PAY AS YOU FLOW:

MEASURING THE SLOT MACHINE ZONE WITH ATTENTIONAL DUAL TASKS

by

William Spencer Murch

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Abstract

Why do people seek out gambling activities? In addition to acknowledging the excitement or ‘rush’ that gambling provides, a contemporary hypothesis highlights escape from stress or other aversive mood states as a key motive for slot machine play and risk factor for gambling disorders. Anecdotal accounts tell of machine gamblers becoming fully immersed in gambling: losing track of time, failing to notice peripheral events, and thinking exclusively about the game. It has been argued that electronic gaming machines (EGMs, including slot machines) are inherently more harmful than other gambling forms, perhaps owing to their ability to immerse players in prolonged gambling sessions. In four studies, I investigated the subjective, behavioural and psychophysiological underpinnings of immersion during EGM play. Studies 1, 2 and 3 used a peripheral target detection task during EGM gambling in order to test the hypothesis that peripheral inattention predicts immersion and risk of problem gambling. Study 2 also examined a mind wandering probe task in relation to immersion during EGM gambling. Study 3 examined the effects of EGM “practice” on immersion and peripheral attention. Study 4 examined solitary versus joint gambling as a potential moderator of EGM immersion. In addition, studies 1, 2 and 4 recorded respiratory sinus arrhythmia, a physiological marker of the parasympathetic nervous system, as a potential predictor of immersion and gambling risk. My results showed that risk of problem gambling significantly predicted both peripheral inattention and subjective immersion during EGM use by regular gamblers, but that inattention was not directly related to immersion. A reliable parasympathetic withdrawal effect was found during EGM play on respiratory sinus arrhythmia, but this was not related to markers of immersion. Implications are considered for the development of problem gambling and responsible gambling practices.
Preface

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These studies were approved by UBC’s Behavioural Research Ethics Board (H14-02509).
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1. Introduction

Gambling is a diverse behavior that is found in nearly every world culture, and has existed for thousands of years (Binde, 2005). Broadly speaking, a gamble involves a decision to place a wager on an uncertain event that offers the potential for a larger prize. Early forms of gambling involved rudimentary chance devices fashioned from readily-available materials like rock and bone. The knuckle bones of sheep were formed into astragaloi, an item shaped and thrown in the same manner as modern dice. These early games of chance added excitement to the exchange of goods and tools, but are a far cry from the dizzyingly complex ethos of modern commercial gambling.

This thesis limits itself to modern forms of gambling where money is the commodity for both the wager and the prize. The gambler has been defined very broadly as anyone who takes up this invitation to wager on chance (Bolen & Boyd, 1968). It has been noted, however, that activities not traditionally considered to be gambling (e.g. investment in mutual funds, or getting married) can look a lot like gambling because they also entail a stake of personal resources on an outcome determined by chance (Reber, 2012). Under this conception, nearly everyone is a gambler. Ultimately, since gambling is regulated in British Columbia by the British Columbia Lottery Corporation, a simple and pragmatic test of whether an activity should be considered gambling is whether or not that activity is regulated by the BCLC. As such, the gambler is defined more stringently in these studies as any individual who seeks out activities that fall under BCLC’s purview and where the monetary outcome is decided by chance (including the lottery, BINGO, sports betting, card games, dice games, and electronic gaming machines, or EGMs).
Gambling of this type has a high participation rate in western cultures (Kessler et al., 2008; Toce-Gerstein, Gerstein, & Volberg, 2009). Most forms are offered by commercial organizations such as casinos or bookmakers, who maintain a *house advantage* by programming or arranging the games such that they maintain a positive expected value for the vendor. As such, continued play on the part of the gambler will inexorably result in a net loss for them and a net gain for the service provider.

Although gambling represents a harmless form of entertainment for most consumers, the activity becomes dysfunctional in a small fraction of players. In these individuals, the negative consequences can be severe, and include financial debt, bankruptcy, family dissolution, criminal behavior and suicide (Shaffer & Martin, 2011). Pathological gambling was first recognized in the DSM-III (American Psychiatric Association, 1980), and was classified as an Impulse Control Disorder. Following a programme of research describing the substantial overlap between patients with gambling problems and substance use disorders, in neurocognitive functioning and neurobiological sequelae (see Potenza, 2006), the condition – now termed ‘Gambling Disorder’ – was recently reclassified in the DSM-V (American Psychiatric Association, 2013) into the ‘Substance-Related and Addictive Disorders’ category. As such, Gambling Disorder has become the first recognized *behavioural addiction* (Clark, 2014). This account is the dominant conception held by researchers at this time. Nuanced conceptions of this biomedical model recognize that gambling involvement exists on a continuum from casual, recreational gambling to severe gambling disorder, and that gamblers who do not meet the full diagnostic threshold can nevertheless experience significant gambling-related harms (Toce-Gerstein, Gerstein, & Volberg, 2003). Further, recent evidence suggests that there may be no ‘safe’ level gambling involvement: a recent cross-jurisdictional study found no level at which increasing expenditure
on gambling was unrelated to increases in gambling-related harm (Markham, Young, & Doran, 2015).

It is widely accepted that drugs of abuse vary in their capacity to promote dependence in regular users (Nutt, King, Saulsbury, & Blakemore, 2007). These ‘capture rates’ are higher in epidemiological data for tobacco users (31.9%) compared to cocaine users (16.7%) which, in turn, are higher than cannabis users (9.1%) (Anthony, Warner, & Kessler, 1994). Of course, drugs of abuse vary widely in their pharmacological actions. Does the same hold true for gambling? Lotteries are consistently found to be the most prevalent form of gambling but are less related to problematic engagement than various other forms (Orford, Wardle, & Griffiths, 2013; Welte, Barnes, Wieczorek, Tidwell, & Parker, 2004). EGMs, by contrast, show lower rates of overall engagement in the general population, but are more closely associated with problematic use and harms (Bischof et al., 2016; MacLaren, 2015). For example, in individuals seeking treatment for problem gambling, EGMs rank highly in the preferred and/or problematic form of gambling (Meyer and Hayer, 2005; Michalczuk, Bowden-Jones, Verdejo-Garcia, & Clark, 2011). When EGMs were removed from all Norwegian gambling establishments in 2007, rates of gambling-related problems dropped considerably, with little evidence of substitution towards other available forms (Lund, 2009). Other work describes an accelerated trajectory from beginning gambling to meeting diagnostic criteria for problem gambling in EGM gamblers (M = 1 year) compared to non-EGM gamblers (M = 3.5 years; Breen & Zimmerman, 2002). These games are also more strongly related to psychological distress than other gambling forms (Khanbhai, Smith, & Battersby, 2016).

There are a number of reasons why EGMs may be more harmful than other forms of gambling. First, EGMs provide an engaging and continuous audiovisual experience that may
stimulate continued, harmful play (MacLaren, 2015; Murch & Clark, 2015). These devices also employ a faster pace of play compared to more traditional gambling forms. Where a bet on a sporting event or a set of lottery numbers may take several days to be resolved, an EGM can resolve dozens of concurrent bets each minute (Murch & Clark, 2015). A number of other structural characteristics endemic to EGMs may also contribute to increased betting behaviour (Griffiths, 1993). Along with determining bet outcomes almost instantaneously, nearly all new EGMs allow multiple bets to be placed across different ‘paylines’ (defined as a unique path across the reels that can be any combination of straight across, diagonal, or zig-zag pattern; see also Dixon et al., 2014).

1.1 The Machine Zone

The psychological mechanism by which some individuals develop excessive, harmful EGM use is still incompletely understood. Individual differences in the tendency to become immersed in EGM play may contribute to the development of harmful gambling behaviour. Being ‘in the zone’ is a feeling that commonly reported with recreational or occupational activities. It is a descriptor often applied to some gamblers’ style of play. In this state of immersion, players in the ‘slot machine zone’ (Schüll 2012) may fail to acknowledge events beyond the game, upcoming appointments or bodily cues (for example, the need to eat or urinate), in favour of keeping their focus centered on the game. Schüll (2012, p. 2) interviews an EGM gambler named Mollie who remarked that “in the beginning, there was excitement about winning, but the more I gambled, the wiser I got about my chances. Wiser, but also weaker, less able to stop. Today, when I win – and I do win, from time to time – I just put it back in the machines. The thing people never understand is that I’m not playing to win. It’s like being in the eye of a storm, is how I’d describe it. Your vision is clear on the machine in front of you but the
whole world is spinning around you, and you can’t really hear anything. You aren’t really there—you’re with the machine and that’s all your with.”

In contrast to the lay belief that the appeal of casino gambling is the pursuit of financial gain, this new ‘zone’ account of EGM gambling emphasizes the sense of escape provided to players by suggesting that EGMs provide relief from chronic stressors or from negative emotions (Schüll, 2012; Jacobs, 1986; Blaszczynski & Nower, 2002). This assertion may hold some truth in gambling behaviour, generally. A recent study showed that, while positive reinforcement (winning money) was the most common motivation among gamblers, seeking negative reinforcement (escape) was a stronger predictor of problem gambling severity (Cookman & Weatherly, 2016). While relatively little empirical work has been done to characterize EGM immersion, Schüll (2012, p. 12) argues that for some players this escape-state may be the object, and not merely an effect, of EGM play: “the solitary, absorptive activity can suspend time, space, monetary value… [The gamblers’] aim is not to win, but simply to continue.” Schüll’s hypothesis emphasizes the active seeking out of the zone and thus merges with a substantial literature on coping and enhancement as the two dominant motivations for gambling (Stewart, Zack, Collins, & Klein, 2008). She coalesces a body of work on the geography of casino floors, arguing that major casinos are laid out in a deliberate effort to support escape into the machine zone. The author further notes that the most successful EGMs are most often located in “insulated enclaves, tucked or hidden in small alcoves, recesses or corners.” (Schüll, 2012, p. 41). If gamblers seek out machine zone sensations, perhaps they are more easily achieved in this kind of solitary environment.
1.2 Flow and EGM Gambling

Schüll’s qualitative and anecdotal accounts of the slot machine zone bear resemblance to Csikszentmihalyi’s theory of flow (for review, see Csikszentmihalyi, 2014). Originating in the field of Positive Psychology, flow is the term given to a constellation of subjective experiences reported by people engaged in fulfilling, skilful activities such as rock climbing, competitive chess or painting (Csikszentmihalyi, 1990). The experience of flow is multifaceted. First, it involves the attenuation of various attentional processes; Csikszentmihalyi argues for a merging of action and awareness, decreased sense of the passage of time and an absence of self-conscious thought (Conti, 2001; Csikszentmihalyi 1975, 1982, reprinted in Csikszentmihalyi, 2014; and see also Noseworthy & Finlay, 2009). It is conditional upon the activity being one that is intrinsically motivated (or “autotelic,” Csikszentmihalyi 2002) and successfully striking a balance between the challenge posed by the task and the level of skill possessed. The activity should also have a strong correspondence between the known possible actions of the agent and the outcome that is generated; a lack of surprise endemic to the act. For example a competitive chess player may know with a great deal of certainty that his rook will be lost if he takes the opponent’s queen with a bishop standing adjacent. In this case, the situation’s outcome is determined by the agent causing it to be so. Goal-orientation is also an important factor in the flow state. A recent study showed that athletes whose appraisal of their skill was based on masterful completion of the task (and not better relative social comparison) reported higher levels of flow state (Stavrou, Psychountaki, Georgiadis, Karteroliotis, & Zervas, 2015).

