goal of the task is for the subject to discover the rule that allows for correct pairing off, using feedback given when the card is place in a correct or incorrect pile. After 10 cards have been correctly paired off in a category, the rule is changed without the participant's knowledge. When the rule is changed, correct pairing according to the previous rule will lead to incorrect pairings based on the new (and to be discovered) rule. The participants must then discover the rule that allows for correct pairing. Participants completed a total of 128 trials on the WCST. The number of incorrect pairings made is an indication of poor cognitive flexibility, thus higher error scores indicate poor performance.

Results

Preliminary Analysis

The normality of the distribution of scores for craving to gamble, hunger and the WCST were examined using frequency histograms, skewness, and kurtosis plots. There were no significant univariate outliers identified. There were however, three participants with missing values on the WCST and four participants with missing values on the GACS. These participants were not included in the analysis for which they were missing

data. Previous research has identified gender and age as potential covariates of craving (e.g. Elman, Karlsgodt, & Gastfriend, 2001; Willner, Field, Pitts, & Reeve, 1998; Pelchat & Schaefer, 2000), ECF (e.g., Barrett-Connor & Kritz-Silverstein, 1998) and hunger (e.g., De Castro, 1993; Del Parigi et al., 2002). Therefore, in order to ensure that neither gender nor age affected performance on the WCST, craving to gamble, or hunger, a one-way ANOVA was conducted on the WCST, each subscale of the GACS separately, and each subscale of the SFCQ separately in order to determine if being male as opposed to female affected scores on these variables.

Males (M = 14.50, SD = 8.89) did not have significantly different scores on the WCST compared to females (M = 16.55, SD = 9.42), $F(1,45) = 0.52$, $p = .48$, $\eta_p^2 = .01$. Males (M = 4.70, SD = 1.51) did not significantly differ from females (M = 4.11, SD = 1.21) on craving for the anticipation of positive affect from gambling, $F(1,44) = 1.71$, $p = .20$, $\eta_p^2 = .04$. Similarly, males (M = 2.27, SD = 1.36) did not significantly differ from females (M = 2.22, SD = 1.60) on craving for the relief of negative affect from gambling, $F(1,44) = 0.01$, $p = .92$, $\eta_p^2 < .001$. Finally, males (M = 2.50, SD = 1.59) did not significantly differ from females (M = 2.22, SD = 1.38) on craving for the immediate desire to gamble, $F(1,44) = 0.33$, $p = .57$, $\eta_p^2 = .008$.

In terms of the SFCQ subscales, males (M = 3.05, SD = 1.24) did not significantly differ from females (M = 2.64, SD = 1.20) on an intense desire to eat, $F(1,48) =1.50$, $p = .28$, $\eta_p^2 = .02$. Males (M = 2.87, SD = 1.00) did not significantly differ from females (M = 2.63, SD = 1.15) on relief from negative states and feelings that result from eating, $F(1,48) = 1.58$, $p = .45$, $\eta_p^2 = .01$. Males (M = 2.21, SD = 0.96) did not significantly differ from females (M = 1.98, SD = 1.09) on a lack of control over eating, $F(1,48) = .58$,

p = .45, η_p^2 = .01. Males (M = 3.00, SD = 1.27) did not significantly differ from females (M = 2.48, SD = 1.20) on the hunger for food as a physiological state, $F(1,48) = 1.88$, p = .18, η_p^2 = .04. However, males (M = 3.37, SD = 1.15) had significantly higher scores than females (M = 2.35, SD = 1.33) on the anticipation of positive affect from eating, $F(1,48) = 7.64$, p = .008, η_p^2 = .14. In other words, males experienced more anticipation of positive affect that may result from eating. In order to control for this significant difference, gender was included as a covariate for future analysis using this subscale.

In order to determine if age affected performance on the WCST, craving to gamble, or hunger, separate regression analysis were conducted on the WCST, each subscale of the GACS, and each subscale of the SFCQ. Age was not a significant predictor of performance on the WCST, β = .44, $t(44) = 1.43$, p = .16, craving for the anticipation of positive affect from gambling, β = -.04, $t(43) = -.80$, p = .43, craving for the immediate desire to gamble, β = -.02, $t(43) = -.43$, p = .67 or craving for the relief of negative affect from gambling, β = -.01, $t(43) = -.26$, p = .80.

Age was not a significant predictor of the intense desire to eat, β = -.02, $t(47) = -.45$, p = .66, the anticipation of positive affect from eating, β = -.06, $t(47) = -1.34$, p = .19, the relief from negative states and feelings that result from eating, β = -.03, $t(47) = -.88$, p = .38, or a lack of control over eating, β = -.04, $t(47) = -1.24$, p = .22. Surprisingly however, age was significantly related to hunger for food as a physiological state, β = -.10, $t(47) = -2.42$, p = .02, such that increases in age predicted lower craving for food as a physiological state. Therefore, in order to control for the effects of age on hunger, age was used as a covariate in further analysis on this subscale.

Manipulation Check

In order to determine if exposure to the casino environment increased craving to gamble over the neutral environment, a one-way ANOVA was conducted on each subscale of the GACS. Results revealed that those in the craving condition (M = 4.86, SD = 1.39) had higher levels of anticipatory craving than those in the control condition (M = 4.10, SD = 1.41), $F(1,44) = 3.37$, $p = .07$, $\eta_p^2 = .07$, however, this effect failed to meet traditional levels of significance. Similarly, those in the craving condition (M = 2.67, SD = 1.50) had significantly higher levels of desire-related craving than those in the control condition (M = 1.78, SD = 1.21), $F(1,44) = 4.73$, $p = .04$, $\eta_p^2 = .10$. However, those in the craving condition (M = 2.51, SD = 1.68) did not significantly differ in craving for the relief of negative affect as a result of gambling than those in the control condition (M = 2.28, SD = 1.34), $F(1,44) = .25$, $p = .62$, $\eta_p^2 = .006$.

Condition by Hunger on ECF

Given that there were significant differences in craving to gamble between the craving and control conditions, the craving manipulation was used as a moderator to test the relationship between hunger and ECF. Specifically, moderation was examined using the PROCESS macro developed by Hayes (2012) for probing interactions in ordinary least squares regression models (Model 1). Thus, the craving manipulation was entered as a predictor, each individual subscale of the SFCQ was entered as another predictor, and an interaction term between the two was created and entered into a simultaneous regression model. Importantly, both the predictors were automatically centered using the PROCESS macro.

SFCQ Desire Subscale. Results indicated that the craving manipulation (coded 0 for control, 1 for craving) was negatively associated with errors on the WCST, b = -14.22, SE = 6.70, p = .04, CI [-27.04, -.70], but the intense desire to eat was not associated with performance on the WCST, b = -1.51, SE = 1.51, p = .32, CI [-4.56, 1.55]. Importantly, an interaction between the craving manipulation and the intense desire to eat quantified these results, b = 4.27, SE = 2.10, p = .05, CI [.03, 8.51], suggesting that effect of the intense desire to eat on WCST performance depends on the craving manipulation.

In order to fully examine the interaction, simple slopes were first conducted for the association between the craving manipulation and WCST performance and were probed at 1 SD above and below the mean score of the intense desire to eat. Simple slope tests revealed a negative association between the craving manipulation and WCST errors at 1 SD below the mean of the intense desire to eat, b = -7.08, SE = 3.72, p = .06, CI [-14.61, .44], however, this effect failed to meet traditional levels of significance. That is to say, at low levels of the intense desire to eat, performance on the WCST was improved when moving from the control to craving condition. An association between the craving manipulation and WCST errors was absent at 1 SD above the mean of the intense desire to eat, b = 3.66, SE = 3.70, p = .33, CI [-3.81, 11.13]. Figure 3 plots these simple slopes for this interaction.

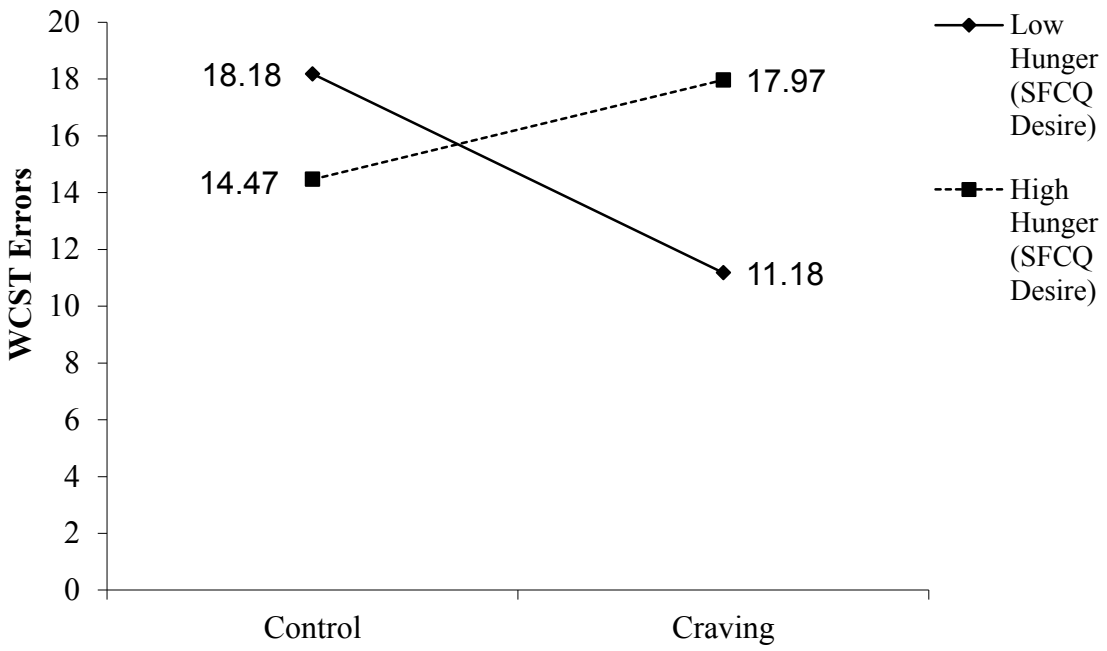

Figure 3. The effect of the craving manipulation on WSCT performance probed a 1 standard deviation above and below the mean of hunger.

Simple slopes were then conducted for the association between the intense desire to eat and WCST performance in the craving and control condition, respectively. Simple slope tests revealed a positive association between the intense desire to eat and WCST errors in the craving condition, $b = 2.76$, $SE = 1.46$, $p = .06$, CI [-.17, 5.70], however, this effect failed to meet traditional levels of significance. That is to say, in the craving condition increased hunger predicted increased errors on the WCST. An association between the intense desire to eat and WCST errors was absent in the control condition, $b = -1.51$, $SE = 1.51$, $p = .32$, CI [-4.57, 1.55]. Figure 4 plots these simple slopes for this interaction.

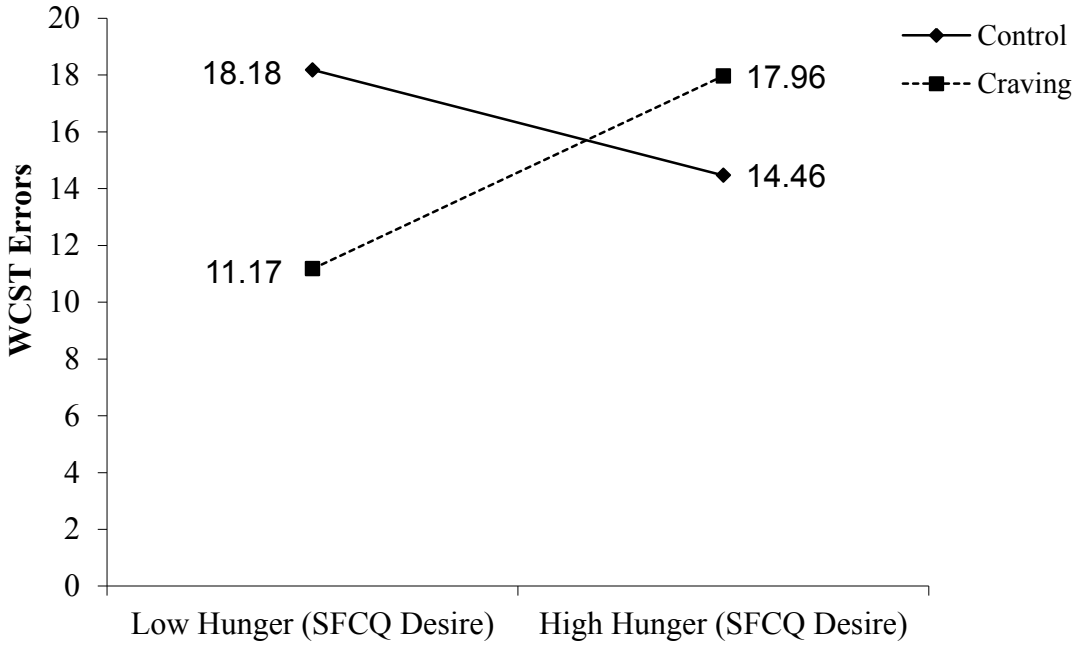

Figure 4. The effect of hunger on WSCT performance probed at the control and craving conditions.

SFCQ Anticipation Subscale Controlling for Gender. Results indicated that the craving manipulation was not associated with errors on the WCST, b = -13.09, SE = 7.45, p = .08, CI [-28.14, 1.96], nor was the anticipation of positive affect from eating, b = -1.90, SE = 1.76, p = .28, CI [-5.44, 1.65]. Additionally, the interaction between the craving manipulation and the anticipation of positive affect from eating was not significant, b = 3.77, SE = 2.29, p = .10, CI [-.86, 8.41].

SFCQ Relief Subscale. Results indicated that the craving manipulation was negatively associated with errors on the WCST, b = -20.73, SE = 7.04, p = .005, CI [-34.94, -6.53]. Additionally, the relief from negative states and feelings that result from eating was negatively associated with performance on the WCST, b = -4.60, SE = 1.73, p = .01, CI [-8.08, -1.11]. Importantly, an interaction between the craving manipulation and

the relief from negative states and feelings that result from eating quantified these results, $b = 6.86$, $SE = 2.37$, $p = .006$, CI [2.08, 11.64].

In order to fully examine the interaction, simple slopes were first conducted for the association between the craving manipulation and WCST performance were probed 1 SD above and below the mean score of the relief from negative states and feelings that result of eating. Simple slope tests revealed a negative association between the craving manipulation and WCST errors at 1 SD below the mean of the relief from negative states and feelings that result from eating, $b = -8.91$, $SE = 3.53$, $p = .02$, CI [-16.04, -1.78]. That is to say, at low levels of the relief from negative states and feelings that result from eating, performance on the WCST was improved when moving from the control to craving condition. An association between the craving manipulation and WCST errors was absent at 1 SD above the mean of the relief from negative states and feelings that result from eating, $b = 5.71$, $SE = 3.57$, $p = .12$, CI [-1.48, 12.91]; however, there was a trend in the predicted direction, such that at high levels of the relief from negative states and feelings that result from eating, increased craving lead to increased errors on the WCST. Figure 5 plots the simple slopes for this interaction.

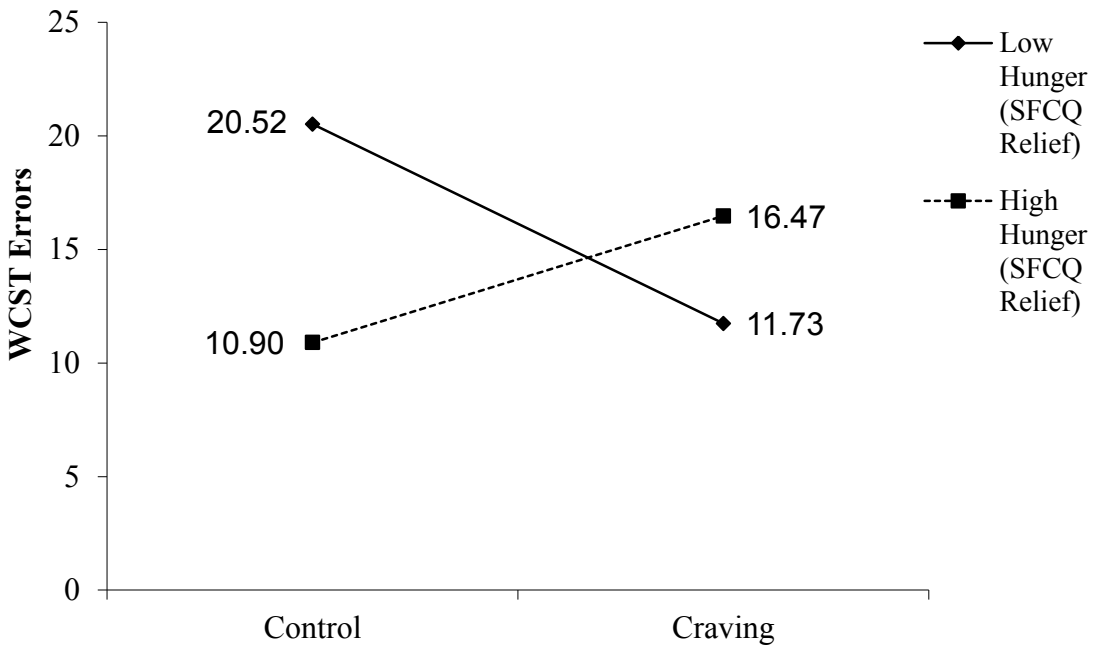

Figure 5. The effect of the craving manipulation on WSCT performance probed a 1 standard deviation above and below the mean of hunger.

Simple slopes were then conducted for the association between the relief from negative states and feelings that result from eating and WCST performance in the craving and control condition, respectively. Simple slope tests revealed a negative association between the relief from negative states and feelings that result from eating and WCST errors the control condition, b = -4.60, SE = 1.73, p = .01, $CI_{.95}$ = -8.08, -1.12. In other words, increased the relief from negative states and feelings that result from eating predicted fewer errors on the WCST in the control condition. However, this association was absent in the craving condition, b = 2.26, SE = 1.62, p = .17, $CI_{.95}$ = -1.00, 5.53; however, there was a trend in the predicted direction, such that in the craving condition, increased hunger lead to increased errors on the WCST. Figure 6 plots the simple slopes for this interaction.

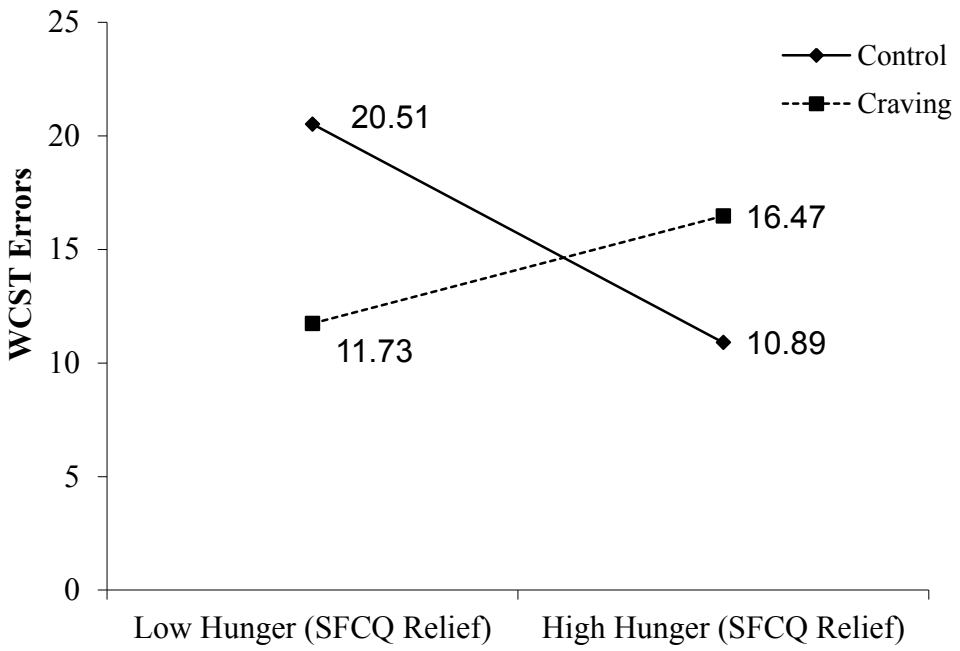

Figure 6. The effect of hunger on WSCT performance probed at the control and craving conditions.

SFCQ Control Subscale. Results indicated that the craving manipulation was negatively associated with errors on the WCST, b = -13.50, SE = 6.22, p = 0.04, CI [-26.06, -.94]. A lack of control over eating was not associated with performance on the WCST, b = -2.26, SE = 1.80, p = .22, CI [-5.91, 1.38]. Importantly, an interaction between the craving manipulation and a lack of control over eating quantified these results, b = 5.45, SE = 2.65, p = .05, CI [.11, 10.80], suggesting that the effect of lack of a lack of control over eating on WCST performance depends on the craving manipulation.

In order to fully examine the interaction, simple slopes were first examined for the association between the craving manipulation and WCST performance at 1SD above and below the mean of a lack of control over eating. Simple slope tests revealed a negative association between the craving manipulation and WCST errors at 1SD below the mean

the mean of a lack of control over eating, *b* = -7.33, *SE* = 3.73, *p* = .06, CI [-14.85, .18], however, this effect failed to meet traditional levels of significance. That is to say, at low levels of a lack of control over eating, performance on the WCST was improved when moving from the control to craving condition. An association between the craving manipulation and WCST errors was absent at 1SD above the mean of a lack of control over eating, *b* = 3.57, *SE* = 3.72, *p* = .34, CI [-3.93, 11.08]. Figure 7 plots the simple slopes for this interaction.

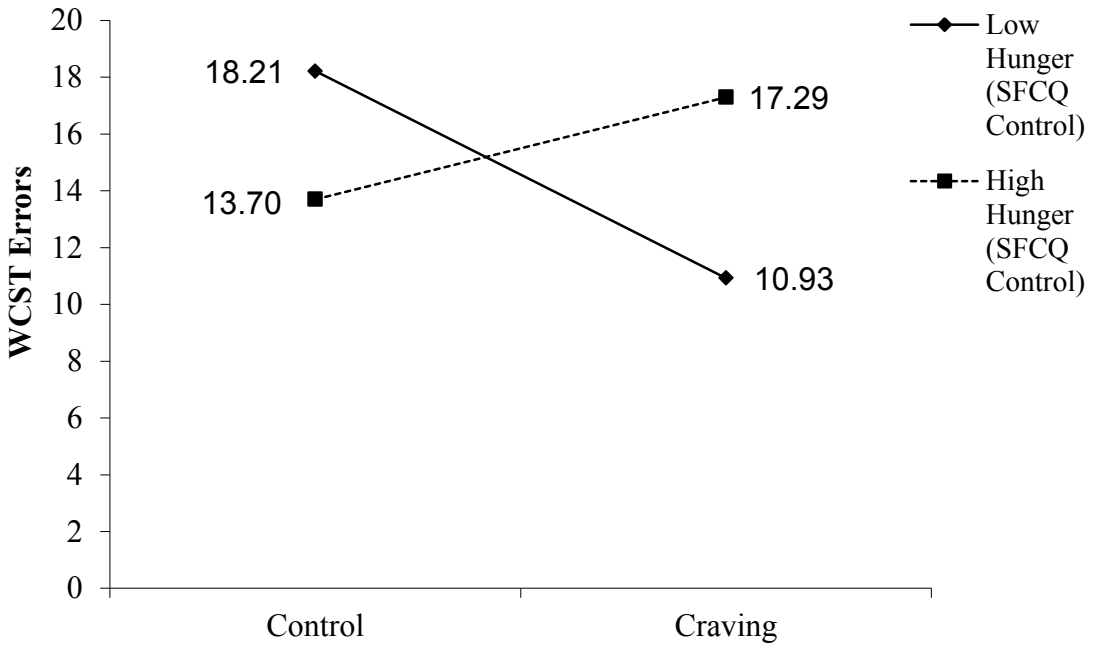

Figure 7. The effect of the craving manipulation on WSCT performance probed a 1 standard deviation above and below the mean of hunger.

Simple slopes were then examined for the association between a lack of control over eating and WCST performance in the craving and control condition, respectively. Simple slope tests revealed no association between a lack of control over eating and WCST errors in the control condition, *b* = -2.27, *SE* = 1.80, *p* = .22, CI [-5.91, 1.38], nor

craving condition, $b = 3.19$, $SE = 1.94$, $p = .11$, CI [-.71, 7.10]; however, there was a trend in the predicted direction, such that in the craving condition, increased hunger lead to increased errors on the WCST. Figure 8 plots the simple slopes for this interaction.

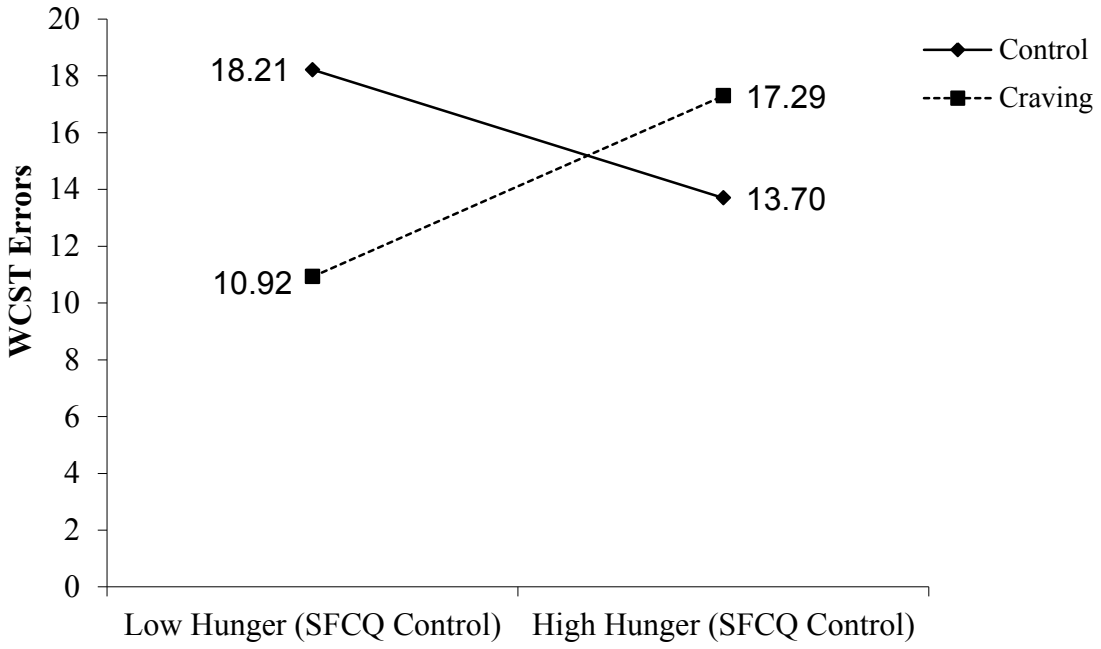

Figure 8. The effect of hunger on WSCT performance probed at the control and craving conditions.

SFCQ Hunger Subscale Controlling for Age. Results indicated that the craving manipulation was negatively associated with errors on the WCST, $b = -18.42$, $SE = 6.45$, $p = .007$, CI [-31.45, -5.40]. Hunger for food as a physiological state was also negatively associated with performance on the WCST, $b = -2.66$, $SE = 1.38$, $p = .06$, CI [-5.46, .13], however, this effect failed to meet traditional levels of significance. Importantly, an interaction between the craving manipulation and hunger for food as a physiological state quantified these results, $b = 5.43$, $SE = 2.65$, $p = .01$, CI [1.29, 9.57], suggesting that the

effect of hunger for food as a physiological state on WCST performance depends on the craving manipulation.

In order to fully examine the interaction, simple slopes were first examined for the association between the craving manipulation and WCST performance and were probed at 1 SD above and below the mean of hunger for food as a physiological state. Simple slope tests revealed a negative association between the craving manipulation and WCST errors at 1 SD below the mean of hunger for food as a physiological state, $b = -9.82$, $SE = 3.71$, $p = .01$, CI [-17.31, -2.34]. That is to say, at low levels of hunger for food as a physiological state, performance on the WCST was improved when moving from the control to craving condition. An association between the craving manipulation and WCST errors was absent at 1 SD above the mean of hunger for food as a physiological state, $b = 4.07$, $SE = 3.63$, $p = .27$, CI [-3.25, 11.41]. Figure 9 plots the simple slopes for this interaction.

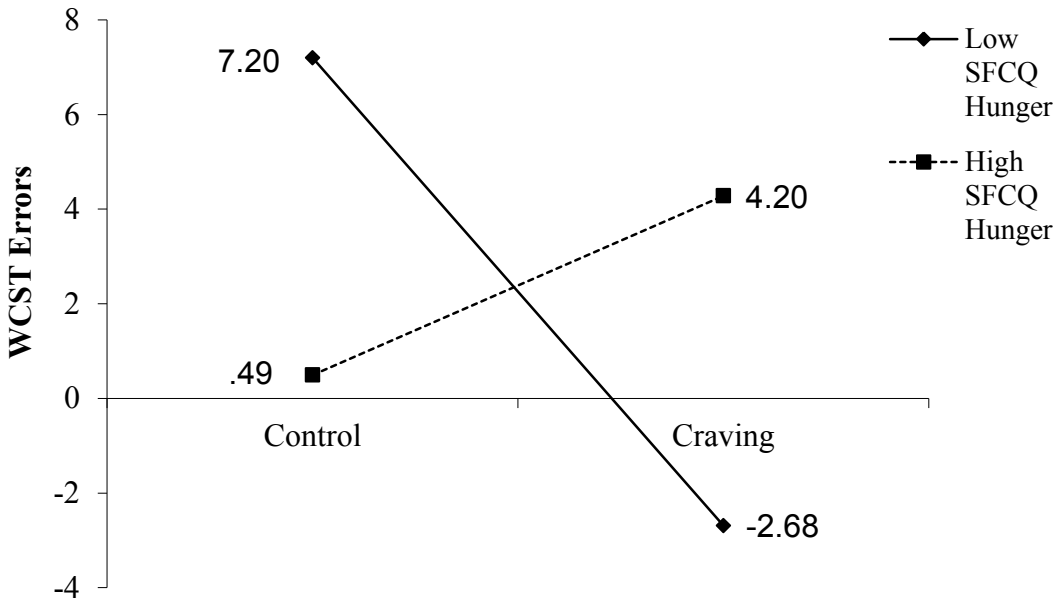

Figure 9. The effect of the craving manipulation on WSCT performance probed a 1 standard deviation above and below the mean of hunger.