The most heavily emphasized symptom of flow is a strong positive or rewarding feeling toward the act, and a pleasant feeling in general. For this reason, Csikszentmihalyi has repeatedly referred to flow as “the highest level of well-being” (Csikszentmihalyi, 2014). However, this
assertion rests on the assumption that the activity from which one is deriving flow is either positive or benign. If gambling activities (particularly EGMs, with their rapid pace of play) can provide a flow-like experience, players might unknowingly persist in betting to the point of serious financial loss or self-harm. If objective, evaluative thought is attenuated during flow, individuals may be less capable of discerning when accrued financial losses exceed intended limits.

This ‘darker’ conception of flow related to EGM gambling has been the subject of increasing inquiry. Dixon and colleagues (2014), showed that the introduction of “losses disguised as wins” by virtue of the multi-line feature on modern EGMs promotes a more continuous, less volatile pattern of reinforcement (See Schüll, 2012, p. 112). Effectively, this feature creates a steady trickle of small wins as opposed to occasional large pay-outs separated by long streaks of losses. In the study by Dixon et al, participants playing on multi-line setting reported increased flow-type experiences, as measured by the items “I forgot everything around me [while playing the EGM]” and “I felt completely absorbed [while playing the EGM].”

One limitation with the flow interpretation of EGM immersion is that EGM gambling at an objective level constitutes an unskilled activity. By contrast, traditional flow activities like writing or rock-climbing involve a high degree of perceived skill, which Csikszentmihalyi argued was necessary for flow to occur. Nevertheless, EGM gamblers are well known to erroneously perceive a high degree of skill in the activity, consistent with the general construct of the ‘illusion of control’ (Ladouceur & Sévigny, 2005; Langer, 1975). In the only empirical study seeking to measure flow directly in gamblers, Wanner, Ladouceur, Auclair, and Vitaro (2006) found that college athletes scored higher than recreational and problem gamblers on flow-specific questionnaires, while the gamblers scored higher on questionnaires of “dissociation-
like” states. I turn my attention to this theory next. As such, the data from Wanner et al (2006) indicate that the similarities between EGM immersion and flow may be superficial, and that alternative conceptualizations may better explain the phenomenon described by Schüll (2012).

1.3 Dissociation-like Experiences during EGM Play

An alternative framework for EGM immersion is Jacobs’ influential General Theory of Addictions (1986), which was developed to integrate research findings across the range of substance use disorders as well as problem gambling. Jacobs contends that individuals who develop substance use disorders experience a chronic, aversive physiological state of either hypo- or hyper- arousal, which causes them to seek out ameliorative means through the abused drug or behaviour. In other words, addiction is construed as a repetitive seeking-out of substances or activities to relieve chronic physiological imbalance; a form of self-medication.

Under this model, two predictions are made about the physical and experiential expression of behavioural addictions. The first argues that problem gamblers and individuals with substance use disorders will display difficulties with physiological self-regulation at rest. This deficient self-regulation should be present generally, and ameliorated by the abused drug or behaviour. An early examination of this prediction using self-report scales found that adolescent problem gamblers report greater excitability and disinhibition, a combination of traits taken to reflect an abnormal physiological resting state (Gupta & Derevensky, 1998). It was speculated that the act of gambling reduces this aversive state among these adolescents. Additionally, some work has established a link between problem gambling and trait susceptibility to boredom (Hopley & Nicki, 2010; Kuley & Jacobs, 1988), itself an aversive physiological state (Bench & Lench, 2013; Killingsworth & Gilbert, 2010). In attempting to address this theory objectively, I have opted to use direct, psychophysiological measures, thus bypassing the potential confounds
of participant retrospection or self-report biases. To date, a careful examination of gamblers’ adaptive self-regulation using psychophysiological measures has not been conducted (relevant work on arousal during gambling is considered in section 1.5). It is attempted in studies 1, 2 and 4 to follow.

The second prediction made by Jacobs argues that a set of dissociation-like experiences characterize the subjective experience of the drug or behaviour (Jacobs, 1988). Like flow, these experiences reflect the feeling of separation from reality. From his early work, Jacobs proposed a four-question scale to address these kinds of experiences. The scale contains the following questions:

<table>
<thead>
<tr>
<th>Question</th>
</tr>
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<tbody>
<tr>
<td>&quot;After (activity noted) have you ever felt like you had been in a trance?&quot;</td>
</tr>
<tr>
<td>&quot;Did you ever feel like you had taken on another identity?&quot;</td>
</tr>
<tr>
<td>&quot;Have you ever felt like you were outside yourself – watching yourself (doing it)?&quot;</td>
</tr>
<tr>
<td>&quot;Have you ever experienced a memory blackout for a period when you had been (doing the given activity)?&quot;</td>
</tr>
</tbody>
</table>

Table 1.1 Jacobs’ original Dissociation Questionnaire (1988)

A state of dissociation could help EGM players cope with stressors and provide relief from aversive states like anxiety, boredom or depression. A number of qualitative (Wood & Griffiths, 2007) and quasi-experimental self-report studies (Cartmill, Slatter, & Wilkie, 2015; Diskin & Hodgins, 1999, 2001, 2003; Gupta & Derevensky, 1998; Hopley & Nicki, 2010; Kuley & Jacobs, 1988; Noseworthy & Finlay, 2009; Wanner et al., 2006) have indicated a relationship between problem gambling and dissociation-like experiences while gambling. For example, Cartmill and colleagues (2015) compared 142 Australian gamblers on the basis of anxiety, dissociation-like states and problem gambling severity score (the latter two questionnaires were
the same as those used in the current thesis). The team concluded that dissociation and anxiety were both significant predictors of problem gambling, but that dissociation was the stronger predictor.

Blaszczynski and Nower's (2002) influential Pathways Model is a contemporary theory of gambling that was inspired by Jacobs’ theory, suggesting that a subtype of problem gamblers are prone to dissociation because of a history of seeking gambling in order to cope with distress or external hardship (Wood & Griffiths, 2007; see also Scannell, Quirk, Smith, Maddern, & Dickerson, 2000). In its original form, Jacobs’ theory (1988) posited that these dissociation-like experience might arise in part "by the manner in which an activity (e.g., gambling) so completely concentrates one's attention on a specific here-and-now event that coexisting aversive aspects of one's life situation are blurred out." I address the relation between problem gambling and attention next.

1.4 EGM Gambling and Attention

While the aforementioned accounts of immersion experiences vary slightly depending on whether a ‘machine zone’, flow or dissociation lens is used, they generally point to a consistent pattern of highly selective attention that attenuates peripheral, game-irrelevant processing and task-independent thought. A growing body of research further supports the notion that basic attention is disrupted among problem gamblers. Attentional bias towards substance-related cues is a well-established effect in substance use disorders (Field & Cox, 2008) and similarly, gambling stimuli interfere with information processing in studies where problem gamblers completed gambling versions of the Stroop task (Boyer & Dickerson, 2003; McCusker & Gettings, 1997). A similar bias was observed for gambling-related stimuli compared to
household objects when examining speed of saccades and duration of fixation to gambling-related cues present in stimulus arrays (Brevers et al., 2011).

As well as a bias towards gambling-related stimuli, pathological EGM gamblers react more slowly to peripheral, game-irrelevant stimuli during EGM play (Diskin & Hodgins, 1999, 2001). This finding is strikingly consistent with the account of Mollie’s gambling activity reported by Schüll (2012). In Diskin and Hodgins’ studies, a group of occasional EGM players and a second group of problem EGM gamblers played a genuine EGM that had two lights positioned 9.5 inches to either side of the device, thus situated in the visual periphery of the player. Occasionally, one of these lights would illuminate, and participants were instructed to button press if they noticed the light. This classic “dual-task” procedure was conducted over a period of 10 minutes while the participants played the EGM, and the peripheral lights were illuminated 45 times in total. The group of problem EGM gamblers (M = 950.2 ms, SD = 233.2) were significantly slower to respond to the presented targets than the occasional players (M = 729.4 ms, SD = 150.7)). This latency difference was interpreted as attentional narrowing arising a result of the problem gamblers over-valuing game-relevant visual stimuli at the expense of peripheral events.

In addition to visual processing deficits, the cognitive science of mind wandering may provide an alternative means of quantifying the machine zone (see for review: Handy & Kam, 2015; Smallwood & Schooler, 2006). Mind wandering is a universal attentional state in which the content of thought becomes separate from the task at hand. It is a familiar feeling to those who have read a newspaper or book and found that their thoughts shifted away from the text while their eyes continued down the page, causing them to miss the content of the passage.
While it is a common human experience, attenuated mind wandering might help to identify immersed gamblers and clarify the relationship between problem gambling and EGM immersion.

Mind wandering episodes are estimated to occupy half of all waking activity (Killingsworth & Gilbert, 2010). Mind wandering episodes often focus on personal issues, and as such may be experienced negatively (Killingsworth & Gilbert, 2010; Mcvay, Kane, & Kwapil, 2009), perhaps explaining why gamblers with pre-existing mood disorders may seek out gambling as a form of escape (Blaszczynski & Nower, 2002). Mind wandering has a profound impact on cognition and the experiential content of our individual, perceptual worlds. For example, mind wandering has been shown to interfere with the processing of affective information, diminishing both the P300 ERP component and empathetic ratings of painful stimuli (Kam, Xu, & Handy, 2014). These perceptual deficits can, in turn, cause functional impairment: older adults with a high risk of idiopathic falling report a higher frequency of mind wandering, suggesting that mind wandering may lead to physical injury via decreased processing of environmental information (Nagamatsu, Kam, Liu-Ambrose, Chan, & Handy, 2013). Smallwood (2013) wrote poignantly that “an important feature of the mind is self-generated cognitive activity that is minimally constrained by external perception.”

If EGM gamblers have a myopic focus on the games they play, then they may show diminished peripheral attention and/or attenuated task-independent thought, indicative of a cognitive state unconcerned with alternate goals or activities. If this is true, then individual differences in both peripheral attention and mind wandering may be behavioural markers of ongoing attention to the EGM gambling task. If attention is captured by the EGM to a greater degree in some participants, I expect lower relative scores on both markers of attention to peripheral space and spontaneous thought. In other words, if EGM gamblers show diminished
peripheral attention and attenuated mind wandering frequency, then their present attention can be assumed to be occupied to a greater extent by the EGM (an alternative view may assert individual differences in attentional capacity; this possibility is addressed in study 3).

1.5 Psychophysiological Responses to EGM Gambling

In addition to changes in attentional processes, the various accounts of EGM immersion provided above imply that a positive, appetitive physiological experience (a general sense of pleasant calmness of the body and mind) accompanies the activity. Generally, however, work on the physiological responses to gambling has focused on the more intense ‘high’ experience of the activity. The approach in this thesis is distinct in emphasising parasympathetic, rather than sympathetic, autonomic nervous processes. It is widely accepted that arousal is central to gambling motivations and the aetiology of disordered gambling (Baudinet & Blaszczynski, 2013; Blaszczynski & Nower, 2002). EGM gamblers show reliable increases in heart rate (HR) and skin conductance response following wins (Coventry & Constable, 1999; Coventry & Hudson, 2001; Rockloff, Signal, & Dyer, 2007).

Most psychophysiological work on gambling has examined mean heart rate, a coarse measure of general cardiac activity. Although heart rate was employed in the study of dissociation during EGM gambling by Diskin & Hodgins (described above), that study did not report a test of the relationship between HR and dissociative states. Nevertheless, changes in HR reflect dual control by both the parasympathetic and sympathetic branches of the autonomic nervous system (Grossman & Taylor, 2007). As such, HR by itself is unlikely to reveal a specific psychophysiological signature of the machine zone. Separation of the two branches may be necessary in order to properly differentiate cardiac effects caused by sporadic, big wins and those
due to the calm, ongoing maintenance of continuous EGM play. If the purpose of immersion is to provide pleasant relief or escape (termed ‘equanimity’ by Mendes), sympathetic nervous activation may not be chiefly involved. Instead, we may look to the parasympathetic branch, which helps aid the body in achieving a comfortable homeostatic balance. Parasympathetic nervous system activation is implicated in mental effort (Porges & Raskin, 1969; Tozman, Magdas, MacDougall, & Vollmeyer, 2015) and adaptive emotional self-regulation (Blascovich & Mendes, 2010; Gramzow, Willard, & Mendes, 2008; Waters, West, & Mendes, 2014). I hypothesized that the profile of immersed EGM gambling is more dependent upon this second branch.

Cardiac parasympathetic activity originates in the brain’s Nucleus Ambiguus. Located in the reticular formation of the brainstem medulla, it is the origin of Vagus nerve (cranial nerve X) efferents. The term ‘vagal tone’ is used to describe the pattern of activation derived from these nerve fibres that acts to intermittently delay firing of cells in the heart’s natural pacemaker, the sinoatrial node. Respiratory sinus arrhythmia (RSA) is a well-studied heart rate variability (HRV) metric that is regarded as a marker of cardiac vagal tone (Grossman & Taylor, 2007). RSA reflects variation in cardiac rhythms in phase with the respiration cycle. It is used here as a first step towards characterizing the psychophysiological correlates of machine gambling. RSA has been examined in psychophysiological context with respect to the homeostatic regulation of affect, task-engagement and attention to key events, (see for reviews: Blascovich & Mendes, 2010; Porges, 2007). In this view, high RSA indicates relatively higher adaptive self-regulation, indicating calmness or lack of stress and low RSA indicate more strenuous mental effort or active engagement with a given task.
Evidence has linked changes in heart rate variability to both task engagement and flow. A recent study by Tozman, Magdas, MacDougall, and Vollmeyer (2015) collected heart rate variability data while participants completed a simulated driving task that varied in difficulty. They found that participants had the highest HRV under mundane, unchallenging driving conditions, and the lowest HRV (indicating ‘vagal withdrawal’) in a highly demanding driving simulation of the Monaco Grand Prix. Furthermore, and of critical importance for my hypothesis, in this more demanding condition, HRV changes were related to subjective flow experiences; albeit in a complex manner: moderate or unchanging levels of parasympathetic arousal (reflecting a maintenance of vagal control) were related to the heightened experience of flow. In light of these findings, Studies 1, 2 and 4 employed heart rate variability (and controlling for heart rate per se) as a measure of parasympathetic function, and possible physiological marker of EGM immersion.

1.6 Quantifying the Slot Machine Zone

As the previous sections have discussed, recent research has begun to study the subjective, behavioural and physiological elements of EGM immersion, but no work has yet established a correspondence between them. In my view, this link constitutes the linchpin of the zone hypothesis: that the experience is discrete, phenomenologically distinct, and encompasses several of these components in a coherent manner. In the studies to follow, I attempt to observe the trait and dispositional factors associated with the zone experience, utilizing deficits in peripheral attention, absence of stimulus-independent thought, subjective immersion feelings, the role of solitary (versus joint) EGM play, and the accompanying physiological profile. The hypotheses for each component are summarized next.
Conscious perception requires some amount of attention to be paid to the features of particular objects. Highly unusual events can evade conscious perception if attention is not cast on the area where they occur (as in the famous ‘invisible gorilla’ experiments by Simons & Chabris, 1999). Such an effect was shown in the two papers by Diskin and Hodgins (1999, 2001). I modified Diskin and Hodgins’ attentional paradigm for the experiments in this thesis. In Studies 1, 2 and 3, participants completed a simple target-detection task while playing a genuine EGM for a period of time. To examine any potential confounding or attenuating effects on immersion due to the presence of this secondary task during EGM play, Study 1 also tested a control group who did not perform the target-detection task, and compared self-reported EGM immersion.

If perceptual information coming from an EGM were to demand an excessive share of the attentional resources of certain gamblers, I might reasonably expect stimuli peripheral to the machine to be missed more often. In a similar vein, I expect that EGM users who were more immersed in the game will report fewer mind wandering episodes during play (Study 2), and will display poorer estimates of the elapsed time on the device (Study 1, 2 and 3). I further predicted that immersion would be more pronounced when individuals are playing EGMs in solitude compared to players with other players nearby. In each Study, I predicted that the immersion state would be marked by a distinct somatic state that is evident in both physiological recordings and in subjective self-report indices. Finally, I expect that this state develops with EGM experience such that novice participants given some prior EGM training will report more immersion during subsequent use.

With these elements together, I sought to characterize the slot machine ‘zone’ using data from four independent samples (one involving regular gamblers in the community and three
involving undergraduate students). In these experiments, I attempted to determine whether the cognitive, subjective and psychophysiological components discussed above tend to appear together, if at all, and whether individual differences related to problem gambling risk can predict their presence and magnitude.
2. Study 1

The first study sought to establish whether immersion experiences varied between individuals using EGMs. For ease of recruitment, the sample comprised undergraduate students, a group that I expected to have limited prior experience with EGMs. If variation was observed in subjective immersion and on the peripheral target task, I sought to determine if these factors were related to each other and to the risk score for problem gambling.

2.1 Methods

2.1.1 Participants

The sample consisted of 59 undergraduate psychology students from the University of British Columbia (age M = 20.2 SD = 1.6; 26 males). Participants signed up through the psychology department’s Human Subject Pool, by which students earn class credit for participating in psychology experiments. Participants were at least 19 years old (in accordance with British Columbia gambling law), and had normal or corrected-to-normal (through the use of eyeglasses or contact lenses) eyesight. Individuals were excluded from participation if they reported current use of psychotropic medications and any history of adverse allergic reactions to the kinds of gels, adhesives and alcohols used in the psychophysiology. Additionally, participants were excluded if their PGSI score (detailed in section 2.1.2) exceeded 7 out of 27, indicating a high risk of problem gambling. Two respondents were excluded on this basis. Upon completion of the study, participants were debriefed with a full study description and informational resources pertaining to the mathematic and visual workings of slot machines.
2.1.2 Questionnaires

i. Problem Gambling Severity Index (PGSI)

The PGSI is a 9-item subscale of the Canadian Problem Gambling Inventory (Ferris, Wynne, Ladouceur, Stinchfield, & Turner, 2001). It provides an indication of problem gambling behaviour on the basis of 9 symptoms of problem gambling (chasing losses, borrowing money to continue gambling, etc., Abbott & Volberg, 2006). According to conventional criteria for the PGSI, relative risk can be approximated by scoring 0 = non-problem gambler, 1-2 = low-risk, 3-7 = moderate risk, >7 = high risk (Ferris et al., 2001).

ii. Game Experience Questionnaire (GEQ)

The GEQ is a 14-question survey initially designed for video gaming research which probes various elements of electronic gaming experiences (Ijsselsteijn, Poels & De Kort, 2008). Participants report various game related experiences on a 5-point Likert scale (0 = “Did not experience at all,” 1 = “Slightly,” 2 = “Moderately,” 3 = “Fairly,” 4 = “Extremely”). Two questions on the GEQ directly relate to player immersion (termed “flow,” in the original description). Prompts include statements such as “I forgot everything around me,” and “I felt completely absorbed.” Three additional subscales, each comprised of two questions, were analysed in these studies: positive affect (“I felt content,” “I felt good”), negative affect (“I felt bored,” “I found the game tiresome”) and a measure of game interest (“I was interested in the game’s theme,” “I found the game impressive”). Please note that the GEQ documentation refers to the game interest subscale as “immersion”, which I regard as a misnomer in this context.
iii. Dissociation Questionnaire (DQ) and Distorted Perception of Time-Passage

This is a 5-item questionnaire that probes gamblers’ dissociation-like feelings, using the original 4-items used by Jacobs (1986) with a further time-distortion item that was added by Diskin and Hodgins (2001) (“I felt like I lost track of time while I played the slot machine.”) Items were modified to reflect state experiences during the play session in this study. Participants answered on a 5-point Likert scale ranging from “Not at all,” (0) to “Extremely” (4). Building upon Hopley and Nicki’s (2010) study of online poker players, I also added a participant estimate of the length of the gambling session (to the nearest minute). Dissociation has previously been related to underestimates of time spent gambling in some situations (Noseworthy & Finlay, 2009). Both the DQ and time estimation accuracy will be used in assessing player immersion during the gambling task.