Simple slopes were then examined for the association between hunger for food as a physiological state and WCST performance in the craving and control condition, respectively. Simple slope tests revealed a negative association between hunger for food as a physiological state and WCST errors in the control condition, b = -2.66, SE = 1.38, p = .06, CI [-5.46, .13], however, this effect failed to meet traditional levels of significance. In other words, increased hunger for food as a physiological state predicted fewer errors on the WCST in the control condition. There was no association in the craving condition, b = 2.77, SE = 1.56, p = .08, CI [-.38, 5.92]; however, there was a trend in the predicted direction, such that in the craving condition, increased hunger lead to increased errors on the WCST. Figure 10 plots the simple slopes for this interaction.

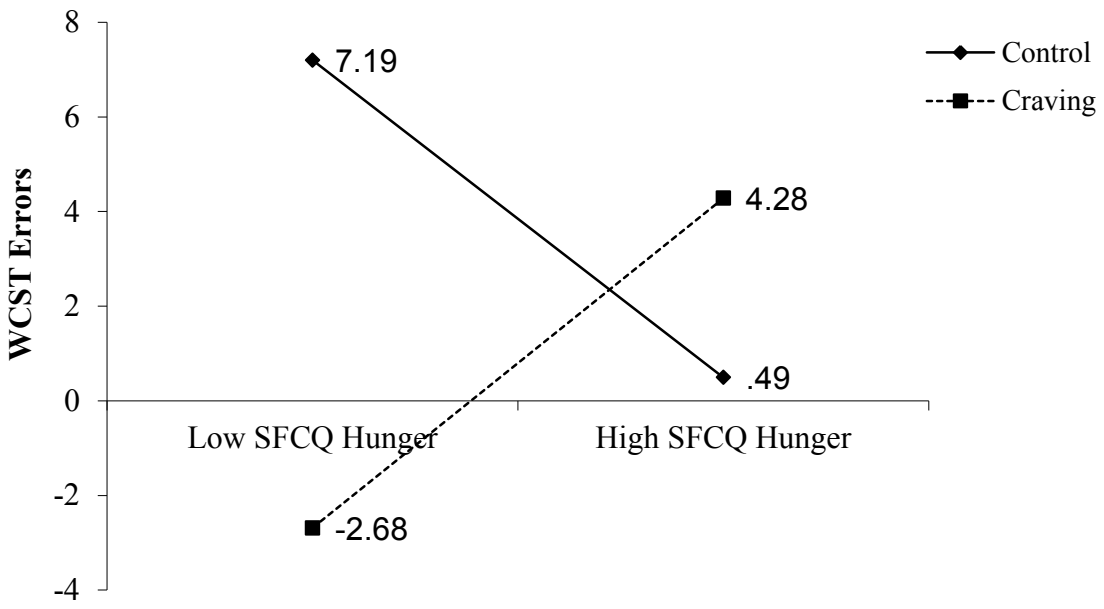

Figure 10. The effect of hunger on WSCT performance probed at the control and craving conditions.

Discussion

Results of Study 2 further support my general hypothesis that craving to gambling undermines ECF and that hunger moderates the craving to gamble-ECF link. Half of participants were exposed to a neutral environment and half of participants were exposed to a casino environment. This cue reactivity paradigm is both an ecologically valid and reliable means through which to elicit a craving response in general (see Wilson et al., 2004) and with respect to gambling specifically (e.g., Kushner et al., 2007; 2008). Indeed, the manipulation check suggests that exposure worked in creating a control group and a craving group. Specifically, those in the craving condition experienced heightened levels of craving for the anticipation of positive affect and immediate desire to gamble cravings. However, there were no group differences in craving for the relief from negative affect

from gambling between conditions. This may be due to the nature of the manipulation. Exposure to a casino environment may serve to heighten anticipation of positive affect and desire to gamble, but not anticipation of relief from negative affect. Indeed, the casino environment was designed to be exciting and produce a sense of thrill through the use of visual (slot machines, poker tables, neon signs) and auditory elements (the sound of a lively casino with people occasionally winning money). Craving for relief of negative affect is more likely to be elicited as a result of a desire to escape negative life events (Matheson, Wohl, & Ansiman, 2009). It is unlikely that the manipulation used in Study 2 elicited a stress response from participants. As such, it should not be surprising that the desire to gamble to relieve negative affect did not vary by condition. Moreover, although it is likely that some gamblers came to the laboratory with pre-existing cravings to gamble in order to get relief from negative affect, an influence of such a factor would have been nullified by random assignment to condition.

Importantly, as predicted, hunger moderated the link between craving to gamble and ECF. Indeed, there was a significant interaction between the craving manipulation on WCST errors for *Desire*, *Relief*, *Control*, and *Hunger* subscales of the SFCQ. These interactions suggest that craving is dependent on the intense desire to eat, the anticipation of relief from negative states and feelings that result from eating, a lack of control over eating and hunger as a physiological state. The most consistent interaction pattern was that among those who were neither hungry nor craving to gamble, performance on the WCST was the worst. However, performance on the WCST improved as craving increased. Although this result was not expected, it may have a relatively straightforward explanation. Specifically, participants who were neither craving to gamble nor hungry

may have been unengaged, uninvolved or bored in the experiment, which in turn lead to poor performance on the WCST. Exposure to a neutral environment, coupled with low desire to gamble may have thusly undermined the participant's involvement with the study, including the ECF task. In this explanation, it is only when participants craved to gamble, and had an interest in the study, that their ECF would show improvement – as pattern that appears to play out in the observed results.

Another consistent finding was that among those who were craving to gamble, increased hunger lead to increased errors on the WCST. It would appear that craving mixed with hunger might be a particularly dangerous cocktail, in that the presence of both hunger and craving drained participant's cognitive recourses. Among those who were not craving, however, increased hunger was associated with decreased errors on the WCST. This makes sense as previous research suggests that hunger by itself may lead to increased ECF (see Michaud, et al., 1991)

There are two major caveats in the current study. First, only half of the participants were exposed to a casino environment. In real world casino environment (i.e., when individuals are actually engaged in gambling), however, there is little opportunity to avoid gambling related cues. Thus, in a real gambling environment, there is no equivalent 'control' condition, and all participants would experience heightened levels of craving. For this reason, the current study may lack external validity. What the Study 2 did find, is that among those who were craving, hunger was associated with ECF deficits. However, this finding failed to meet traditional levels of significance or existed as a trend in the predicted direction – possibly due to a lack of power. Therefore, Study 3 examined participants with heightened levels of craving by exposing all participants to a

gambling environment. Second, this study did not assess actual gambling behaviour. As such, I was unable to examine if ECF deficits lead to problem gambling behaviour. In order to assess gambling behaviour, Study 3 further examined those who were craving, but provided gamblers with the opportunity to gamble.

Study 3

The purpose of Study 3 was to examine the effects that both craving and hunger play on ECF and gambling behaviour among a sample of disordered gamblers. Specifically, Study 3 expanded on Study 2 in three important ways. First, in Study 3 hunger was manipulated by requiring all participants to fast prior to experiment – half of them were then fed before beginning the study. All participants in Study 3 were exposed to a casino environment, thus craving to gamble was not manipulated, but instead assessed. Second, Study 3 aimed to assess actual gambling behaviour by offering participants the chance to gamble on a slot machine. The slot machine looks like a standard casino multi-line slot machine, with touch interface, however outcomes were completely programmable. Specifically, I programed it such that gamblers would eventually experience a series of losses. How long gamblers continued to bet in the face of this series of losses was used as a measure of gambling persistence (referred to as extinction trials). Research suggests that both hunger and craving may have an impact on gambling persistence. Indeed, hungry participants may make take financial risks (Symmonds, Emmanuel, Drew, Batterham, & Dolan, 2010) and gamblers who crave to play persist longer in the face of continued loss (Young & Wohl, 2009). Finally, Study 3 examined the links between hunger, craving, and ECF among disordered gamblers. Disordered gamblers were selected as they report higher levels of craving (Young &

Wohl, 2009) and deficits in ECF (Roca et al., 2008). In addition, disordered gamblers persist longer in the face of loss (Young & Wohl, 2009).

It was hypothesized that participants who were not fed prior to the experiment would experience higher levels of hunger compared to those that were fed prior to the experiment. This hunger manipulation was then used as a moderator. Specifically, it was hypothesized that craving to gamble would predict ECF deficits, and this relationship would be increased among hungry participants. In addition, it was hypothesized that craving to gamble would predict gambling persistence, and this relationship would be increased among hungry participants. Finally, a mediated-moderated model was hypothesized such that hunger would moderate the effect of craving to gamble on ECF, which in turn would predict gambling persistence.

Methods

Participants.

Fifty-one gamblers were recruited from a catalogue of student gamblers compiled by the Carleton University Gambling Laboratory (n = 2261), who had previously indicated that they would be willing to participate in research pertaining to gambling at Carleton University. Potential participants were contacted via phone (see Appendix I). Based on participants previously obtained scores on the DSM-IV screen for pathological gambling, only those who experienced some form of gambling problems were invited to participate in the study (i.e., >=1 symptom on the DSM-IV screen). Gambling pathology was then again measured when participants came into the lab using the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001). According to the PGSI, the sample consisted of 33 low-risk gamblers, 16 moderate-risk gamblers and 2 problem

gamblers. All participants were included in the final analysis, as all participants passed attention checks. The final sample consisted of 30 males and 21 females, and the age of the sample ranged from 18 to 26 years old (*M* = 19.25, *SD* = 1.90).

Procedure.

Prior to arriving at the laboratory, participants were provided with explicit instructions regarding their eating schedule for that day. Specifically, participants were asked to refrain from eating breakfast before they came into the lab. The experiment was scheduled at the time when participants would "normally eat breakfast". In addition, participants were sent a Carleton Gambling Lab $15 voucher to bring with them. This voucher was then 'cashed' when they came into the lab for credits on the slot machine (see Appendix J).

Upon arriving at the laboratory, participants were provided with an informed consent (Appendix K), and the experimenter explained to the participant that the purpose of the study was to investigate gambling behaviour using slot machines. Participants were then randomly assigned to a hungry (*n* = 30; 11 females) or not-hungry (*n* = 21; 9 females) condition. In the not-hungry condition, participants were fed a high caloric muffin. This muffin was *not* provided to participants in the hungry condition until after the experiment was over. Participants were then directed into a casino room, in order to acclimatize participants to the gambling environment and to play slots. Specifically, at the start of play all participants were given $15 dollars (the equivalent of 1500 credits) to play with on the slot machine. Participants were instructed to play 'max bet' on a multi-line slot machine, in order to keep betting amounts consistent. The experimenter then informed the participant that they would gamble for five minutes before a timer in the

other room went off, at which point they were to stop gambling. Unbeknownst to the participants, the slot machines were preprogrammed and in reality, participants were stopped after 25 spins - at which time all participants experienced winnings of 500 credits. Therefore, participants ended the first gambling session with a total of 2000 credits (or $20.00).

After participants gambled for 25 spins, they were then interrupted by the experimenter and asked to complete the GACS, SFCQ, and ECF was assessed using a computer version of the WCST task (The PEBL Psychological Test Battery; Mueller, 2004, 2010). Participants were then informed that they could continue gambling for as long as they liked. Following the methodology of Cote et al. (2003), unbeknownst to participants, all subsequent spins were losses. The number of spins they made during this gambling session was recorded and used as a measure of extinction (i.e., persistence in the face of loss).

Upon voluntary cessation, participants in the hungry condition were given a muffin. All participants were verbally debriefed as well as provided with a debriefing form (see Appendix L) that explained the intent of the research. As deception was involved in the study, following debriefing, participants were asked to sign a form permitting the use of data for research and teaching purposes (see Appendix M). At the end of the session, regardless of how long participant's gambled for in the face of losses during the extinction trial, all were given $20, a $10 gift card to a local coffee and doughnut shop, and partial credit towards an introductory psychology course for their time.

Measures.

Craving. The Gambling and Craving Scale (GACS; Young & Wohl, 2009). Please see Study 1 for a more complete description of this measure. The GACS is comprised of three subscales: craving for the anticipation of positive affect from gambling (α = .67), craving for the immediate desire to gamble (α = .91), and craving for relief from negative affect from gambling (α = .90).

Hunger. Hunger was assessed using the hunger subscale of The State Food-Craving Questionnaire (SFCQ; Cepeda-Benito, Gleaves, Williams, & Erath, 2001). The hunger subscale consists of 3-items (α = .75) and assess hunger for food as a physiological state (e.g., "If I ate right now, my stomach wouldn't feel as empty").

The Wisconsin Card Sorting Task (WCST). This task assesses the ability to shift cognitive strategies in response to changing environmental conditions, also called set-shifting and/or cognitive flexibility. Please see Study 2 for a more complete description of this measure.

Gambling Persistence. After being allowed to gamble for as long as they like, the number of slot spins played by participants until voluntary cessation was be recorded. This number was used as a measure of gambling persistence. Increased gambling persistence was indicated by the extent to which participants persisted with gambling in the face of loss.

Results

Preliminary Analysis

The normality of the distribution of scores for craving to gamble, hunger, and the WCST were examined using frequency histograms, skewness, and kurtosis plots. There

were no significant univariate outliers identified. There were however, two participants with missing values on the WCST and these participants were not included in the analysis for which they were missing data. Previous research, has identified gender and age as potential covariates of craving to gamble (e.g. Elman, Karlsgodt, & Gastfriend, 2001; Willner, Field, Pitts, & Reeve, 1998; Pelchat & Schaefer, 2000) and ECF (e.g., Barrett-Connor & Kritz-Silverstein, 1998) and hunger (e.g., De Castro, 1993; Del Parigi et al., 2002). Therefore, in order to ensure that neither gender nor age affected performance on the WCST or craving to gamble, a one-way ANOVA was conducted on the WCST, each subscale of the GACS separately, and hunger for food as a physiological state separately in order to determine if being male as opposed to female affected scores on these variables.

Males (M = 11.90, SD = 3.95) did not have significantly different scores on the WCST compared to females (M = 13.11, SD = 3.32), $F(1,48) = 1.30$, $p = .26$, $\eta_p^2 = .03$. Males (M = 4.72, SD = 1.17) did not significantly differ from females (M = 5.10, SD = 1.31) on craving for the anticipation of positive affect from gambling, $F(1,50) = 1.13$, $p = .29$, $\eta_p^2 = .02$. Similarly, males (M = 2.29, SD = 1.37) did not significantly differ from females (M = 2.40, SD = 1.51) on craving for the relief of negative affect from gambling, $F(1,50) = .07$, $p = .79$, $\eta_p^2 = .001$. Males (M = 2.58, SD = 1.59) did not significantly differ from females (M = 2.94, SD = 1.46) on craving for the immediate desire to gamble, $F(1,50) = .67$, $p = .42$, $\eta_p^2 = .014$. Males (M = 4.00, SD = 1.13) had significantly higher scores than females (M = 3.22, SD = 1.22) on the *Hunger* subscale of the SFCQ, $F(1,50) = 5.45$, $p = .02$, $\eta_p^2 = .10$. In other words, males had higher craving for food as a

physiological state than females. In order to control for these differences in hunger, gender was included as a covariate for future analysis using this subscale.