2.1.3 EGM Session

After the PGSI and resting state recording, participant were given an endowment of $40 cash to load into the real game they would be playing. The study used a genuine “Super Times Pay®” EGM (IGT, Las Vegas, Nevada) previously in commission in British Columbia’s Lower Mainland. The machine was a 3 reel, 20 payline machine, set on a 1 cent (per line) denomination and 88.9% return-to-player. Thus at infinite plays, it is expected that the player will lose 11.1% of any given bet amount. I instructed participants to play the ‘maxi-min’ bet – the maximum number of lines at the minimum bet (20 cents per spin) – for the duration of their session. The maxi-min strategy ensures the most frequent hit rate with few long losing streaks, by virtue of including frequent ‘losses disguised as wins’ (Templeton, Dixon, Harrigan, & Fugelsang, 2014). The maxi-min strategy is the modal strategy of regular EGM players (Livingstone et al., 2008), and this constraint was imposed in the present study in order to reduce volatility and ensure that
the endowment would last players for the intended duration of each play session, 30 minutes. The mean credits on completion on the session were $32.82 (SD = $16.89). Participants were informed that their remaining credits would be converted into a cash bonus between $2 and $12 using a conversion chart with decrements of $2 for every 800 credits lost over the session.

Gameplay information was gathered using user input and audio-video devices peripheral to the EGM. A Makey Makey (Joylabz, Cambridge, Massachusetts) computer input device was used to output a signal to the recording laptop each time the EGM’s ‘bet’ button was depressed. Play button data was isolated from synchronized Biopac input and exported for analysis. The time duration between successive play button presses was used to calculate speed of play (considering only intervals between 0.5 and 10 seconds). The EGM screen was recorded for each full session using a Logitech webcam mounted on a tripod, in order to have a transcript for coding rare game events (jackpots, bonus features, etc.) as well as any long breaks in play.

2.1.4 Target Detection Task

Building upon the target detection paradigm used by Diskin and Hodgins (1999, 2001), I projected moving objects onto two screens (20” wide by 30” tall) mounted on the left and right sides of the EGM façade, at a 30 degree angle. Stimuli were 2” and occupied approximately 5.72 degrees of visual angle at the outer edge of the screens and approximately 4.98 degrees at the inner edge. Participants sat approximately 20” from the outer edge of the screen and 23” from the inner edge, but were allowed to seat themselves at a comfortable distance from the EGM. Stimuli were 700 white circles (distractors) and 15 red squares (targets). Targets were randomized to appear on either the left or right screen. They were presented in a semi-random fashion, with each target occurring randomly within a 2 minute bin to ensure unpredictability. Stimuli appeared at the outer edge of the projection screens and moved toward the EGM over a
2.52 second display duration, before disappearing at the inner edge of either screen. Responses to target stimuli were given by pressing an arcade-style button (0.85” in diameter) mounted on the EGM dashboard immediately adjacent to the play button.

The target detection task was programmed and ran on a 64-bit Windows 7 desktop computer using MatLab 2014b (Mathworks, Natick, Massachusetts) with the Psychtoolbox (Brainard, 1997; Pelli, 1997; Kleiner et al, 2007). The projector used was a BenQ MS502 with an 800x600px resolution and a brightness rating of 2700 lumens. The desktop computer which ran the projector corresponded via parallel port to the BIOPAC MP150 psychophysiology system using AcqKnowledge version 4.4 on a Lenovo Windows 7 laptop.

In order to test whether this secondary task interfered in some way with the game immersion experience, 19 students from the undergraduate sample acted as a control group who played the EGM for 30 minutes without monitoring for the peripheral visual targets. Forty participants played the EGM with the secondary task.

2.1.5 Psychophysiological Measures

Psychophysiological data were collected using a BIOPAC systems MP150, sampling at a rate of 1,000Hz. I obtained cardiography data using BIOPAC’s wireless ECG module, via adhesive Ag/AgCl electrodes (Vermed, Buffalo, New York) attached to the lower left abdomen and upper pectoral regions. Electrodermal activity was recorded using the EDA module with adhesive patches on the first and third fingertips of the left hand. A 5 minute baseline period of data was acquired before the slot machine session. Mean heart rate (HR), respiratory sinus arrhythmia (RSA) and mean skin conductance level was extracted in six 5-minute bins through the slot machine session. RSA is defined as the 0.12 - 0.40 Hz band-limited natural log of peak-
to-peak latencies (ms) between the r-component of the QRS complex (Allen, Chambers, & Towers, 2007). Cases were included in analysis only if data for the baseline and at least five of six blocks was available. In cases where electrode contact became dry or otherwise badly artefactual (e.g. by movement or loosened attachment) toward the end of the recording, bin values were discarded, and the value from the preceding bin was imputed (carry-forward imputation). This method avoids the possibility of either over-estimating inter-beat variability or losing whole participants from repeated-measures analyses by virtue of missing data for a single block. In these analyses, instances of non-spherical within-subjects data were treated with the Greenhouse-Geisser correction using fractional degrees of freedom. A corresponding model was also run on heart rate, based on the recommendation of Grossman and Taylor (2007) who argue that joint-reporting of HR and RSA is key for making inferences about RSA as a valid marker of parasympathetic activity.

In further cleaning the RSA data, respiration rate was estimated from the ECG trace using the ECG-Derived Respiration (see Moody et al., 1985; 1986) script in the WFDB Toolbox for Matlab (Goldberger et al., 2000; Silva & Moody, 2014). This derived respiration rate was removed from the RSA dependent variable using semi-partial correlations; this method removes the variance associated with a confounding factor from just one variable – RSA – in the correlation test. The test prevents the capitalization on error variance that could arise in partial correlations where one of the two factors of interest and the extraneous third variable are related by measurement error alone.

Skin conductance has been previously used in experiments with simulated EGMs (Dixon, Collins, Harrigan, Graydon, & Fugelsang, 2013), but in the context of a real EGM, skin conductance data proved exceptionally difficult to associate with game events (jackpots, bonus
rounds, etc.), and were ultimately discarded. Though some have had some success using skin conductance response for marking winning events in genuine EGM play (Lole, Gonsalvez, Barry, & Blaszczynski, 2014), the method is unfeasible here for a couple of reasons. First, the practice involves marking each win individually. Lole and colleagues achieved this by having the researcher watch the gambling session and press a button each time a win occurred, then compensating for the researcher’s response latency by applying a flat 1s reduction to the event mark. These analyses could be achieved post-hoc using the video recording obtained from each session. However, since the EGM used displays wins on 76% of spins, the measure would require combing through hundreds of hours of video and marking nearly all spins by hand. Second, the spin rate on a modern EGM is faster than the skin conductance response (which typically peaks 4 - 6 seconds post-stimulus onset; Dixon, Harrigan, Sandhu, Collins, & Fugelsang, 2010; Lole et al., 2014), causing responses to be ongoing in the face of numerous successive spins, potentially confounding the response magnitude. For these reasons, we did not pursue the measure in these analyses.

2.2 Results

2.2.1 Self-report results

As expected, the undergraduate sample reported few gambling harms, with a mean PGSI score of 1.05 (SD = 1.77). The sample was comprised of 38 non-problem gamblers (62%), 11 low-risk gamblers (18%) and 12 moderate-risk gamblers (20%, figure 2.2.1.1).
The first set of analyses compared the dual-task group (playing the EGM while monitoring for peripheral targets) against the control group who only played the EGM (table 2.2.1.2). There were no difference between groups on the DQ score, Positive Affect or Negative Affect following EGM play. Control participants reported lower estimates of elapsed time, and reported significantly higher levels of immersion as indexed by the GEQ Flow subscale, compared to the dual-task group. Indeed, only the control group showed reliable underestimation of the length of time spent playing. Single sample t-tests indicated that the control group significantly under-estimated the 30 minute play period \(t(16) = -4.37, p < .001\) and the dual task experimental group did not \(t(41) = 0.73, p = .47\).
<table>
<thead>
<tr>
<th></th>
<th>Dual-Task Condition</th>
<th>EGM Only Condition (Control)</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>42</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DQ (/20)</td>
<td>5.26 (4.86)</td>
<td>4.95 (3.91)</td>
<td>0.25</td>
<td>59</td>
<td>.81</td>
</tr>
<tr>
<td>GEQ Positive Affect (/8)</td>
<td>2.86 (2.20)</td>
<td>2.95 (1.75)</td>
<td>0.16</td>
<td>59</td>
<td>.88</td>
</tr>
<tr>
<td>GEQ Negative Affect (/8)</td>
<td>4.21 (2.06)</td>
<td>5.11 (1.97)</td>
<td>1.59</td>
<td>59</td>
<td>.12</td>
</tr>
<tr>
<td>GEQ Flow (/8)</td>
<td>1.88 (1.66)</td>
<td>3.26 (2.38)</td>
<td>2.62</td>
<td>59</td>
<td>.01*</td>
</tr>
<tr>
<td>Time Estimation (minutes)</td>
<td>31.00 (8.85)</td>
<td>24.41 (5.27)</td>
<td>2.86</td>
<td>57†</td>
<td>.006**</td>
</tr>
</tbody>
</table>

Table 2.1 Study 1 self-report comparisons of treatment and non-treatment conditions. Mean values are provided with standard deviation in parentheses. * = statistically significant at p < .05, ** = significant at p < .01. † Two subjects in the control group did not provide time estimates.