In order to determine if age affected craving to gamble, hunger for food as a physiological state, or performance on the WCST, separate regression analysis were conducted on the WCST, each subscale of the GACS and the hunger subscale of the SFCQ. Age was not a significant predictor of performance on the WCST, $\beta = -.47$, $t(48) = -1.75$, $p = .09$, or craving for the relief of negative affect from gambling, $\beta = -.12$, $t(50) = -1.15$, $p = .25$. However, increases in age were significantly related to decreases in craving for the anticipation of positive affect from gambling, $\beta = -.17$, $t(50) = -1.85$, $p = .07$, decreases in craving for the immediate desire from gambling, $\beta = -.22$, $t(50) = -2.00$, $p = .05$, and increases in hunger for food as a physiological state, $\beta = .25$, $t(50) = 3.02$, $p = .0042$. In other words, increases in age were associated with less craving for the anticipation of positive affect from gambling, less immediate desire to gamble and more craving for food as a physiological state. Therefore, in order to control of the effects of age on craving to gamble, age was used as a covariate in further analysis on these subscales.

Manipulation Check

In order to determine if those in the hungry condition were indeed more hungry that those in the not-hungry condition, a one-way ANOVA was conducted on the hunger subscale of the SFCQ. Results revealed that those in the hungry condition ($M = 3.99$, $SD = 1.02$) had higher scores on hunger for food as a physiological state compared to those in the not-hungry condition ($M = 3.23$, $SD = 1.37$), $F(1,50) = 3.91$, $p = .06$, $\eta_p^2 = .07$, after controlling for gender and age. In other words, those in the hungry condition had

more hunger for food as a physiological state. Although this effect failed to meet traditional levels of significance, this effect was hypothesized.

Executive Cognitive Functioning

Given that the manipulation check revealed significant differences in hunger between the hungry and not-hungry conditions, the hunger manipulation was used as a moderator to test the relationship between craving to gamble and ECF. Moderation was examined using the PROCESS macro developed by Hayes (2012) for probing interactions in ordinary least squares regression models (Model 1). Thus, the hunger manipulation was entered as a predictor, and each scale was entered as another predictor, and an interaction term between the two was created and entered into a simultaneous regression model. Importantly, both the predictors were automatically centered using the PROCESS macro.

GACS Anticipation Subscale Controlling for Age. Results indicated that neither the hunger manipulation (coded 0 for hungry, 1 for not-hungry) b = -1.93, SE = 4.30, p = .65, CI [-10.60, 6.73], craving for the anticipation of positive affect from gambling, b = -.68, SE = .60, p = .63, CI [-1.88, .53], nor the interaction, b = .41, SE = .85, p = .63, CI [-1.31, 2.13], were significantly associated with errors on the WCST.

GACS Desire Subscale Controlling for Age. Results indicated that neither the hunger manipulation (coded 0 for hungry, 1 for not-hungry) b = .13, SE = 2.26, p = .95, CI [-4.42, 4.67], craving for the immediate desire to gamble, b = -.35, SE = .47, p = .46, CI [-1.29, .60], nor the interaction, b = -.0008, SE = .71, p = .99, CI [-1.43, 1.43], were significantly associated with errors on the WCST.

GACS Relief Subscale. Results indicated that neither the hunger manipulation (coded 0 for hungry, 1 for not-hungry) b = -1.73, SE = 2.12, p = .42, CI [-6.00, 2.55], craving for the relief of negative affect from gambling, b = -.54, SE = .50, p = .28, CI [-1.54, .46], nor the interaction, b = .79, SE = .79, p = .32, CI [-.80, 2.39], were significantly associated with errors on the WCST.

Gambling Behaviour

Although the hunger manipulation and craving to gamble were not related to ECF, they were examined with respect to gambling behaviour. Specifically, the hunger manipulation was used as a moderator to test the relationship between craving to gamble and the number of spins participants played in the face of continued loss (extinction trails). Moderation was examined using the PROCESS macro developed by Hayes (2012) for probing interactions in ordinary least squares regression models (Model 1). Thus, the hunger manipulation was entered as a predictor, and each scale was entered as another predictor, and an interaction term between the two was created and entered into a simultaneous regression model. Importantly, both the predictors were automatically centered using the PROCESS macro.

GACS Anticipation Subscale Controlling for Age. Results indicated that the hunger manipulation (coded 0 for hungry, 1 for not-hungry) was significantly, positively related to spins, b = 49.15, SE = 15.69, p = .003, CI [17.56, 80.73]. Similarly, craving for the anticipation of positive affect from gambling was significantly, positively related to spins, b = 7.10, SE = 2.19, p = .002, CI [2.68, 11.52]. Importantly, an interaction between the hunger manipulation and craving for the anticipation of positive affect from gambling qualified these results, b = -9.86, SE = 3.13, p = .003, CI [-16.17, -3.56].

In order to fully examine the interaction, simple slopes first examined the association between craving for the anticipation of positive affect from gambling and the number of spins in the hungry and not-hungry conditions, respectively. Simple slope tests revealed a positive association between craving for the anticipation of gambling and spins in the hungry condition, $b = 7.10$, $SE = 2.19$, $p = .002$, CI [2.68, 11.52]. In other words, increased craving for the anticipation of gambling predicted higher gambling persistence when participants were hungry. There was no association in the not-hungry condition, $b = -2.76$, $SE = 2.30$, $p = .23$, CI [-7.38, 1.86]. Figure 11 plots the simple slopes for this interaction.

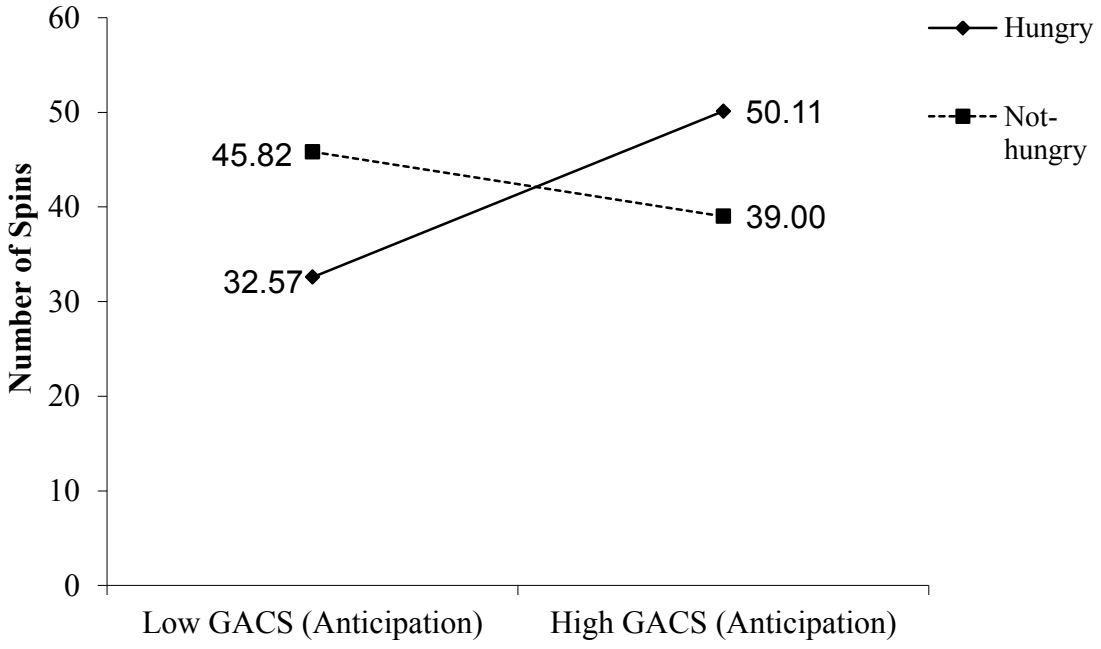

Figure 11. The effect of craving on gambling persistence probed at the hungry and not-hungry conditions.

Simple slopes were then examined for the association between the hunger manipulation and the number of spins and were probed at 1 SD above and below the mean of craving for the anticipation of positive affect from gambling. Simple slope tests revealed a positive association between the hunger manipulation and spins at 1 SD below the mean of craving for the anticipation of gambling, b = 13.24, SE = 5.42, p = .02, CI [2.32, 24.16]. That is to say, at low levels of craving, the number of extinction spins increased as participants went from being hungry to not-hungry. Simple slope tests revealed a negative association between the hunger manipulation and spins at 1 SD above the mean of craving for the anticipation of gambling, b = -11.10, SE = 5.51, p = .05, CI [-22.20, -.003]. That is to say, at high levels of craving, the number of extinction spins decreased as participants went from being hungry to not-hungry . Figure 12 plots the simple slopes for this interaction.

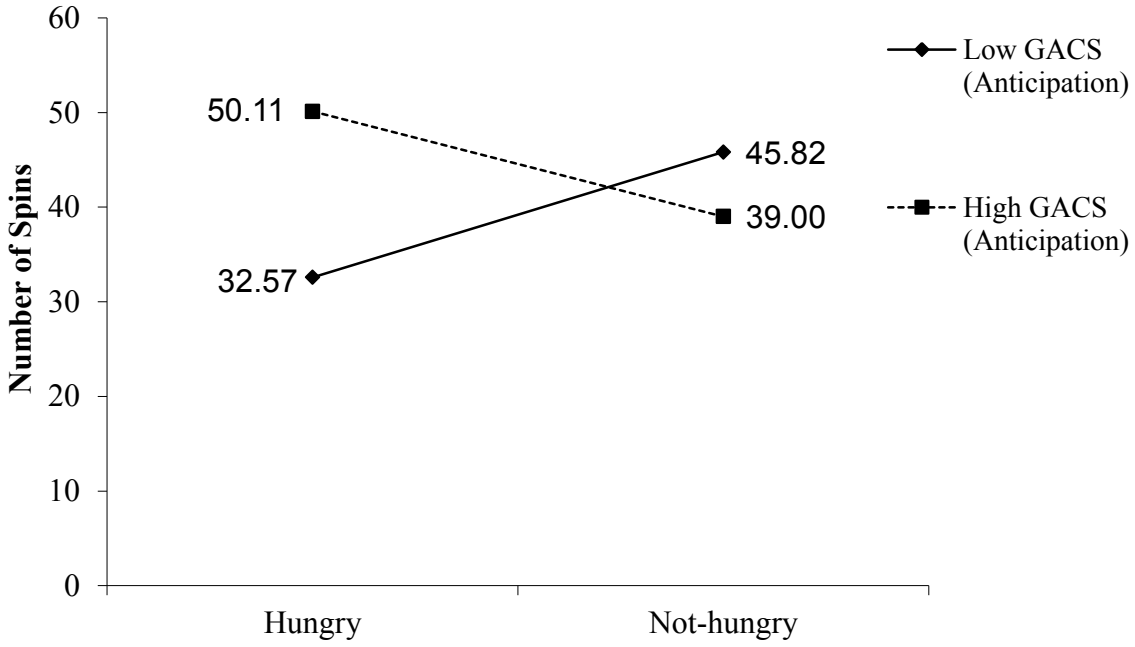

Figure 12. The effect of the hunger manipulation on gambling persistence probed 1 standard deviation above and below the mean of craving.

GACS Desire Subscale Controlling for Age. Results indicated that the hunger manipulation (coded 0 for hungry, 1 for not-hungry) was significantly and positively related to spins, $b = 16.07$, $SE = 8.24$, $p = .06$, CI [-.52, 32.67], however, this effect failed to meet traditional levels of significance. Desire to gamble was significantly and positively related to spins, $b = 4.61$, $SE = 1.75$, $p = .01$, CI [1.08, 8.14]. Importantly, an interaction between the hunger manipulation and desire to gamble quantified these results, $b = -5.52$, $SE = 2.64$, $p = .04$, CI [-10.85, -.20].

In order to fully examine the interaction, simple slopes first examined the association between craving for the immediate desire to gamble and the number of spins in the hungry and not-hungry condition, respectively. Simple slope tests revealed a

positive association between the desire to gamble and spins in the hungry condition, *b* = 4.61, *SE* = 1.75, *p* = .01, CI [1.08, 8.14]. In other words, increased desire to gamble predicted higher gambling persistence when participants were hungry. There was no association in the not-hungry condition, *b* = -.91, *SE* = 2.05, *p* = .65, CI [-5.04, 3.21]. Figure 13 plots the simple slopes for this interaction.

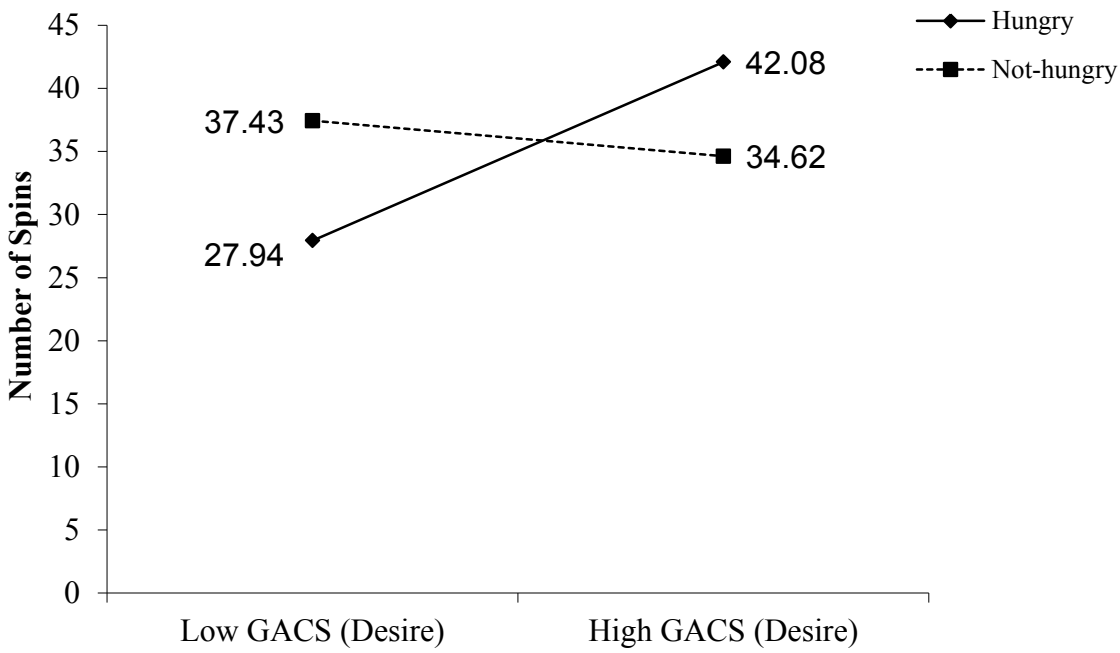

Figure 13. The effect of craving on gambling persistence probed at the hungry and not-hungry conditions.

Simple slopes were then examined for the association between the hunger manipulation and the number of spins and were probed at 1 SD above and below the mean of desire to gamble. Simple slope tests revealed no association between the hunger manipulation and spins at 1 SD below the mean of desire to gamble, *b* = 9.49, *SE* = 5.70, *p* = .10, CI [-2.00, 20.98], nor at 1 SD above the mean of desire to gamble, *b* = -7.46, *SE* = 5.74, *p* = .20, CI [-19.02, 4.09]. Figure 14 plots the simple slopes for this interaction.

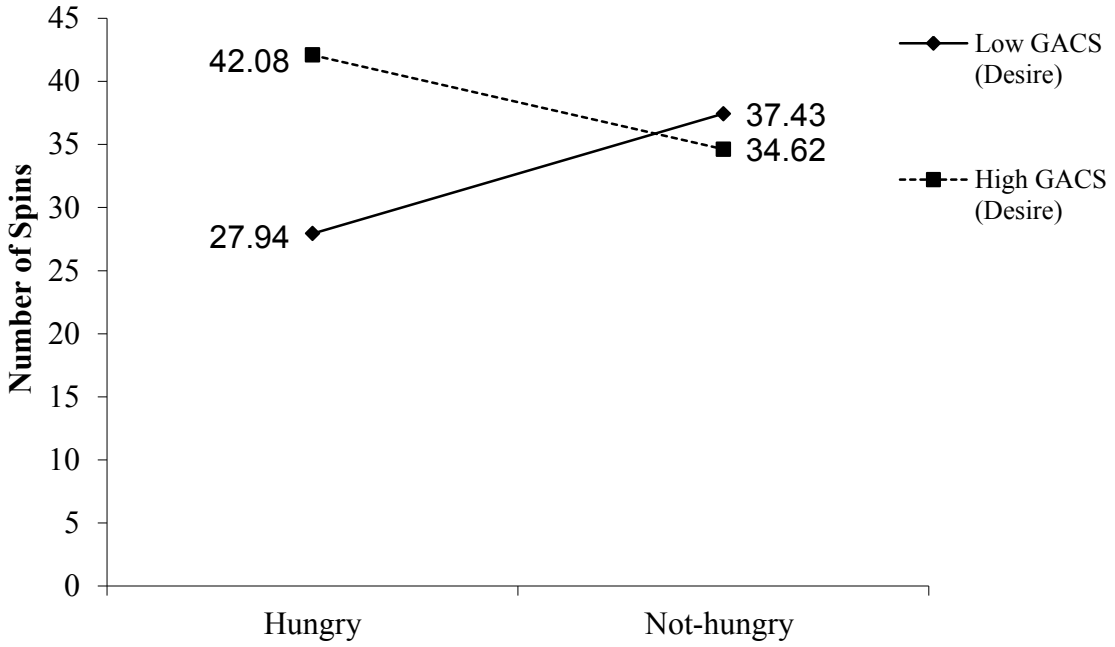

Figure 14. The effect of the hunger manipulation on gambling persistence probed 1 standard deviation above and below the mean of craving.

GACS Relief Subscale. Results indicated that the hunger manipulation (coded 0 for hungry, 1 for not-hungry) was significantly, positively related to spins, b = 18.27, SE = 7.50, p = .02, CI [3.17, 33.37]. Similarly, relief was significantly and positively related to spins, b = 5.86, SE = 1.79, p = .002, CI [2.26, 9.45]. Importantly, an interaction between the hunger manipulation and relief qualified these results, b = -6.97, SE = 2.84, p = .02, CI [-12.70, -1.25].

In order to fully examine the interaction, simple slopes first examined the association between craving for the relief from negative affect via gambling and the number of spins in the hungry and not-hungry condition, respectively. Simple slope tests revealed a positive association between relief and spins in the hungry condition, b = 5.85, SE = 1.79, p = .002, CI [2.96, 9.45]. In other words, increased craving for the relief of

negative affect via gambling predicted higher gambling persistence when participants were hungry. There was no association in the not-hungry condition, b = -1.12, SE = 2.21, p = .62, CI [-5.57, 3.33]. Figure 15 plots the simple slopes for the interaction.

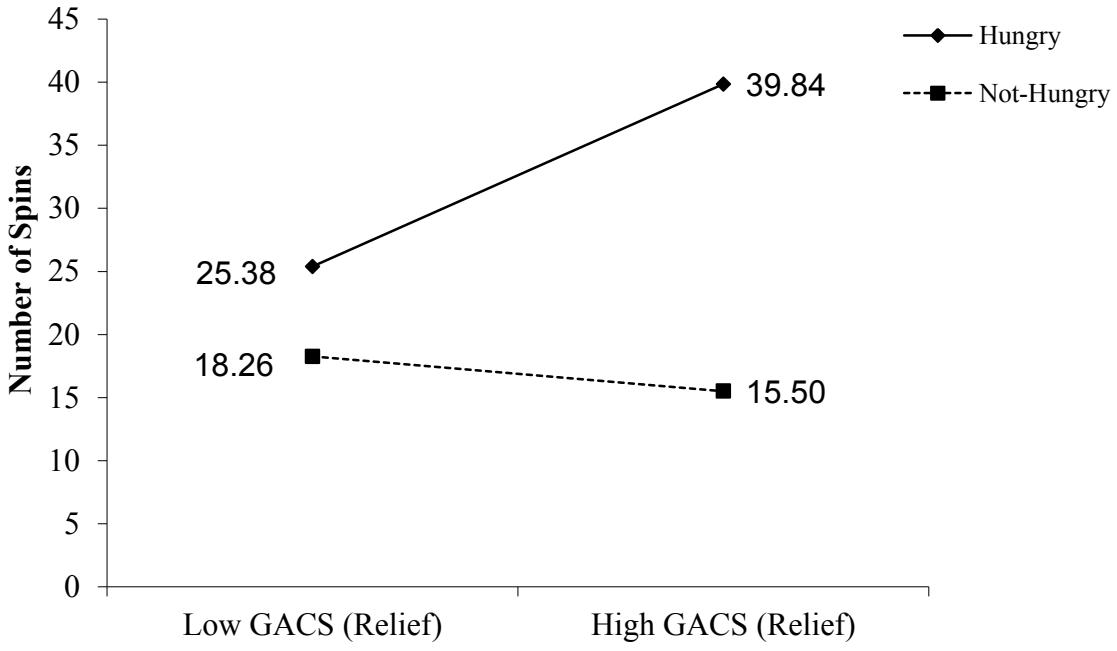

Figure 15. The effect of craving on gambling persistence probed at the hungry and not-hungry conditions.

Simple slopes were then examined for the association between the hunger manipulation and the number of spins and were probed at 1 SD above and below the mean of craving for the relief of negative affect via gambling. Simple slope tests revealed a positive association between the hunger manipulation and spins at 1 SD below the mean of relief, b = 11.29, SE = 5.30, p = .04, CI [.62, 21.97]. That is to say, at low levels of craving for the relief of negative affect via gambling, the number of extinction spins increased as participants went from being hungry to not-hungry. Simple slope tests revealed no association between the hunger manipulation and spins at 1 SD above the

mean of craving for the relief of negative affect via gambling, b = -7.88, SE = 5.84, p = .18, CI [-19.65, 3.88]. Figure 16 plots the simple slopes for this interaction.

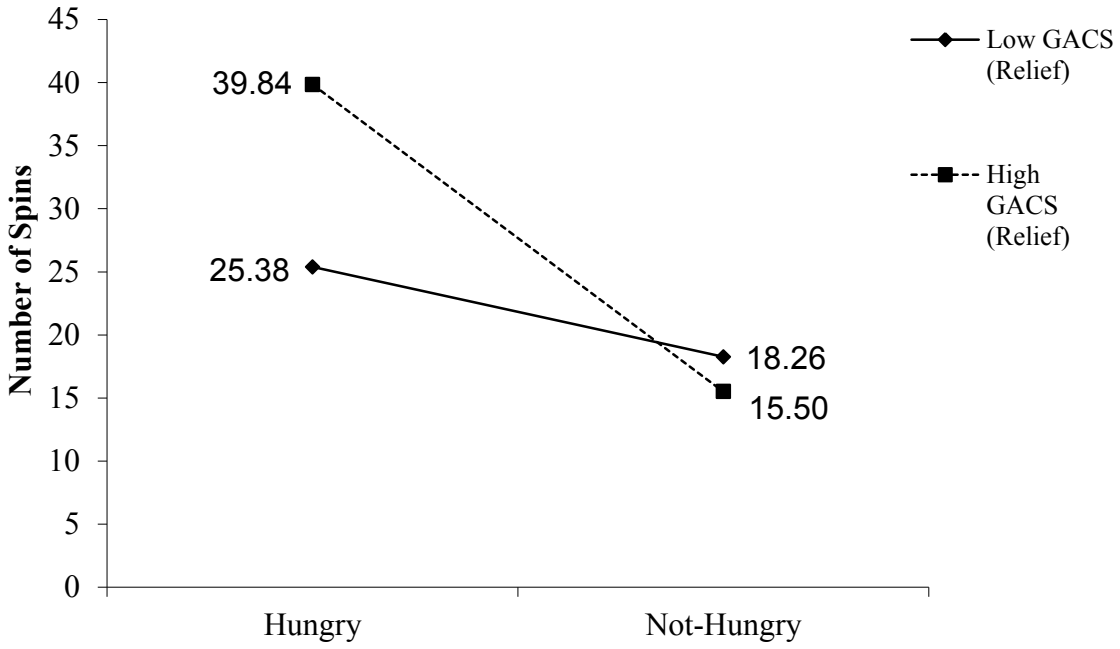

Figure 16. The effect of the hunger manipulation on gambling persistence probed 1 standard deviation above and below the mean of craving.

Discussion

Results of Study 3 support the general hypothesis that craving to gambling and hunger interact to produce problematic gambling behaviour. Specifically, it was hypothesized that hunger would interact with craving to predict problematic gambling behaviour. Results show that gamblers who were hungry and craving to gamble engaged in the most risky gambling behaviour (i.e., they continued betting in the face of loss longest). This makes sense, as previous research suggests that gamblers who crave persist longer in the face of continued loss (Young & Wohl, 2009), and that hunger may result in financial risk taking (Symmonds, Emmanuel, Drew, Batterham, & Dolan, 2010). Results

support this research, suggesting that craving and hunger are a dangerous duo when gambling.

Importantly, however, among those who are hungry, not craving to gamble seemed to be protective against this type of behaviour. That is to say, those who were hungry and did not crave to gamble persisted the least in the face of continued loss. Thus, hunger by itself may be a protective factor against gambling. This makes sense, as participants who are hungry but do not necessarily want to gamble would be the most likely to end the gambling session early in order to feed their hunger. In other words, hungry gamblers who do not want to gamble may simply want to just eat – gambling does not fill their need for food.

Interestingly, results of Study 3 were not in line with those observed in Study 2 with regard to the effect hunger and craving to gamble has on ECF. Specifically, craving to gamble and hunger did not interact to predict deficits in ECF. Two major methodological differences may explain this discrepancy between the EFC-related findings of Study 2 and Study 3. Firstly, participation in Study 3 was restricted to only those who endorsed one or more criteria of disordered gambling. Perhaps ECF is not easily manipulated through hunger among disordered gamblers. Specifically, hunger may have no effect on ECF among disordered gamblers because heightened craving may be 'washing out' these effects. In other words, it is possible that pre-existing craving is so high among disordered gamblers that it hindered my ability to detect an interaction. An inspection of the means across all three studies supports this condition. Specifically, the mean total GACS score in Study 3 was 9.93 (*SD* = 3.70), whereas the mean in Study 2 was 9.16 (*SD* = 3.70) and 7.34 (*SD* = 1.95) in Study 1. Secondly, while Study 3

manipulated hunger, it did not manipulate craving as in Study 2. Instead, all participants were exposed to the gambling environment. This may have altered the findings in two ways. Firstly, exposing all participants to a gambling environment may have contributed to the high levels of craving in the current study, as compared to Study 1 and 2. This in turn may have caused a 'ceiling' effect, such that differences in ECF were not detected due to high craving. Secondly, it is possible that manipulating hunger is not a feasible way to induce differences in ECF. Perhaps the results from Study 2 are due to the craving manipulation – specifically the existence of a control condition where craving is lowered (not cued). Indeed, examination of the simple slopes in Study 2 suggest the majority of significant interactions were due to the 'control' condition, suggesting that in order to detect differences in ECF due to craving, craving should be lowered. Unfortunately, in the current study, craving is heightened, and this may explain why there was no interaction of craving with hunger on ECF. In order to determine if this is indeed the case, future research should attempt to manipulate both craving (through a cue exposure paradigm) and hunger (through a fasting paradigm).

Since there was no interaction of the hunger manipulation with craving to gambling on ECF, a mediation model could not be examined. Specifically, it was hypothesized that hunger and craving to gamble would lead to ECF deficits, which would then lead to problem gambling behaviour. However, since there was no association in the current study between hunger and craving (the IVs) on ECF (the proposed mediator), a mediation model was not statistically appropriate. However, future research should examine if there are other possible factors that account for the craving to gamble, hunger and gambling persistence relationship.

Meta-Analysis

Due to the low sample sizes in the previous set of studies, a meta-analysis was conducted using data from Studies 1-3 to provide stronger support for the hypothesized effect of craving on ECF among those participants who were hungry versus not hungry. In order to produce meaningful effect sizes, which could be used in the meta-analysis, hunger in Studies 1 and 2 were mean-split to create a 'hungry' and 'not-hungry' group. Within each hunger group, the effect size between craving (the IV) and ECF (the DV) was determined using Pearson's correlation coefficient, *r*. Specifically, for Study 1, hunger was mean split, and the effect size of the relationship between the desire subscale of the GACS and performance on the IGT was determined separately for those who were hungry and not-hungry. Only the desire subscale of the GACS was used in calculating the effect size for Study 1, as it is the only valid subscale given the methodological limitations of the study (e.g., craving was measured after play).

For Study 2, a total score for the SFCQ (i.e., the measure of hunger) was first calculated. I then mean split the SFCQ to create a hungry and not-hungry group. The effect size between the total score for the GACS and performance on the WCST was then determined. For Study 3, hunger was split by condition, and the effect size between the total score for the GACS and both performance on the WCST and gambling persistence was calculated. The effect size for both these dependent variables was then combined by averaging these effect sizes together (see Card, 2013). Both the WCST and gambling persistence measure persistence in the face of a failing strategy, and hence assess a similar underlying self-control construct. Thus, the results of this meta-analysis provide a metric of the magnitude of the effect of craving on the self-control construct across all

studies and whether this effect is moderated by hunger. Importantly, effect sizes were coded such that positive correlations represent increased persistence in the face of a failing strategy. The analyzed effect sizes are reported in Table 1.

Table 1

Effect Size by Study and Condition

		Effect Size (*r*)	Sample Size (*n*)
Study 1			
	Hungry	.51	13
	Not Hungry	.24	13
Study 2			
	Hungry	.23	20
	Not Hungry	-.32	26
Study 3			
	Hungry	.29	30
	Not Hungry	-.06	21

Results

Effect sizes were weighted using the inverse variance ($1/SE^2$; Card, 2013). Results of the meta analysis suggest that the effect sizes of all three studies are homogenous, $Q(5) = 8.39$, $p = .14$, however this analysis is only based on six effect sizes, and thus the analysis of homogeneity should be interpreted with caution as it may be underpowered. Whether the effect sizes differed as a function of being hungry versus not-hungry was then examined. Results revealed a significant between group difference, $Q(1) = 8.39$, $p = .02$, suggesting that the effect size among those that were hungry was different from those

that were not-hungry. Examination of the effect sizes by group reveled a significant effect among the hungry group, *Mean ES* = .31, Z = 2.39, *p* = .02, CI[.06, .53]. The effect size was not significant in the not-hungry group, *Mean ES* = -.12, Z = -.86, *p* = .39, CI[-.37, .15].