Considering only participants in the dual-task condition, higher PGSI scores were associated with higher levels of both GEQ positive affect \((r(40) = .48, p = .001)\) and GEQ negative affect \((r(40) = -.43, p = .004)\) in response to EGM play. PGSI was also significantly associated with self-reported dissociation-like experiences on the DQ \((r(40) = .65, p < .001, \text{figure 2.2.1.2})\). Positive \((r(40) = .54, p = .004)\) and negative affect \((r(40) = -.34, p = .03)\), too, were significantly related to DQ score. Time estimation was not significantly predicted by affect, DQ or PGSI score (all \(p > .11\)). Comparing the relative strength of these results post-hoc, Steiger’s test indicated a significantly stronger relationship between DQ and PGSI than between negative affect and PGSI \((Z = 4.95, p <.001)\) that was not observed when comparing the relative strength of DQ and positive affect in predicting PGSI \((Z = 1.40, p = .16; \text{Lee \\& Preacher, 2013})\).
2.2.2 Behavioural Results

Of the 15 target shapes shown during the dual-task, participants responded to a mean of 12.9 (SD = 2.22). No relationship was observed between target task performance and PGSI score ($r(40) = -0.17, p = .28$, figure 2.2.2.1). A weak relationship was observed between DQ score and target task performance ($r(40) = -0.27, p = .08$), which did not meet our criteria for statistical significance (figure 2.2.2.2).

*Figure 2.2 Scatterplot of self-reported dissociation-like states during EGM play and risk of problem gambling.*
Figure 2.3 Scatterplot of target task performance by PGSI score.

Figure 2.4 Scatterplot of target task performance by DQ score.
2.2.3 Gameplay Results

Participants across both conditions pressed the spin button every 3.69 (SD = 1.36) seconds. PGSI score significantly predicted faster pace of play ($r(59) = -.33, p = .009$). A weak relationship was also observed between PGSI score and the standard deviation of the time between successive plays ($r(59) = .23, p = .08$).

2.2.4 Psychophysiological Results

To improve the power of these analyses to detect real effects, participants in the dual task and control conditions were collapsed; 58 participants yielded usable baseline recordings and 48 provided a usable task-related trace for both the baseline and EGM blocks. There was no significant change in heart rate from the baseline recording ($M = 79.3 \text{ bpm}, SD = 10.8$) to the EGM session ($M = 77.7 \text{ bpm}, SD = 9.2$) ($F(2.16, 101.71) = 0.26, p = .79$). However, RSA decreased significantly during EGM play relative to baseline ($F(3.08, 144.92) = 13.22, p < .001$, figure 2.2.4.1), consistent with a ‘vagal withdrawal’ effect. On average (collapsing across the 6 bins), participants’ RSA decreased by 7.7% of the baseline value ($M = 6.22, SD = 1.03$).

Three self-report variables were of interest in these analyses: problem gambling severity indicated by the PGSI, dissociation-like gambling states indicated by the modified DQ, and affective state. As Positive Affect and Negative Affect were highly anti-correlated, a single variable was created by averaging the GEQ positive affect and (reverse-coded) negative affect scales, so as to avoid unduly inflating the type 1 error rate. These variables were entered separately as covariates in the repeated-measures ANOVA model for heart rate. HR change was not significantly related to PGSI ($F(1,46) = 0.66, p = .42$), DQ ($F(1,46) = 1.97, p = .17$), or affect ($F(1,46) = 0.54, p = .46$).
An RSA change score was calculated from the difference between the baseline RSA block and the mean RSA of the six EGM blocks. Semi-partial correlations were carried out between the RSA change and each of PGSI, DQ and Affect, while controlling for RSA variance associated with the respiration rate. RSA change was not significantly related to PGSI ($r(45) = -0.18, p = 0.20$), DQ ($r(45) = -0.14, p = 0.34$) or affect ($r(45) = -0.18, p = 0.19$).

2.3 Discussion

This first study was a preliminary investigation of the slot machine zone hypothesis. I tested a number of putative indicators of immersion in EGM gambling. Subjective ratings included the Dissociation Questionnaire, the flow subscale of the Game Experience Questionnaire, and a time estimate of the EGM session length. Behavioural measures included
response rates to both the peripheral target task and the EGM itself. Psychophysiological markers were mean heart rate and heart rate variability. The subjective measures showed promising results, in terms of both variability between participants and the relationships with other variables of interest. DQ scores varied within novice EGM players, and strongly predicted low-to-moderate risk of problem gambling. From the GEQ flow scale and time estimation measures between groups, we obtained some indication that immersion may vary depending on whether or not a secondary task was employed. The data on the peripheral target task were limited by the near-ceiling performance by the student sample employed here. Pace of play was related to gambling risk. Finally, RSA was observed to track the transition from baseline recording to the EGM gambling session, with evident ‘vagal withdrawal’, although no immersion, gambling risk, or affect-related variables predicted this decrease.

This study provides evidence in support of the assertion that self-reported dissociation-like experiences predict severity of problem gambling, thus supporting previous reports by Diskin and Hodgins (1999, 2001). In addition, both positive and negative affect were strongly related to DQ score. These links with game enjoyment raise a note of caution in interpreting the relationship between the DQ and the PGSI: it may be the case that game enjoyment promotes dissociation-like experiences. The old adage “time flies when you’re having fun,” if true in any amount is reason to suspect that positive affect might lead to dissociation-like experiences like losing track to time. While such observations cannot strictly determine causality between variables, it is also the case that DQ was a stronger predictor of PGSI score than negative (but not positive) affect.

Time estimation was less promising as a marker of immersion. In the dual task condition, participants were mostly accurate in their time estimates, and the measure was unrelated to either
the PGSI or the DQ. That said, the control group who completed the EGM session with the dual task present significantly underestimated time and reported higher levels of immersion on the GEQ flow scale, suggesting that the insertion of the target detection task may interfere with immersion to some extent.

The other significant group difference between dual task and control group was on the GEQ flow scale, although this effect is somewhat ambiguous as it did not transfer to the conceptually-similar DQ. Since one of the two questions comprising the GEQ Flow subscale asks the participant if s/he “forgot everything around” themselves, and since the dual task condition literally involved projecting things on screens that were adjacent to the participants, it is possible that participants in the dual task condition construed the question as relating to the attention task itself, rather than the experience of flow. Thus, this result may be spuriously detected. Of course, it is also possible that the presence of a visual dual task during EGM play actually does attenuate the immersion experience to some extent, as reflected by the significant differences observed in time estimation and GEQ flow. Attentional dual tasks may interfere to some extent with participants’ experience of EGM immersion.

Interestingly, I found that an accelerated pace of play significantly predicted heightened problem gambling risk. Some might rightly suggest that as problem gambling severity is putatively reliant upon greater gambling exposure, it may simply be that at risk gamblers more rapidly reach a continuous, automatic playstyle. If that were the case we might expect to see a negative correlation between PGSI and the standard deviation of button presses. However, no such effect was observed and, indeed, the data showed a non-significant correlation in the positive direction instead. If this effect is observed in a sample of experienced EGM gamblers, it may serve as an elegant, easily obtained measure of the slot machine zone.
The psychophysiological measures in this first study provided no obvious marker for game immersion or problem gambling risk. I observed a significant decrease in RSA within subjects from baseline recording to the six task blocks. This effect is indicative of a withdrawal of the cardiac vagal ‘brake’ which antagonizes the regular action of the SA node. Such an effect, if present, may be indicative of mental effort or attention exerted on the task (Porges & Raskin, 1969). However, a problem arises with the hypothesis that immersed gamblers should show greater relative decreases in RSA when we also account for the prediction that higher-PGSI participants (who certainly have more gambling experience than novice participants in the sample), presumably exert less mental effort on the EGM due to their experience. Thus, there is reason to predict that problem gambling could either decrease or not decrease RSA. Thus, the null associations with the RSA measure may be confounded to some extent by potentially competing effects of these correlated individual factors. A sample in which all participants are experienced, regular gamblers may help to untangle these competing hypotheses.

I hypothesized that the target task would be related to risk of problem gambling and self-reported dissociation-like states while playing the EGM. No relationships were observed between target task performance and either DQ or PGSI score despite observing strong relationships between the two. This null finding may reflect type 2 error, indicating either that an undergraduate sample is insufficiently sensitive to detect the effects or that the parameters of the task are in need of fine-tuning. First, near-ceiling levels of performance were observed, which reduces the ability to detect individual differences. Second, since the study’s participants were mostly inexperienced with slot machine gambling and were thus unlikely to be at risk of problem gambling, I observed considerable range-restriction in the PGSI predictor variable which may have impaired the sensitivity of these analyses. Third, the proportional target response rate may
be a coarse measurement and response time may have value as a behavioural indicator of immersion. In Study 1, it was not possible to extract latencies because the task script was not set up to count responses made after the target shapes disappeared 2.52 seconds post-appearance on screen, thus confounding targets that were missed entirely and those for which a response was given too slowly to be captured. We attempt to address these problems in studies 2 and 3.
3. Study 2

Study 1 observed a correlation between self-reported dissociation-like states and problem gambling risk in a student sample. However, the peripheral attention task was less successful in identifying a significant behavioural marker of the immersion experience. This may have been due to the sampling method employed. In this second study, I recruited recreational EGM users from the community of Metro Vancouver. Participants completed two concurrent EGM play-sessions in the lab. In one of these sessions, participants completed the same target task used in Study 1. On the other session, I used an alternative dual-task looking at probe-caught mind wandering. For EGM players in an immersed state, and for those players at increased risk of problem gambling, I expect reduced detection of peripheral visual targets, and fewer mind wandering experiences.

3.1 Methods

3.1.1 Participants

The sample was comprised of 30 residents (14 male, age M = 42.0 years, SD = 12.5) of Greater Vancouver who reported past-year EGM play. Participants were recruited through online the message-board Craigslist (craigslist.com). The advert noted that the research team was seeking individuals who had previously played slot machines. Exclusion criteria were previous attempt to reduce gambling in any way (through seeking gambling treatment services, consulting with counselling or community figures or by enrolling in the BC Voluntary Self Exclusion program, which allows persons to bar themselves from entering gambling establishments for an agreed period of time). One participant was excluded from analyses due to general non-compliance with task instructions.
3.1.2 Target Detection Task

This task was identical to the one used in Study 1 and was administered in the same way.