Discussion

The goal of a meta-analysis is to provide a more accurate representation of the magnitude of the effect, and describe the possible range of the effect. Results suggest a medium effect among those who are hungry. Specifically, increased craving results in decreased self-control (as measured through ECF tasks and gambling persistence) among those who are hungry. Based on the confidence intervals of the effect size, it is possible that this effect may range from small to very large, thus representing a moderate range of possible values. A possible reason for this moderate range may be due to the small number of effect sizes included in the meta-analysis (i.e., six). To get a better gage on the true effect size for the moderating effect of hunger on the relationship between craving and gambling more studies are needed. With that said, results of the meta-analysis add confidence to the interpretation of the findings in this program of research; hunger and craving seem to be a dangerous duo that undermines gamblers ability to control their behavior.

General Discussion

Disordered gamblers often persist in the face of loss, and report an inability to stop gambling despite repeated efforts (O'Connor & Dickerson, 2003). One of the reasons for this continued gambling is low ECF. Specifically, gamblers may lack the ability to control and regulate their behaviour. Indeed, poor ECF may result in disjointed,

disinhibited, and uncontrolled behaviour, and research suggests that poor ECF may help to explain the development and progression of disordered gambling (e.g., von Hippel, Ng, Abbot, Caldwell, Gill, & Powell, 2009; Betancourt et al., 2012; Romer, Betancourt, Giannetta, Brodsky, Farah, & Hurt, 2009). While there are many factors that may affect ECF (e.g., stress, exercise, mindfulness), the current program of research examines the role of craving and hunger.

Craving – the intense urge or desire to engage in play – may play a key role in lowering ECF. Indeed, research suggests that cravings may explain why gamblers preform poorly on a number of ECF tasks. Unfortunately, no data is available to substantiate this claim – until now. Results of Study 1 suggest a relationship between craving to gamble and ECF, such that increased craving to gamble was related to increased deficits in ECF. Craving may affect ECF by refocusing cognitive resources towards gambling and away from self-control. Importantly, the ECF task used in Study 1, the IGT, assesses decision-making and sensitivity to reward and punishment. Thus, results suggest deficits in these areas, which may help to explain why gamblers choose to continue gambling, even though it is not the best decision – gamblers may be insensitive to punishment and seek immediate reward. The IGT also shares overlap with other measures of ECF, suggesting general deficits in ECF as well.

In addition to establishing the link between craving to gamble and poor ECF, Study 1 established the role of hunger as a moderator. Specifically, participants who were both craving and hungry reported the greatest deficits in ECF. This makes sense in light of previous research that suggests craving (Goudriaan et al., 2004) as well as hunger (Stucke & Baumeister, 2006) may cause ECF deficits. Results from Study 1 point to the

combination of craving and hunger as a possible a dangerous cocktail when it comes to ECF – when both are present, ECF is rather poor. Surprisingly, results showed that people who were hungry but not craving had the best ECF. It is possible that hunger, in itself, is not sufficient to produce deficits in ECF, it is only when combined with craving that deficits in ECF are realized. Indeed, research suggests that hunger may actually be beneficial to ECF (e.g., Dhurandhar, Allison, van Groen, & Kadish, 2013). Thus, Study 1 was an initial test of the theoretical associations between craving, hunger and ECF. In order to examine if craving to gamble and hunger are the *cause* of poor ECF, Studies 2 and 3 manipulated craving and hunger, respectively.

Study 2 used a cue reactivity paradigm to manipulate craving to gamble. To this end, gamblers were exposed to a casino or neutral environment. After cue exposure, participants' hunger was measured and ECF was assessed. Results showed that the craving manipulation was successful and participants exposed to the casino environment reported increased craving. This is in line with previous research that found exposure to gambling-relevant cues heightens craving to gamble (Kushner et al., 2007 2008; Young, Wohl, Matheson, Baumann, & Anisman, 2008). Importantly, people in the craving condition (with high levels of craving) that had high levels of hunger showed deficits in ECF. In this way, results of Study 2 suggest that craving interacts with hunger to influence ECF - at least in terms of cognitive flexibility and set-shifting, which was examined using the WCST. Troubles switching between tasks and difficulty learning from one's mistakes is why I predicted that gamblers who were craving and hungry would persist in the face of loss longer than those who were not hungry or craving – a hypothesis tested in Study 3.

In Study 3, all participants were exposed to a casino environment in order to heighten craving to gamble. This is analogous to an actual casino, where all patrons are exposed to the casino environment and gambling related stimuli (sights and sounds). Craving to gamble however, was not manipulated. Instead, hunger was manipulated. Specifically, all participants were instructed not to eat prior to the experiment. Half of participants were then fed a high caloric muffin upon start of the study, where others were not – thus creating a group of hungry participants and a group of not-hungry participants. Participants were then given the opportunity to gamble as long as they wish on a multi-line slot machine. Unbeknownst to participants, the slot machine was pre-programmed so that all outcomes resulted in a loss. Persistence in the face of this loss was used as a measure of problem gambling behaviour. Craving to gamble and ECF were assessed as well. Surprisingly, the hunger manipulation did not moderate the relationship between craving to gamble and ECF. Instead, moderation analysis revealed an interaction of hunger with craving to gamble in predicting problem gambling behaviour. Specifically, those that were hungry and craving to gamble persisted longer in the face of continued loss on the slot machine. Thus, it seems that being hungry whilst gambling may be a preciously unidentified risk factor for disordered gambling. However, ECF did not explain why hunger and craving to gamble interact to lead to disordered gambling. It is possible that ECF did not account for this relationship because all gamblers in Study 3 were cued with gambling stimuli. That is to say, once gamblers enter a casino, the heightened craving they experience due to the sights and sounds may confound differences with respect to hunger on ECF performance. Therefore, future research needs

to examine possible mechanisms responsible for the craving, hunger, problem gambling relationship.

Although significant between group differences were found in Studies 2 and 3, some findings failed to meet traditional levels of significance. To better understand the effect of craving and hunger on ECF, a meta-analysis was conducted. Results of this meta-analysis suggested that there is an effect of craving in predicting poor self-control when individuals are hungry, but not when they full (i.e., not hungry). Thus, the meta-analysis improves confidence in the findings that craving and hunger may be particularly dangerous when present together. However, the confidence intervals for this effect were relatively large, and thus more studies examining the craving and hunger relationship are needed to narrow down the confidence intervals and understand the exact magnitude of the effect. Nonetheless, results of all three studies and the meta-analysis suggest that research on craving and hunger is a promising program of research, with potential to assist gamblers in controlling their behavior.

Implications

One possible (and potentially significant) implication for the set of studies conducted for my dissertation is that eating before gambling may be a low-cost, easy to implement, responsible gambling strategy. Specifically, people might facilitate their responsible gambling by eating before playing. In doing so, the likelihood that they will play in the face of continued loss (and perhaps beyond their pre-set monetary limit on play) would be reduced. Unfortunately, disordered gamblers are apt to either not set a limit or exceed their pre-set limit on play (Dickerson, Baron, Hong, & Cottrell, 1996; Nower & Blaszczynski, 2010). Current responsible gambling strategies are, by-in-large,

aimed at making modifications to the structural characteristic so games such that tools are being installed that help gamblers set and adhere to a pre-set monetary limit (e.g., Blaszczynski, Gainsbury, & Karlov, 2013). Unfortunately, retrofitting RG tools into existing games may be costly. Thus, there is a need for low cost RG strategies that are easy to implement. Encouraging gamblers to eat before they gamble may be one such strategy. From a policy standpoint, casinos should be encouraged to have food readily available on the casino floor. Perhaps casinos should be encouraged to provide free snack-food as they do coffee and alcohol (in some jurisdictions).

Although hunger and craving did not affect ECF in Study 3, they did interact in Study 1 and 2. A possible reason for this lack of interaction is that high levels of craving to gamble among disordered gamblers may have negated the ability to detect differences in ECF. Improving ECF among gamblers may nonetheless be beneficial in assisting gamblers to regulate their behaviour. Therefore, another implication from the current research is that hunger and craving may undermine ECF, but perhaps by improving gamblers ECF, responsible gambling could be facilitated. One way to improve ECF could be by using mindfulness mediation, which has shown efficacy in improving sustained attention, error monitoring, and promotion of higher-order cognitive processing (Zeidan, Johnson, Diamond, David, & Goolkasin, 2010). Mindfulness meditation is a collection of meditation practices designed to enhance the ability to remain immersed nonjudgmentally in the moment (Nolen-Hoeksema & Rector, 2011). Research has demonstrated that even a brief regime of mindfulness meditation training can result in marked enhancements in executive functioning, visuo-spatial processing, and working memory (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). If mindfulness can thus increase ECF, gamblers

may be able to regulate their self-control and behaviour. Thus, mindfulness meditation may be another easy-to-implement and low costing harm reduction strategy.

Results thusly suggest that hunger and craving to gamble may interact without affecting ECF. Future research should examine other possible mechanisms that may explain the link between craving to gamble, hunger and problematic gambling beahviour. One possible mechanism that explains this link may be Ghrelin - a 28 amino-acid peptide hormone produced by the stomach and involved in regulating energy balance and food intake. Ghrelin release increases food intake and the accumulation of fat (Tschop, Smiley, & Heiman, 2000) and plasma ghrelin levels are elevated after a fast and increase in anticipation of every meal (Cummings et al., 2001). Importantly, ghrelin has been implicated in compulsive addictive behaviours, including gambling and overeating (Knutson et al., 2001; Potenza et al., 2003; Volkow et al., 2003; Wang, Volkow, Thanos, & Fowler, 2004). Ghrelin underlies the experience of craving for these addictive behaviours. Indeed, craving for substances and craving for compulsive addictive behaviours may share common neural circuits (Addolorato et al., 2006; Dickson et al., 2011). Thus, increased ghrelin levels may lead to both increased hunger and cravings to gamble. Gambling is an ideal context in which to study the effects of ghrelin levels on craving because gamblers experience stronger cravings than both cocaine addicts and alcoholics (Castellani & Rugle, 1995; Ziberman, Hodgins, & el-Guebaly, 2005). Ghrelin should be investigated in future studies examining hunger and craving.

Limitations

A significant limitation of the findings observed in the current program of research is the small sample sizes in all three studies. Although precautions were made to

recruit enough participants to satisfy power concerns, recruitment for laboratory-based experiments is increasingly difficult, and thus we were not able to recruit as many participants as we wished. In addition, the need for participants must be balanced with the time and effort necessary to recruit and run participants. However, current sample size was still adequate to detect between group differences, although some findings failed to meet traditional levels of significance. If additional participants had been acquired, these results may have reached the traditional 0.05 alpha level. In light of this limitation, a meta-analysis was conducted. The results of this meta-analysis suggest the observed effects of craving on ECF are valid across studies for those that are hungry. However, more research is needed to assess the impact hunger has on the relationship between craving and gambling.

Another caveat of these studies is that they were conducted within a laboratory setting using young-adults. Specifically, results may not generalize from an artificial environment to a real-world casino, especially with a university-aged sample. However, although the laboratory is setting is artificial, great care was taken in creating the Carleton University Gambling Lab (CUGL), such that it closely resembles that of a real casino. The CUGL has a typical 'busy' carpet, three slot machines, a poker table and neon lights. In addition, the use of a laboratory setting was necessary in order to achieve proper methodology, and achieve validity in the findings. Since the slot machines in the laboratory were pre-programmed, the casino environment stayed static, and each participant had the same experience with the slot machine, regardless of which machine they chose or manipulation they were in. Additionally, the use of young adults adds, not subtracts, from the generalizability of the results. Specifically, young adults are

particularly at risk for developing gambling problems (Parker & Bauermann, 2011). If RG strategies can be tailored to curb disordered gambling among young-adults, there is no reason to assume that it would not hold true for the gambling population at large.

One limitation of the current research is that only two ECF tasks were used.. The IGT and WCST assess cognitive processes associated with sensitivity to reward and punishment, decision making under uncertainty, cognitive shifting and flexible responding. These processes were of interest because they may help explain why gamblers persist in the face of continued loss. Both the IGT and WCST assess (in their own way) lack of self-control and persistence in a faulty strategy – which are both defining features of disordered gambling. However, ECF also involves other processes that might be relevant to explaining disordered gambling behavior, such as planning (measured by the Tower of London task) and working memory (measured by the Digit Span test). Future research should examine how these and other ECF sub-processes are influenced by craving as well as hunger and thus implicated in disordered gambling behavior.

Lastly, one final limitation that may affect generalizability is that participants were given $15 to gamble with in Study 3. As this was not their personal money, participants may have viewed this $15 as surplus funds. The belief that they were not playing with their 'own' money may have altered the way participants chose to gamble with it. Specifically, participants may have been more apt to gamble with this $15 because they "had nothing to lose". While this is a valid concern, Study 3 attempted to circumvent this limitation be e-mail participants a $15 gambling voucher ahead of participation, and having participants "cash" it when they entered the laboratory. In this

way, participants may have been more apt to perceive the money as theirs. In addition, participants were told that they would leave the study with whatever amount they won or lost, thereby shifting ownership of the $15 to the participants. As a final note, it is against APA ethical regulations to allow participants to use their own money, thus the $15 given to them to gamble also served as an incentive for participation.

Conclusion

The present study is the first to examine the effects of craving and hunger on ECF and gambling behaviour. Results of this study are important, as ECF may explain why disordered gamblers persist in the face of loss, and report an inability to stop gambling. Results suggest that those who are both craving and hungry have decreased ECF and are at an increased risk for problem gambling behaviour. Therefore, in order to combat the negative effects on ECF and problem gambling behaviour, craving to gamble or hunger should be targeted. For example, one low-cost, easy to implement strategy may be to encourage gamblers to eat if they are craving to gamble, or are planning on heading to a casino. Overall, this study furthers research on craving to gamble and explains some of the factors that may underlie its relationship with problem gambling behaviour.

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Appendices

Appendix A: Phone Recruitment Script for Study 1

Hi, my name is _____; I'm with a team of researchers at Carleton University As you may remember, you filled out a quick survey earlier in the academic year asking you about your gambling behaviours. At that time we told you that we would be contacting you later in the year for a follow-up session. Before I get into that, is this a good time to call?

If yes, continue.
If no, schedule another time to call.

First of all, I just need to ask you a quick series of questions to see if you're still eligible to participate in this survey:

Are you currently or have you been in treatment for your gambling behaviour?
Are you currently or have you been in treatment for any addiction or mental health issue?
Since you completed mass testing, have you willingly stopped your gambling behaviour?

If yes: Thank the person for their time on the phone, but tell them that it would not be appropriate to have them participate in the current study. Thank them again for their time.

If no: Describe the given study.

If interested, Arrange time.

If no, Thanks and good-bye

Appendix B: Informed Consent for Study 1

Informed Consent

The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your involvement. The informed consent has to provide sufficient information such that you have the opportunity to determine whether you wish to participate in the study.

Study Title: Gambling Behaviour among Slot Players

Study Personnel: Dr. Michael Wohl, Department of Psychology, Carleton University
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Travis Sztainert, Department of Psychology, Carleton University
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This study has received clearance by the Carleton University Psychology Research Ethics Board (11-188). Please use this number if you need to contact the Chair of the Department or Chair of Ethics Committee concerning this study. Should you have any ethical concerns about this study please contact, Dr. Monique Sénéchal (Chair, Carleton University Research Ethics Board, monique_senechal@carleton.ca, 613-520-2600, ext. 1155). Should you have any other concerns please contact, Dr. Anne Bowker (Chair, Department of Psychology, psychchair@carleton.ca, 613-520-2600, ext. 8218).

Purpose and Task Requirements: The purpose of this study is to assess perceptions about gambling while playing a slot machine. We are asking you to fill out a number of questionnaires regarding your gambling (e.g., propensity to gamble and attitudes toward gambling).

Potential Risk and Discomfort: There are no physical risks in this study. Some individuals may experience distress or anxiety when asked to respond to personal, sensitive questions involving frequency and consequences of gambling. As researchers, we are not qualified to offer any sort of counseling, but we will provide you with a list of resources that you can contact for support if you need or want it.

Anonymity/Confidentiality: All of the data collected in this study will be kept confidential. Because we will want to keep track of your answers in this questionnaire to match up with possible later measures, we will have to be able to identify who you are on your questionnaire. We will do this by assigning you a personal code, and we will take special precautions to make sure that no one else will be able to identify you and what your responses were. Any identifying information associated with your code will be confined to a single page that will be separated from your questionnaire, and kept by the research investigators in a separate, secured and confidential file. At the end of this study, we will be asking you for your permission to keep your contact information on file for one year in order to contact you to ask if you'd be willing to participate in follow-up studies.

Right to Withdraw: Your participation in this study is entirely voluntary. At any point during the study you have the right to not complete certain questions or to withdraw with no penalty whatsoever.

I have read the above description of the study concerning gambling and behaviors among slot players. The data collected will be used in research publications and/or for teaching purposes. My signature indicates that I agree to participate in the study, and this in no way constitutes a waiver of my right.

Full Name (please print): _____
Participant Signature: _____
Date: _____
Researcher Signature: _____
Date: _____

Appendix C: Debriefing for Study 1

Debriefing

This post-survey information is designed to help you understand the nature of the research. In this study, we have been interested in assessing individual's perceptions about the ways that slot machines operate, and in assessing the relationship between these perceptions and other factors which may be related to the development of problem-gambling, exceeding time limits, and negative outcomes among slot machine players.

Previous research (Wohl, Matheson, & Anisman, 2005; Breen & Zuckerman, 2002) suggests that erroneous cognitions (e.g., a belief in personal luck, feelings of control while gambling, etc.), may play an important role in the development of gambling problems. We argue that among recreational gamblers, adherence to time limits will be unaffected by whether they are in a net win or net loss position (relative to their monetary start point). However, this effect should be moderated by the extent to which participants hold erroneous cognitions, especially belief in luck. Specifically, participants who believe in luck should be relatively unlikely to adhere to limits if they are in a net win position. In such a situation, gamblers are likely to believe they are on a lucky streak and will thus want to "ride the streak."

To assess this, some participants were asked to set a time limit of their play prior to gambling. Half of these people were reminded when they reached their time limit, whereas others were not reminded. We did this to see if reminding people of their limit helped them stay within their limit. Other participants were not told to set a limit prior to gambling. Instead, we asked participants if they had set a limit after the fact. This group of people served as a control group. Specifically, this condition will help us determine if explicitly asking people to set a limit prior to gambling helps them set a lower time limit – a key factor in helping people to gamble responsibly.

We also varied whether people won or lost. That is, half of the people who are in this experiment were randomly assigned to win money while playing, whereas the other half lost money while playing. We did this to assess whether winning or losing influences adherence to time limits people put on their own gambling.

At this time, we would like to inform you of some symptoms of problem gambling. They include borrowing money to gamble, inability to stop gambling, feeling irritable if you do not gamble for a period of time, going back to the casino to win back lost money, lost relationships due to gambling behaviour, spending a lot of time thinking about gambling, and needing to spend more and more money to get the same excitement out of gambling. This is not a comprehensive list; someone who has problems with gambling may experience a few of the above symptoms (2-3), but not necessarily all of the above symptoms. The questionnaires you have just completed will help us to identify factors (e.g., gambling experience, knowledge about gambling and games of chance, coping styles, etc.) that might contribute to gambling frequency and persistence over time, and that might encourage slot machine players to exceed their financial limits.

It is hoped that the results from this project will help us to identify factors that render slot machine players vulnerable to gambling problems, and will assist us in evaluating the efficiency of time limit pop-ups in minimizing or preventing gambling problems among slot machine players over time.

As researchers, we are not qualified to provide advice or treatment regarding gambling problems. However, **if you have a concern about your gambling behaviour or are feeling upset in any way after participating in this study, you may contact any of the following people to talk about your thoughts or experiences:**

- If you have any concerns about your gambling behaviour, you may wish to contact:
    - Gamblers Anonymous at: 613-567-3271

  - Ontario Problem Gambling helpline at: 1-888-230-3505; Web Site: http://www.opgh.on.ca
  - Addictions and Problem Gambling Services of Ottawa at: 613-789-8941; Web Site: http://www.apgso-stjpo.ca/find_eng.html

- If you have a family member who gambles, you may wish to contact:
  - Gamblers Anonymous at: 613-567-3271

- If you are experiencing any sort of distress, it is suggested that you either contact your family physician, or one of the organizations listed below:
  - Ottawa & Region Distress Centre: 613-238-1089; Web Site: www.dcottawa.on.ca;
  - Amethyst Women's Addiction Centre (offering support for gambling, drug and alcohol problems): 613-563-0363; Web Site: http://www.amethyst-ottawa.org/

- It is not a good idea to allow problems to fester, as ruminating over these problems will typically not make them go away. Your family physician or counselor will usually be able to help you or to refer you to someone who can.

If you have any questions or comments about this research, please feel free to contact:

- Dr. Michael Wohl, Email: michael_wohl@carleton.ca; Phone: 613-520-2600 ext. 2908
- Travis Sztainert, Email: tsztaine@connect.carleton.ca
- Nina Hedayati, Email: nhedayat@connect.carleton.ca
- Jessica Palladina, Email: jpalladi@connect.carleton.ca

This study has received clearance by the Carleton University Psychology Research Ethics Board (11-188). Please use this number if you need to contact the Chair of the Department or Chair of Ethics Committee concerning this study.

Should you have any ethical concerns about this study please contact, Dr. Monique Sénéchal (Chair, Carleton University Psychology Research Ethics Board, monique_senechal@carleton.ca, 613-520-2600, ext. 1155). Should you have any other concerns please contact, Dr. Janet Mantler (Chair, Department of Psychology, psychchair@carleton.ca, 613-520-2600, ext. 4171).

We thank you very much for participating in this study. Your assistance will help us better understand gambling behaviour among slot machine players.

Appendix D: The Gambling and Craving Scale

GACS

INSTRUCTIONS: Please indicate your agreement or disagreement to the following statements by circling the appropriate response.

	Strongly Disagree | Strongly Agree
1. If I had an opportunity to gamble right now I would probably take it.	1 2 3 4 5 6 7
2. If I were gambling now I could think more clearly.	1 2 3 4 5 6 7
3. I could control things better right now if I could gamble.	1 2 3 4 5 6 7
4. Gambling would be fun right now.	1 2 3 4 5 6 7
5. I crave gambling right now.	1 2 3 4 5 6 7
6. I need to gamble now.	1 2 3 4 5 6 7
7. I would not enjoy gambling right now.	1 2 3 4 5 6 7
8. I have an urge to gamble.	1 2 3 4 5 6 7
9. Gambling would make me less depressed.	1 2 3 4 5 6 7

Appendix E: Phone Recruitment Script for Study 2

Recruitment Notice

Hi, my name is _____; I'm with a team of researchers at Carleton University As you may remember, you filled out a quick survey earlier in the academic year asking you about your gambling behaviors. At that time we told you that we would be contacting you later in the year for a follow-up session. Before I get into that, is this a good time to call?

If yes, continue.
If no, schedule another time to call.

First of all, I just need to ask you a quick series of questions to see if you're still eligible to participate in this survey:

Are you currently or have you been in treatment for your gambling behavior?
Are you currently or have you been in treatment for any addiction or mental health issue?
Since you completed mass testing, have you willingly stopped your gambling behavior?

If yes: Thank the person for their time on the phone, but tell them that it would not be appropriate to have them participate in the current study. Thank them again for their time.
If no: continue with below

The purpose of the in lab session is to determine attitudes and psychological reactions to gambling. During this session you would be asked to complete a number of questionnaires that assess your perceptions of gambling, and ask you to complete a number of quick, non-invasive cognitive tasks. To compensate you for participating, you'll receive a 1% participation credit for your time. If you're interested, we would like you to participate in this study. This study has received clearance by the Carleton University Psychology Research Ethics Board [12-202]".

If interested, Arrange time.

If no, Thanks and good-bye

Appendix F: Informed Consent for Study 2

Informed Consent

The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your involvement. The informed consent has to provide sufficient information such that you have the opportunity to determine whether you wish to participate in the study.

Study Title: Gambling and Cognitive Functioning
Study Personnel: Dr. Michael Wohl, Tel. 520.2600 ext. 2908; EMAIL**:** mwohl@connect.carleton.ca
Travis Sztainert, Tel. 520.2600 ext.6312; EMAIL: tsztaine@connect.carleton.ca
Kashi Kawatra, Tel. 520.2600 ext. 2683; EMAIL: lkkawatr@connect.carleton.ca
Melanie Simmons, EMAIL: mlosimmo@connect.carleton.ca
ChrisAnn Alvarez, EMAIL: calvare2@connect.carleton.ca

This study has received clearance by the Carleton University Psychology Research Ethics Board (12-202). If you have any ethical concerns about this study please contact Monique Sénéchal, Chair of Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1155 or Anne Bowker, Chair of Department of Psychology, 613-520-2600 ext. 8218.

Purpose: We are interested in assessing cognitive functioning among people who gamble

Task Requirements: You will be asked to complete a series of questionnaires about your background and gambling behaviour. Specifically, we will be administering questionnaires regarding your gambling urges and past year gambling behaviour. We will also be giving you a series of quick, non-invasive, cognitive tasks designed to measure your attention, and cognitive processing speed.

Potential Risk and Discomfort: Some individuals may feel uncomfortable when asked to respond to personal, sensitive questions about gambling behavior. If you feel any discomfort or distress, you may choose not to answer specific questions, and you will not be penalized in any way if you do this. The debriefing form at the end of the study provides contact information for local support services that you may contact if you need or want help. Finally, although potential risks have attempted to be minimized, the present study may still have an impact on your gambling behavior in the future.

Anonymity/Confidentiality: The data collected in this study will be kept confidential. Your informed consent form will be separated from your questionnaire and kept in a separate and secured file by one of the research investigators who will keep this information confidential. It will be associated with a code, and only this code will identify your questionnaire. We will need to have a code associated with your questionnaire so that we are able to match up your responses at the end of the study. The data will also be stored in a secured data file that is only accessible by the researcher and research assistants. Please note that your data, as well as your personal information (from the consent form), will be securely kept for 5 years before being destroyed.

Right to Withdraw: Your participation in this study is entirely voluntary. At any point during the study you have the right to not complete certain questions or to withdraw with no penalty whatsoever.

I have read the above description of the study concerning cognitive functioning and gambling, and agree to have personal information obtained. Personal information gathered includes gambling history, as well as performance on cognitive tasks. The data collected will be used in research publications and/or for teaching purposes. My signature indicates that I agree to participate in the study, and this in no way constitutes a waiver of my rights.

Full Name (please print): _____
Participant Signature: _____
Date: _____
Researcher Signature: _____
Date: _____

Appendix G: Debriefing for Study 2

Debriefing

This post-test information is designed to help you understand the nature of the research. This experiment is part of ongoing research at Carleton examining gambling behaviour and attitudes. Specifically, the purpose of this study is to examine the role that craving to gamble may have on cognitive functioning.

Importance of this type of research
Gambling has been found to share physiological and cognitive/psychological similarities with substance abuse addictions. Indeed, gamblers seem to experience stronger cravings than both cocaine addicts and alcoholics. The current study therefore aimed to examine the possibility that differences in craving may result in differences in cognitive functioning. This difference in cognitive functioning may then go on to be an important factor in influencing problematic play.

Hypotheses tested
Previous research suggests that, in order to elicit craving, objects that are relevant to an addictive behaviour (i.e., cues) can be placed in the environment of the user (Monti et al., 1987; Niaura et al., 1988). Within the gambling literature, pathological gamblers who were exposed to a casino environment reported a significant increase in craving (Kushner et al., 2007). In contrast, participants reported no change in craving in a neutral environment. In the current study, we had half of the participants complete the experiment in a casino-environment and half in a neutral-environment in hopes that it would similarly affect craving. We administered cognitive tasks to all participants to determine whether this craving could have an influence on performance of these tasks. Specifically, we hypothesized that those participants who were craving would do worse on the cognitive tasks.

Possible benefits of participating in this study
- Results from this project will help us understand why people gamble and may provide the basis for us to develop techniques to curb craving and prevent problem gambling.
- We have found that participating in gambling research can benefit gamblers through knowledge gained regarding the pitfalls associated with gambling.
- All participants receive this debriefing sheet that has contact information for problem gambling hotlines as well as health and addiction centers (see the very end of this sheet). Often, this is the first time gamblers are directly and explicitly provided a means through which treatment can be sought. Anecdotally, we have had gamblers with and without problems with their gambling thank us for bringing gambling and the problems associated with this behaviour to their attention.
- Some of our research (e.g., Wohl, Christie, Matheson, & Anisman, 2010, Journal of Gambling Studies) shows that participating can reduce mistaken beliefs associated with play and promote responsible gambling.

If you have questions later
If you have any questions about this study when you leave, please feel free to use the contact information on this debriefing form that you are allowed to keep. If you feel that this experiment has influenced your behaviour towards gambling in any way (i.e. if you now have a craving, or urges, to gamble), please contact or speak to the experimenter immediately.

Helpful resources
Ontario Problem Gambling helpline 1-888-230-3505 http://www.opgh.on.ca/
Addictions and Problem Gambling Services of Ottawa **(613) 789-8941** http://www.apgso-stjpo.ca/find_eng.html
Distress Centre: Ottawa And Region (613) 238-1089 http://www.dcottawa.on.ca
Health and Counselling Services at Carleton University (613) 520-6674.

If you have any questions or comments about this research, then please feel free to contact:
- Michael Wohl (Tel. 520.2600 ext. 2908; EMAIL: mwohl@connect.carleton.ca)
- Kashi Kawatra (Tel. 520.2600 ext. 2683; EMAIL: lkkawatr@connect.carleton.ca)

- Travis Sztainert (Tel. 520.2600 ext.6312; EMAIL: tsztaine@connect.carleton.ca)
- Melanie Simmons (EMAIL: mlosimmo@connect.carleton.ca
- ChrisAnn Alvarez (EMAIL: calvare2@connect.carleton.ca).

If you have any ethical concerns about this study please contact Monique Sénéchal, Chair of Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1155 or Anne Bowker, Chair of Department of Psychology, 613-520-2600 ext. 8218.

Lastly, gambling may become harmful to ones relationships and well being, both emotionally and financially. The current research is in no way an endorsement to gamble but rather aims to discover ways to help and prevent gambling. If you think you may have gambling problems, it is suggested that you contact one of the organizations listed below. It is not a good idea to allow problems to fester, as ruminating over these problems will typically not make them go away. In addition, your family physician or counselor will may also be able to help you or to refer you to someone who can help.

We thank you very much for participating in this study. Your assistance will help us better understand gambling behavior among young adults.

Appendix H: The State Food-Craving Questionnaire

SFCQ

Please indicate the extent to which you agree with each statement right now, at this very moment.