3.1.3 Mind Wandering Task

Mind wandering was examined in a second 30-minute play session. This session used the same EGM as the Target Detection task. Session order was counterbalanced between participants. The task was a variant of the well-validated ‘probe-caught sampling’ method (see: Smallwood and Schooler 2006; Handy and Kam 2015), in which 20 probe statements “Just now, were you thinking about the game, or were you mind wandering?” were presented throughout the session. The duration between probes varied between 60 and 120 seconds (mean 90 seconds). The prompts were projected on a screen directly adjacent to the EGM. Participants were instructed to think only about the few seconds just before the probe appeared, to answer honestly, and that there was no penalty for mind wandering. Responses were provided on a button box mounted on the EGM dashboard. No time limit was imposed on responding. A ‘beep’ tone accompanied the appearance of probes to ensure that they were not missed.

3.1.4 Psychophysiological recording

Cardiac and skin conductance measures were collected in the same manner as Study 1. As the 5-minute baseline recording was only obtained prior to the first EGM session, I restricted the cardiac analysis (HR, RSA) to the first EGM session, and thus half of the participants’ cardiac data was collected with the target detection dual task and the other half on the mind wandering dual-task. The cardiac variables were calculated across 6 EGM blocks of 5 minutes, and the 5 minute baseline.
3.2 Results

3.2.1 Self-report Results

The community sample reported a mean PGSI score of 5.57 (SD = 6.14), indicating a much wider range of problematic gambling behaviour. The group was composed of 5 non-problem gamblers (17%), 3 low-risk gamblers (10%), 15 moderately-at-risk gamblers (50%) and 7 high-risk gamblers (23%, figure 3.2.1.1). Note that based on exclusion criteria, the high-risk problem gamblers did not report any history of seeking treatment for problematic gambling; the session debrief also provided information on local resources for gambling support.

![Histogram of PGSI scores in study 2.](image)

*Figure 3.1 Histogram of PGSI scores in study 2.*

The modal value for frequency of EGM use was 2-6 times per week (9 persons, 30% of sample, see figure 3.2.1.2). The community sample showed a combined mean DQ score of 5.05 (SD = 4.69).
Figure 3.2 Responses to the CPGI prompt "In the past 12 months, how often did you bet or spend money on slot machines in a casino?" among gamblers sampled in study 2 (N = 30).

In the community EGM gamblers, DQ score correlated strongly with PGSI score ($r(27) = .45$, $p = .02$, figure 3.2.1.3), replicating Study 1. No significant relationship was observed between PGSI score and either positive or negative affect (positive affect: $r(27) = -.05$, $p = .78$; negative affect: $r(27) = -.13$, $p = .51$).
3.2.2 Behavioural Results

The community gamblers responded to a similar number of targets on average (mean = 12.4, SD = 3.21), but their variability was increased by nearly 50% over that of Study 1. In this sample, PGSI score was significantly correlated with (reduced) responding to peripheral targets ($r(26) = -.49, p = .009$), although DQ score was not significantly correlated with responding to peripheral targets ($r(26) = .10, p = .62$).
On average, community participants reported mind wandering on 35.0% (SD = 26.7%) of probes. Mind wandering rates were positively correlated with positive affect ($r(26) = -.50$, $p = .007$) and negatively correlated with negative affect ($r(26) = .59$, $p = .001$). These effects are represented together in figure 3.2.2.2. The hypothesis that mind wandering was related to EGM immersion and risk of problem gambling was not supported: mind wandering was not significantly related to either PGSI ($r(26) = .05$, $p = .80$, figure 3.2.2.3) or DQ score ($r(26) = -.29$, $p = .13$).
Figure 3.5 Mind wandering frequency significantly correlates with an aggregated measure of affect from the GEQ (the sum of positive affect score and reverse-coded negative affect score divided by 2) in study 2.

Figure 3.6 Mind wandering did not significantly correlate with risk of problem gambling in study 2.
3.2.3 Gameplay Results

Pace of play during the first play session was not significantly correlated with problem gambling risk \(r(28) = -.27, p = .15\). Similarly, play-speed was not significantly related to positive affect, negative affect, DQ score or peripheral target detection among community gamblers (all \(p > .75\)). No significant correlation was observed between PGSI score and the standard deviation of the time between successive plays \(r(28) = -.10, p = .60\). 

3.2.4 Psychophysiological Results

Complete cardiac data was available for 26 (86.7\%) of the community EGM gamblers. An additional 2 participants provided a usable baseline recording but had task data that was compromised. Mean HR showed minimal change from baseline (M = 75.0 bpm, SD = 16.0) to EGM play (M = 75.4 bpm, SD = 16.0). However, RSA showed an 11.5\% decrease from baseline (M = 5.45, SD = 1.94) to EGM play (M = 4.83, SD = 1.28), consistent with a vagal-withdrawal effect.

A repeated-measures ANOVA on the baseline and 6 EGM bins was conducted for mean HR and RSA. No significant main effect of block was observed for heart rate \(F(2.16, 53.88) = 0.67, p = .53\). PGSI \(F(1.24) = 0.44, p = .51\), DQ \(F(1.23) = 0.17, p = .69\) and affect score \(F(1.23) = 3.08, p = .09\) were not significant as covariates in the heart rate model.
Across participants, significant vagal withdrawal was observed on RSA (main effect of block: $F(6,150) = .4.14, p = .001$, figure 3.2.4.1). Semi-partial correlations were conducted on the self-report variables against the RSA change, controlling for the respiratory influences on the RSA variable. Affect significantly predicted the RSA change ($r(23) = .48, p = .02$, figure 3.2.4.2). Significant differences were not observed for either PGSI ($r(24) = -.02, p = .94$) or DQ ($r(23) = .09, p = .66$).
Figure 3.8 Change in RSA from baseline to task as predicted by affect score in Study 2.

3.3 Discussion

Study 2 provided a number of important insights about EGM immersion. In this sample of experienced EGM gamblers from the community, more markers of immersion was observed than in Study 1 using mostly novice gamblers. Scores on the DQ were again strongly correlated with the risk of problem gambling on the PGSI. Unlike Study 1, PGSI was not significantly associated with the degree of positive or negative affect experienced in response to the EGM session. Thus risk of problem gambling does not seem to be associated with enjoyment of the game, and simple enjoyment of EGMs does not appear to be a key factor in driving continued gambling among regular players.
Performance on the target detection task was strongly related to risk of problem gambling in the community gamblers. These results indicate a potential behavioural indicator of EGM immersion among active gamblers. This study suggests a number of natural follow-up experiments to see whether or not the attentional deficit seen in high-risk gamblers is machine specific or instead reflective of general deficits in attention. Such effects have been previously documented with adolescent and adult problem gambling (Breyer et al., 2009; Waluk, Youssef, & Dowling, 2016).

The community sample failed to replicate the relationship between PGSI score and accelerated pace of play seen in Study 1. The effect in Study 1 could represent a Type 1 error, or it is possible that pace of play is a more meaningful marker of gambling risk in less experienced players. Either way, Study 2 does not support pace of play as a strong candidate for a behavioural index of EGM immersion.

I did not find any support for the hypothesis that problem gambling or the slot machine zone are related to attenuations of mind wandering. These null results are not readily explained by a simple lack of sensitivity for the probe-caught mind wandering procedure, since the task was strongly correlated with participants’ affective state: the frequency of mind wandering was strongly related to positive feelings and low negative affect, including a lack of boredom (see Smallwood and Schooler, 2006 for review). But frequency of mind wandering did not predict PGSI scores. Probe-caught mind wandering may be poorly suited for investigating EGM immersion if gamblers have poor insight into their thought content during the play sessions.

While we again did not find that significant decreases in RSA from baseline to gambling task predicted risk of problem gambling or immersion feelings, we did show a significant relationship between RSA change and affect score. The effect seems to concern the magnitude of
decreases in RSA from baseline, as demonstrated in figure 3.2.4.2. These results indicate that participants who expended more mental effort on the task, as measured by RSA reductions, tended to report more negative affective states during the gambling session.
4. Study 3

Study 3 returned to an undergraduate participant group in order to fine-tune the target detection dual task. In the dual-task in Studies 1 and 2, the occasional targets differed from the frequent distractors in both shape (circles and squares) and colour (red and white). For Study 3, I removed the colour dimension so that both distractors and targets were white. In this way, the only featural difference between target and distractor was the shape. I expected this change to result in decreased pop-out of the targets, reduced task performance and better maintenance of the immersion state.

Study 3 also extracted response latencies for detecting the peripheral targets, predicting that participants who were immersed might ultimately detect the peripheral stimulus but at an increased delay. Acquisition of response latencies should also help ameliorate the ceiling effect seen in Study 1 and 2 for accuracy. As such, both response time and accuracy were the behavioural markers of immersion in Study 3.

A further objective in Study 3 was to examine the effects of repeated experience of the EGM on the degree of subjective immersion. A defining aspect of the flow conceptualization is of a state that emerges over extended practice and automatization (Csikszentmihalyi, 2014). A recent functional imaging experiment using an EGM simulation compared a group of student participants who were playing the game for the first time against a group who had practiced the same game for just 30 minutes, one week earlier. The practiced group showed heightened brain responses in reward-related regions to the anticipatory period of the task (i.e. the spinning reels) and reduced brain responses to winning outcomes (Shao, Read, Behrens, & Rogers, 2013). The subjective consequence of practice may be that the gambler focuses on the game itself,
irrespective of whether they win or lose, and that experienced immersion should increase as a function of repeated play.

Finally, in addressing the nature of the attentional deficit observed in study 2, I included the Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005) as a further questionnaire to allow me to determine whether problem gambling risk per se is predictive of decreased peripheral task performance, or whether the relationship is better explained by pre-existing attentional deficits (see Breyer et al., 2009).

4.1 Methods

Thirty-nine participants (14 males, age M = 21.1, SD = 2.87) were tested. Undergraduate participants were again excluded from participation if their PGSI score exceeded 7. One respondent was excluded due to a PGSI score in the high risk range, and two further participants were excluded from analysis due to task non-compliance. Five participants declined to participate in the second testing session, leaving 34 participants with complete data.