Items	**Strongly Disagree**					**Strongly Agree**
I'm craving tasty food	**1**	**2**	**3**	**4**	**5**	**6**
I have an urge for tasty food	**1**	**2**	**3**	**4**	**5**	**6**
I have an intense desire to eat something tasty	**1**	**2**	**3**	**4**	**5**	**6**
If I ate something, I wouldn't feel so sluggish and lethargic	**1**	**2**	**3**	**4**	**5**	**6**
Satisfying my appetite would make me feel less grouchy and irritable	**1**	**2**	**3**	**4**	**5**	**6**
I would feel more alert if I could satisfy my appetite	**1**	**2**	**3**	**4**	**5**	**6**
If I ate right now, my stomach wouldn't feel as empty	**1**	**2**	**3**	**4**	**5**	**6**
I am hungry	**1**	**2**	**3**	**4**	**5**	**6**
I feel weak because of not eating	**1**	**2**	**3**	**4**	**5**	**6**
My desire to eat something tasty seems overpowering	**1**	**2**	**3**	**4**	**5**	**6**
I know I'm going to keep on thinking about tasty food until I actually have it	**1**	**2**	**3**	**4**	**5**	**6**
If I had something tasty to eat, I could not stop eating it	**1**	**2**	**3**	**4**	**5**	**6**
If I were to eat what I'm desiring, I am sure my mood would improve	**1**	**2**	**3**	**4**	**5**	**6**
Eating something tasty would feel wonderful	**1**	**2**	**3**	**4**	**5**	**6**
Eating something tasty would make things just perfect	**1**	**2**	**3**	**4**	**5**	**6**

Appendix I: Phone Recruitment Script for Study 3

Recruitment Notice

Hi, my name is _____; I'm with a team of researchers at Carleton University As you may remember, you filled out a quick survey earlier in the academic year asking you about your gambling behaviors. At that time we told you that we would be contacting you later in the year for a follow-up session. Before I get into that, is this a good time to call?

If yes, continue.
If no, schedule another time to call.

First of all, I just need to ask you a quick series of questions to see if you're still eligible to participate in this survey:

Are you currently or have you been in treatment for your gambling behaviour?
Are you currently or have you been in treatment for any addiction or mental health issue?
Do you currently have any medical conditions which would prevent you from fasting?
Since you completed mass testing, have you willingly stopped your gambling behavior?
Do you speak fluent English as a first language?

If yes: Thank the person for their time on the phone, but tell them that it would not be appropriate to have them participate in the current study. Thank them again for their time.
If no: continue with below

The purpose of the in lab session is to determine both psycholigcal and physiological reactions to gambing. During this follow-up session you would be asked to engage in gambling on a slot machine. We will ask you to complete a number of questionnaires that assess your perceptions of the gambling experience, and ask you to complete a number of quick, non-invasive cognitive tasks. In addition, we will also ask to take some blood & saliva samples from you in order to assess a number of hormones that we believe are related to gambling. In order to play slots, you will receive $15 to gambling with. To compensate you for participating, you'll receive a $10 gift certificate to Tim Horton's and all of the gambling money you have at the end of the session – be it above or below the initial $15 we give you to start gambling. In addition, you will also receive a 1% participation credit for your time. If you're interested, we would like you to participate in this study. This study has received clearance by the Carleton University Psychology Research Ethics Board #11-003. This study would take place before you eat breakfast, during a weekday.

If interested,
Arrange time
Specify participant to not eat breakfast prior to experiment
E-mail participants $15 voucher

As we are asking you not to eat before coming into the experiment, we are going to have some food for you. Is there anything we should know in terms of your food preferences? For example, are you allergic to any foods, or are there any sweet foods, like chocolate, that you don't particularly like?

If no, Thanks and good-bye

Appendix J: Gambling Voucher

Appendix K: Informed Consent for Study 3

Informed Consent

The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your involvement. The informed consent has to provide sufficient information such that you have the opportunity to determine whether you wish to participate in the study.

Study Title: Gambling Behaviours, Attitudes and Ghrelin

Study Personnel: Dr. Michael Wohl, Tel. 520.2600 ext. 2908; EMAIL: mwohl@connect.carleton.ca
Dr. Alfonso Abizaid Tel. 520.2600 ext. 1544; EMAIL: alfonso_abizaid@carleton.ca
Travis Sztainert Tel. 520.2600 ext.6312; EMAIL: tsztaine@connect.carleton.ca
Nina Hedayati Tel. 520.2600 ext.6312; EMAIL: nhedayat@connect.carleton.ca

This study has received clearance by the Carleton University Psychology Research Ethics Board (insert your ethics file number once obtained). If you have any ethical concerns about this study please contact Monique Sénéchal, Chair of Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1155 or Anne Bowker, Chair of Department of Psychology, 613-520-2600 ext. 8218.

Purpose: We are interested in the effects that a number of hormones and peptides may have on your gambling behaviour.

Task Requirements: In order to evaluate hormones and peptides, we would like to take saliva samples. Saliva samples will be collected using "salivettes". This entails you being instructed to remove a cotton swab from the salivette tube and placing into your mouth for two minutes, and then reinserting it back into the test tube (disposable plastic) and passed to the investigator. All instruments used for saliva sampling will be sterile and one-time use only. The samples will be analyzed for levels of stress related hormones (ACTH, cortisol, norepinephrine, epinephrine, prolactin and oxytocin), and peptides involved with eating behavior (ghrelin, leptin, insulin, neuropeptide Y, neuromedin B, Oxytocin), as well as glucose and cytokines. Once these markers have been analyzed, any remaining samples will be disposed of and will not be used for any other purposes.

You will also be asked to complete a series of questionnaires about your background and gambling behaviour. Specifically, we will be administering questionnaires regarding your medical history, use of medications and eating habits in order for us to properly assess the hormones and peptides in your blood. We will also be administering questionnaires regarding gambling urges and past year gambling behaviour.

In order to assess your gambling behaviour, we will be asking you to play on a slot machine. You will be given $15 to play with, and have the chance to win more money. We will also be giving you a series of quick, non-invasive, cognitive tasks designed to measure your attention, and cognitive processing speed.

We ask that you come into the lab prior to eating breakfast, and the total procedure will last about an hour. As a thank you, you will receive $15 with which to gamble with, a $10 gift certificate to the Carleton University food court, and a 1% participation credit. Your signature below indicates that you have given consent to have a saliva sample taken for the purposes of this study. At the end of this session you will be debriefed about this study in its entirety, and what the researchers are expecting to find.

Potential Risk and Discomfort: Some people may feel uncomfortable when providing a saliva sample. However, providing a sample is a painless and relatively quick (3-4 minute) process. If you do not want to have your saliva taken however, please let us know and we will stop the experiment.

In addition, some individuals may feel uncomfortable when asked to respond to personal, sensitive questions about medical conditions, gambling behavior, eating behavior or anxiety). If you feel any discomfort or distress, you may choose not to answer specific questions, and you will not be penalized in any way if you do this. The debriefing form at the end of the study provides contact information for local support services that you may contact if you need or want help.

Finally, although potential risks have attempted to be minimized, the present study may still have an impact on your gambling behavior in the future.

Anonymity/Confidentiality: The data collected in this study will be kept confidential. Your informed consent form will be separated from your questionnaire and kept in a separate and secured file by one of the research investigators who will keep this information confidential. It will be associated with a code, and only this code will identify your questionnaire. We will need to have a code associated with your questionnaire and saliva samples so that we are able to match up your responses at the end of the study. The data will also be stored in a secured data file that is only accessible by the researcher and research assistants.

Right to Withdraw: Your participation in this study is entirely voluntary. At any point during the study you have the right to not complete certain questions or to withdraw with no penalty whatsoever.

I have read the above description of the study concerning ghrelin and gambling, and agree to have bodily samples and personal information obtained. Personal information gathered includes gambling, medical and eating history, as well as performance on cognitive tasks. Bodily samples obtained include saliva samples, which will be analyzed for the hormones and peptides stated above. The data collected will be used in research publications and/or for teaching purposes. My signature indicates that I agree to participate in the study, and this in no way constitutes a waiver of my rights.

Full Name (please print): _____
Participant Signature: _____
Date: _____
Researcher Signature: _____
Date: _____

Appendix L: Debriefing for Study 3

Debriefing

This post-test information is designed to help you understand the nature of the research. This experiment is part of ongoing research at Carleton examining gambling behaviour and attitudes. Specifically, the purpose of this study is to examine the role that feeding-related hormones (e.g., ghrelin) may play in the experience of craving and thus engagement in problematic gambling.

Importance of this type of research
Gambling has been found to share physiological and cognitive/psychological similarities with substance abuse addictions. Indeed, gamblers seem to experience stronger cravings than both cocaine addicts and alcoholics. The current study therefore aimed to examine the possibility that food restriction may increase gambling cravings as a result of high levels of ghrelin in blood.

Ghrelin is hormone produced by the stomach and involved in regulating energy balance and food intake. Ghrelin release increases food intake, and ghrelin is elevated after a fast and increases in anticipation of every meal. Recent research has suggested that ghrelin is also associated with the use of addictive substances (i.e., not just food). Moreover, ghrelin has been found to be associated with the desire for addictive substances.

Hypotheses tested
Previous studies conducted in our lab have examined the influence of wins and losses on gambling-related craving (i.e., need or desire to play). This research revealed that participants' craving to gamble increased after winning on a slot machine, which led to gambling. In contrast, participants reported no change in craving after losing. The aim of the present study was to examine whether there are differences in desire to gambling between those with high ghrelin levels (i.e., subjects that are hungry) and those with low ghrelin levels (i.e., subjects that have eaten prior to gambling) after a series of losses or a series of wins.

In this study, we asked all participants to refrain from eating before plays – so that all participants were hungry coming into the lab. Half of the participants were given food upon arrival, thus they were no longer hungry before playing. The other half of the participants were given food after playing, thus they were still hungry when they gambled. With this method, we will be able to test whether hunger (as indicated by grhelin levels) influences craving to play and subsequent gambling behaviour. Specifically, we were interested in how long you gambled for after an initial 25 spins. The results of slot machine spins you just played were predetermined to win or lose in a particular sequence.

Additionally, when completing the final questionnaires, you were presented with a bowl of Smarties. We were interested in two things: 1) how long it took you to approach the bowl and 2) how many Smarties you took out of the bowl to eat. Increased ghrelin levels have been associated with eating, thus those with high levels of ghrelin should take more Smarties. We are able to determine how many Smarties you took because we counted the number in the bowl before you entered the lab. Estimating the time it took you to approach the bowl is a little more difficult. After the researcher left you to do the questionnaires, they watched you behind a one-way mirror, and used a stopwatch to record how long it took you to eat your first Smartie.

We were unable to disclose these aspects of the study to you at the onset because it would have influenced your behaviour and responding to the questions.

Why was deception necessary

Deception is necessary in some research because if you were aware of our hypothesis it might cause you to act differently. For example, if you knew we were interested in the number of Smarties taken from the bowl and how fast participants walked to the bowl, it might have changed how many you took or how fast you approached the bowl. Since deception was involved in this study, the experimenter will present a new informed consent form after you finish reading this debriefing form.

The purpose of an informed consent is to ensure that you now understand the true purpose of the study and that you agree to allow your data to be used for research and teaching purposes. Because you were only told of the procedures and not the purpose of this study at the outset, we will be asking for your consent to allow your data to be used for research and teaching purposes.

Possible benefits of participating in this study

- Results from this project will help us understand why people crave to gamble and may provide the basis for us to develop techniques to curb craving and prevent problem gambling.
- We have found that participating in gambling research can benefit gamblers through knowledge gained regarding the pitfalls associated with gambling.
- All participants receive this debriefing sheet that has contact information for problem gambling hotlines as well as health and addiction centers (see the very end of this sheet). Often, this is the first time gamblers are directly and explicitly provided a means through which treatment can be sought. Anecdotally, we have had gamblers with and without problems with their gambling thank us for bringing gambling and the problems associated with this behaviour to their attention.
- Some of our research (e.g., Wohl, Christie, Matheson, & Anisman, 2010, Journal of Gambling Studies) shows that participating can reduce mistaken beliefs associated with play and promote responsible gambling.

If you have questions later

If you have any questions about this study when you leave, please feel free to use the contact information on this debriefing form that you are allowed to keep. If you feel that this experiment has influenced your behaviour towards gambling in any way (i.e. if you now have a craving, or urges, to gamble), please contact or speak to the experimenter immediately.

Intense focus on thinness can lead to negative body image and unhealthy eating behaviors in young women. Sometimes, these unhealthy eating behaviors lead to eating disorders such as anorexia nervosa, bulimia, binge eating disorder or eating disorders not otherwise specified. If you have concerns about your eating behaviors, please contact the Health and Counselling Services on campus.

Helpful resources

Ontario Problem Gambling helpline 1-888-230-3505 http://www.opgh.on.ca/
Addictions and Problem Gambling Services of Ottawa (613) 789-8941 http://www.apgso-stjpo.ca/find_eng.html
Distress Centre: Ottawa And Region (613) 238-1089 http://www.dcottawa.on.ca
Health and Counselling Services at Carleton University (613) 520-6674.

If you have any questions or comments about this research, then please feel free to contact Michael Wohl (Tel. 520.2600 ext. 2908; EMAIL: mwohl@connect.carleton.ca); Alfonso Abizaid (Tel. 520.2600 ext. 1544; EMAIL: alfonso_abizaid@carleton.ca); Travis Sztainert (520.2600 ext.6312; EMAIL: tsztaine@connect.carleton.ca); or Nina Hedayati Tel. 520.2600 ext.6312; EMAIL: nhedayat@connect.carleton.ca.

If you have any ethical concerns about this study please contact Monique Sénéchal, Chair of Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1155 or Anne Bowker, Chair of Department of Psychology, 613-520-2600 ext. 8218.

Lastly, gambling may become harmful to ones relationships and well being, both emotionally and financially. The current research is in no way an endorsement to gamble but rather aims to discover ways to help and prevent gambling. If you think you may have gambling problems, it is suggested that you contact one of the organizations listed below. It is not a good idea to allow problems to fester, as ruminating over these problems will typically not make them go away. In addition, your family physician or counselor will may also be able to help you or to refer you to someone who can help.

We thank you very much for participating in this study. Your assistance will help us better understand gambling behavior among young adults.

Appendix M: Informed Consent for Use of Data for Study 3

Informed Consent to the Use of Data

The purpose of an informed consent is to ensure that you now understand the true purpose of the study and that you agree to allow your data to be used for research and teaching purposes. Because you were only told of the procedures and not the purpose of this study at the outset, we are now asking for your consent to allow your data to be used for research and teaching purposes.

Purpose. The purpose of this study is to assess whether ghrelin levels affect craving and gambling behaviour among gambles who experience a series of losses, compared to those who experience a series of losses.

Anonymity/Confidentiality. The data collected in this study are kept anonymous and confidential. The consent forms are kept separate from your responses.

Right to withdraw data. You have the right to indicate that you do not wish your data to be used in this study. If you indicate this is your choice, then all measures you have provided will be destroyed.

Signatures: I have read the above description of the study investigating ghrelin and craving to gamble. The data in the study will be used in research publications or for teaching purposes. My signature indicates that I agree to allow the data I have provided to be used for these purposes.

Full Name (Print): _____
Participant Signature: _____
Date: _____
Researcher Signature: _____
Date: _____