4.1.1 Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005)

This 6-item scale is widely used to assess ADHD symptomatology in adult gamblers (Chase & Clark, 2010). Items are rated on a 5-point Likert scale (0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Often, 4 = Very Often). Following Seli, Smallwood, Cheyne, and Smilek (2015), I have treated the ASRS scores continuously (maximum 24) rather than imposing a cut-off for likely adult ADHD.
4.2 Results

4.2.1 Self-Report Results

Average PGSI score for the group was 0.67 (SD = 1.36, figure 4.2.1.1). The average score on the ASRS was 10.1 (SD = 3.10). Participants reported an average DQ score of 5.54 (SD = 4.55) after session 1 and 4.32 (SD = 4.71) following the second testing session. This decrease from session 1 to session 2 was statistically significant ($t(33) = 2.31, p = .03$). A mean decrease in GEQ flow scores was also observed, but it was not statistically significant (session 1 mean = 2.03 (SD = 1.94); session 2 mean = 1.94 (SD = 2.42); $t(33) = 0.90, p = .37$). Participants estimated playing for 29.87 minutes (SD = 7.82) in the first session and 28.96 minutes (SD = 5.59) in the second session. Single sample t-tests against the true playtime of 30 minutes were not significant (session 1 $t(37) = -0.10, p = .92$; session 2 $t(32) = -1.08, p = .29$).

Figure 4.1 PGSI score among participants in study 3 who completed session 1 and who subsequently returned for session 2.
PGSI score was not significantly correlated with DQ score after either session 1 \((r(37) = -.18, p = .28)\) or session 2 \((r(32) = -.06, p = .72)\), and did not predict change in DQ reports \((r(32) = .22, p = .21)\). It was also not significantly related to the GEQ Flow scale in either session 1 \((r(37) = -.12, p = .48)\) or session 2 \((r(32) = -.20, p = .26)\). PGSI score was not significantly correlated with ASRS \((r(37) = -.16, p = .32)\), positive affect \((r(37) = .04, p = .80)\), or negative affect \((r(37) = -.05, p = .76)\). PGSI was not significantly related to estimated time spent playing during either session one \((r(36) = -.17, p = .30)\) or session two \((r(31) = -.01, p = .97)\).

4.2.2 Behavioural Results

Mean accuracy on the target detection task was 13.10 targets out of a total of 15 (SD = 1.96) in session 1 and 14.38 / 15 (SD = 1.10) in session 2. Mean response time to detected targets was 1.63s (SD = 0.41) and 1.38s (SD = 0.23) in the two sessions, respectively. These improvements in performance were statistically significant (target detection: \(t(33) = 4.32, p < .001\); response time: \(t(33) = 4.74, p < .001\)). PGSI was not significantly related to target detection or response times in either session (all \(p > .20\)), nor was it significantly correlated with the change in target detection \((r(32) = -.11, p = .53)\) or response time \((r(32) = .19, p = .29)\) between sessions. ASRS score was not significantly related to changes in target detection \((r(32) = .27, p = .12)\) or response time \((r(32) = -.33, p = .06)\). The DQ and GEQ Flow scores on session 1 both significantly predicted the change in response time (DQ: \(r(32) = -.42, p = .02\), GEQ Flow: \(r(32) = -.68, p < .001\), figure 4.2.2.1) but not target detection (DQ: \(r(32) = .06, p = .74\), GEQ Flow: \(r(32) = .28, p = .10\)) from the first to the second recording session.
4.3 Discussion

Study 3 sought to enhance the sensitivity of the target detection dual task, and also to understand the manner in which self-report immersion changes as a function of experience with the activity. I also used an adult ADHD screen to examine the relationships between risk of problem gambling, peripheral attention and any pre-existing attentional dysfunction. With regard to the improved sensitivity of the target detection dual-task, there was mixed success. Accuracy on the modified task remained near to ceiling (87% on session 1). While I did not succeed in lowering target detection task performance from the near-ceiling at which it was observed in studies 1 and 2, I believe I have successfully delineated targets for which the given response was delayed from targets for which the response was wholly absent. This change allowed greater sensitivity of the measures to detect differences in the predictive ability of the subjective immersion measures, the DQ and GEQ. We further attempted to make the task more challenging by having target shapes distinct from distractors in only one way (shape) rather than two (shape, shape).
colour). In understanding the absence of a performance decrement following this change, I suggest active compensation may have played a role. It is possible that intrinsic task motivation to perform the dual task well forced participants to expend more mental effort in attending to the peripheral shapes, precluding the possibility of EGM immersion.

As with Study 1, the restricted range of scores on PGSI in student participants renders any inferences about prediction of problem gambling risk difficult. As such, I was unable to appropriately determine if the change in the dual task performance with practice was mediated by risk of problem gambling. Another major consequence of the PGSI range restriction found in this sample is that the null effects observed between the PGSI and other self-report or behavioural data may be at increasing risk of type 2 error.

The most interesting finding of this study was that, in contrast to my hypothesis, immersion experiences on the DQ decreased from session 1 to session 2, as players became more familiar with the game. This suggests – counter-intuitively – that dissociation-like experiences were more common among players when the task was novel. In addition, I observed significant relationships for the DQ and GEQ Flow scores in session 1 predicting the improvement in response latencies on the target detection task from the first to the second session. This indicates that the subjective immersion (directed toward the EGM) relates in some way to improvements in performance on a secondary task. One possibility here is that the target detection dual-task may have been incorporated by participants into the general ethos of the ‘task’, such that their perceived (single) task was to play an EGM while monitoring for peripheral targets. In conjunction with the observation that time estimations were as accurate as in Study 1, the possibility that the presence of a dual task might alter the intended immersion
experience to the EGM remains a salient consideration. Future research may fruitfully investigate alternative, non-disruptive indices of EGM immersion.

The ASRS, as opposed to the PGSI, did not appear to be range-restricted in this undergraduate sample, with scores varying from 5 to 20, unimodal, with a mean of 10.13 (SD = 3.10). Nevertheless, no significant correlations were observed between the ASRS and relevant behavioural and self-reported measures. As such, the hypothesis that individual differences in adult ADHD symptomatology impair dual-task performance was not supported. By implication, the result observed in study 2 may be due to a game-specific effect of EGM gambling in high-PGSI participants and not a pre-existing individual difference.
5. Study 4

The final study examined the effect of a social manipulation on EGM immersion. Specifically, I measured behavioural and physiological responses to the EGM in two groups of participants who either played alone, or with other active gamblers nearby. It has long been established that the presence of peers can produce a ‘risky shift’ towards more risk-taking behaviour (Kogan, 1967). The effect has further been observed in laboratory betting behaviour and casino blackjack tasks (Blascovich, Veach, Ginsburg, & Ginsburg, 1973; Pruitt & Teger, 1969), and is classically observed in adolescents and young adults. In two studies of EGM gambling, social observation was manipulated using a (false) video feed of a crowd of observers. These experiments found that the perceived presence of other gamblers increases risky betting behaviour and persistence in gambling (Rockloff, Greer, & Fay, 2011; Rockloff & Dyer, 2007). However, although social environments may promote risk-taking, the presence of others may reduce game immersion; Schüll (2012) asserts that seclusion from other gamblers on the casino floor facilitates escape into the slot machine zone, thereby leading to more excessive gambling. The aim of this study was to arbitrate between these competing hypotheses, by investigating whether social or solitary gambling conditions led to more immersed or more risky EGM gambling.

I compared the two groups on behavioural measures (e.g. pace-of-play), subjective immersion, and the cardiac measures from Studies 1 and 2. The study did not employ the peripheral dual tasks.
5.1 Methods

Male students (N = 107) from the UBC Psychology Human Subject Pool participated in this study for partial class credit. The mean age of participants was 20.8 years (SD = 2.39). Inclusion in the study required that participants were at least 19 years of age and had normal or corrected-to-normal vision. Exclusion criteria were current use of anti-depressant, anti-anxiety or antipsychotic medications, and any history of allergic reaction to the kinds of gels and alcohols used in the application of our cardiac psychophysiology electrodes. Participants were excluded from the study if their PGSI score exceeded 7. One such individual exceeded this limit.

Participants completed a single 20-minute EGM session, in either a solitary condition or a social condition. In the solitary condition, the participant was the only player at a row of four modern EGMs. In the social condition, participants were recruited in groups of 2 or 3 participants, and played simultaneously on adjacent machines. In the social condition, it was only possible to collect psychophysiological data from one participant in each group, and thus I over-randomized participants to the social condition to ensure sufficient data. Seventy six participants completed the social condition, with 30 players providing psychophysiological data. Thirty one individuals were tested in the solitary condition (all providing psychophysiological data).

The four EGMs in our Casino Lab are not identical and two machines were replaced during the course of the experiment, due to technical problems. The games used in this study were 3x4x5x®, Super 7’s®, Triple Diamond® (all manufactured by IGT, Las Vegas, Nevada), Buffalo Spirit®, Dragon’s Fire® and Ice Empress® (all manufactured by WMS, Chicago, Illinois). Despite their aesthetic and thematic diversity, the games were mathematically similar, with an 89% return to player rate. We further instructed participants to utilize a fixed bet strategy, 20 paylines with $0.03 bet on each ($0.60 bet on each spin). Participants were endowed
with $40 to use on the game and were awarded a cash bonus depending on how much of their endowment was left after the play session. The bonus payments utilized the same pay-scale as previous studies reported here.

5.1.1 Procedure

After arriving at the office for the study, participants gave signed consent and completed the PGSI. In the social condition, one individual was selected for psychophysiology recording by drawing cards. That participant was taken into the laboratory first, the electrodes were affixed and a 5-minute baseline recording was acquired. During this baseline recording, the researcher left the room and returned to the office where (in the social condition) the other participants were waiting. To avoid ‘singling out’ the participant in the other room, the other participants provided systolic and diastolic blood pressure measurements before and after the EGM session, using a commercially-available blood pressure cuff (Lot Fancy, San Francisco, California). Those participants continued to wear the cuff on their left arm throughout the study.

Following the baseline recording, each participant in the social group entered the Casino Lab and were seated at the bank of four EGMs. The participant providing RSA data was seated either adjacent to (two-player scenario) or between (three player) the other participants. Participants were asked to avoid talking during the EGM session. Some participants (n = 32) ran out of credits before the end of the 20-minute play session. Solitary participants who ran out of credits moved on immediately to the remaining questionnaires. In the social condition, participants were asked to wait for the testing session to conclude. The exact time at which these participants finished was not known, so their time estimations were discarded. For participants who did not run out of credits, sessions were halted after 20 minutes. At that time, all participants
completed the GEQ and time estimation measures. They were paid bonuses, debriefed and dismissed.

5.1.2 Analysis

Cardiac data was handled in the same manner as Studies 1 and 2. The 5-minute baseline recording was compared against 4 × 5 minute blocks of EGM play. Participants without a clean baseline ECG trace or with more than one task block compromised by artifacts were excluded from analysis. If only one task block was compromised, the value for that block was imputed: block 2 or 3 was replaced by the average value of the two adjacent blocks, while block 1 or 4 was replaced with the value of the adjacent valid block.

Play button data was collected. Total number of plays, mean interval between plays and the standard deviation of spin intervals was computed for each player. Individual player data was isolated, and filtered to button-press latencies between 2 and 10 seconds. Participants were excluded if fewer than 50 spins were registered, which was taken to indicate either an unwillingness to engage with the game or a malfunction on the part of the Makey Makey input device.

5.2 Results

5.2.1 Self-Report Results

The mean PGSI score in this sample was 1.10 (SD = 1.57, figure 5.2.1.1). Although PGSI scores were heavily skewed, the difference between the social condition (M = 1.28, SD = 1.70) and the solitary condition (M = 0.68, SD = 1.08) was statistically significant (t(86.41) = 2.18, p = .03). Scores on the GEQ Flow scale differed significantly between groups, with solitary participants reporting more flow during EGM use (social condition M = 2.09, SD = 1.95; solitary
condition M = 3.16, SD = 2.05; \( t(105) = 2.53, p = .01 \). On average, participants over-estimated the session length (M = 24.23 minutes, SD = 7.18, single-sample t-test for a 20 minute session: \( t(72) = 5.04, p < .001 \), but there was no significant difference between the social (M = 24.5 minutes, SD = 7.42) and solitary (M = 23.8 minutes, SD = 6.80) conditions (\( t(71) = 0.40, p = .69 \)). Participants in the social condition reported levels of positive and negative affect (positive affect M = 2.46, SD = 1.87; negative affect M = 3.75, SD = 2.05) that did not significantly differ from the solitary group (positive affect M = 2.39, SD = 2.16, \( t(105) = 0.18, p = .86 \); negative affect M = 4.36, SD = 2.29, \( t(105) = 1.34, p = .18 \)).

GEQ Flow scores were significantly associated with positive affect (\( r(105) = .48, p < .001 \)) but not associated with negative affect in a manner that met strict statistical significance (\( r(105) = -.19, p = .051 \)). PGSI scores were not significantly associated with GEQ Flow (\( r(105) < .01, p = .99 \), positive affect (\( r(105) = .08, p = .44 \)) or negative affect (\( r(105) = -.08, p = .43 \)).

Figure 5.1 Breakdown of problem gambling risk reported by study 4 participants.
5.2.2 Behavioural Results

Pace of play data was available for 53 participants in the social condition and 22 participants in the solitary condition. The average pace of play was one spin every 5.01 seconds (SD = 0.82), with no significant difference observed between the social (M = 5.02s, SD = 0.85) and solitary (M = 4.99s, SD = 0.74) groups (t(73) = 0.13, p = .90). A significant difference between the groups was observed for the standard deviation of play button latencies, such that the solitary condition (mean = 1.60s, SD = 0.29) was more variable than the social condition (mean = 1.38s, SD = 0.32; t(73) = 2.82, p = .006).

5.2.3 Psychophysiological results

ECG data were available for 28 participants in the social condition and 29 participants in the solitary condition. There was no significant difference in baseline heart rate between the social condition (M = 81.18, SD = 12.60) and the solitary condition (M = 80.34 BPM, SD = 12.42), although baseline RSA was marginally lower in the social condition (social M = 5.88, SD = 0.74; solitary M = 6.30, SD = 0.86) (t(55) = 1.97, p = .05). After cleaning the data for movement-related artifacts, task-related data was available for 20 participants in the social condition and 26 participants in the solitary condition.

The mixed-model ANOVA for HR showed a significant main effect of Block: $F(1.87, 82.43) = 4.38, p = .02$, figure 5.2.3.2), driven by a temporary decrease in HR from baseline to bin 1. There was no significant main effect of Group ($F(1.44) = 0.08, p = .78$) or Block x Group interaction ($F(1.87,82.4) = 0.81, p = .44$). The corresponding ANOVA model for RSA used estimated respiration rate as a covariate. As in Studies 1 and 2, there was a significant main effect of Block ($F(2.14, 91.92) = 6.81, p = .001$) driven by a sustained decrease in RSA from
baseline across the four blocks of EGM play. There was no significant main effect of Group 
($F(1, 43) = 1.11, p = .30$, figure 5.2.3.3) or a Block x Group interaction ($F(2.14, 91.9) = 0.62, p = .55$). Semi-partial correlations were carried out on the RSA change scores against PGSI and GEQ 
Flow scores, with respiration-associated variance removed from RSA. Neither PGSI ($r(43) = .20, 
p = .16$) nor the flow subscale of the GEQ were significant covariates of the RSA model ($r(43) = 
-.07, p = .62$).

Figure 5.2 Mean heart rate during a 20 minute gambling session in study 4. Bars represent SEM.
5.3 Discussion

Study 4 aimed to determine whether solitary and social gambling contexts differ in their impact on EGM immersion, as hypothesized by Schüll (2012). I found that participants who played the EGM in seclusion, with no other players in the lab, reported significantly increased immersion on the GEQ Flow scale (“feeling completely absorbed in the game” and “forgetting about everything around [them]”) compared to participants in the social condition. This lends support to the notion that geographical factors in the layout of a casino environment might make some games more conducive to the immersion experience (as described in Schüll, 2012). This effect is specific to nearby EGM users as a researcher was present in the testing room in both experimental conditions. By extrapolation, it might be said that secluded, quiet or otherwise out-of-the-way areas on a given casino floor might be places one could expect to find escape or

*Figure 5.3 RSA recording by social condition through a 20 minute gambling session in study 4. Bars represent SEM.*
immersion-motivated gamblers. Looking forward, these results may have implications for traditional, land-based gambling versus burgeoning online venues. Some gamblers may find a greater sense of immersion or escape in the seclusion of their own home, continuing their gambling behaviour without any supervision by responsible gambling agents or hospitality staff.

It should be noted that I did not observe any relationships between PGSI risk of problem gambling and immersion-type experiences in this student sample. This may be due to a true lack of effect in the student population, or may again be due to range restriction of the PGSI outlined earlier. It was also unfortunate that the social condition sampled participants with a significantly higher PGSI scores for gambling risk than the solitary condition. In absolute terms, the group difference was small, with the mean PGSI score for both groups approximately corresponds to a score of 1 out of 27. Moreover, the lack of association between PGSI and the GEQ Flow scores indicates that the baseline difference in gambling risk is unlikely to confound the observed difference in immersion.

Playing in a solitary, rather than a social, condition also increased significantly the variability with which participants played the game. This finding seems counter to the hypothesis that immersion in the game should make the pace of play more constant. However, it is important to examine some of the reasons for variation in EGM play speed. Classic work by Delfabbro and Winefield (1999) showed that gamblers naturally pause for a short time following wins; an effect called the “post-reinforcement pause.” Thus, with regard to the relationship between solitary play and speed variability, it is possible that gamblers playing under solitary conditions are less distracted by peripheral events and thus better able to regulate their play according to the specific events of the game. The presence of nearby players may constitute a distraction from play or a re-anchoring of individual performance cues such that the participant
judges their performance in a socially evaluative manner, as opposed to looking to the game for feedback. It is also possible that the presence of others directly impacts the pace of play, if players synchronize their speed to the pace of those nearby. This hypothesis is being tested in ongoing analyses.

Significant vagal withdrawal response was again observed from the baseline recording to the EGM session. This vagal withdrawal effect did not vary with the social manipulation, and as in the prior experiments, it was not reliably associated with gambling involvement or subjective immersion. Unlike Studies 1 and 2, a significant change in HR was observed during the EGM session, although this effect also did not differ between social and solitary conditions. HR showed a transient decrease from baseline to the first EGM gambling block, in contrast to the sustained decrease in RSA indicating vagal withdrawal. Graham and Clifton (1966) proposed that, in orienting to a stimulus, accelerations in heart rate were associated with a reaction geared toward avoidance while HR decelerations reflected enhancement of the stimulus. An interpretation based on this theory might suggest that the EGM play session, which is initially novel and stimulating to participants, constitutes an appetitive or interesting stimulus toward which participants orient.
6. General Discussion

6.1 General Discussion

These studies were part of an attempt to examine several psychological factors implicated in the experience of immersion in EGM gambling. They sought to clarify the inter-relations between several putative subjective and behavioural measures of immersion, and their relation to the symptoms and personal harms associated with problem gambling. To these ends, I first sought to determine whether subjective immersion experiences would be reported during EGM gambling in samples of less experienced university students and more experienced EGM gamblers. I investigated the claim that these subjective experiences were related to an impaired ability to accurately reflect on the passage of time while engaged in the immersive activity. I looked for behavioural markers of immersion in the ways people attend to game-irrelevant stimuli, using two alternative probes: a peripheral visual target detection task, and a mind wandering probe task for self-generated thoughts. I attempted to determine whether immersion experiences were evident in behavioural responses during EGM play; specifically in the pace or variability with which participants played the game. Finally, I explored the possibility of a physiological instantiation of immersion in cardiac markers of parasympathetic activity, thought to reflect adaptive self-regulation. In each case, I examined relations to subjective immersion experiences and risk of problem gambling.

Below, I provide a synopsis of the conclusions drawn from each experiment and competing interpretations which I hope will clarify somewhat the role of immersion in EGM gambling. I then discuss factors which have limited these findings and how they might be
overcome in future investigations. Finally, I will outline a number of potentially fruitful follow-up directions, to both clarify and expand the topic.

As outlined in the General Introduction, the construct that I have termed EGM immersion has been considered in the existing literature in relation to the established psychological construct of ‘flow’, and the clinical construct of dissociation. Drawing upon measures from both literatures (the GEQ Flow scale, and a modified DQ scale), EGM immersion was related to problem gambling symptomatology. In studies 1 and 2, I found a significant relationship between participants’ scores on the PGSI and their experience of flow or dissociation-like states during their EGM session in the Casino Lab. Thus, in a semi-controlled laboratory environment, both novice gamblers and regular EGM gamblers report experiences of being ‘in the zone,’ ‘in a trance,’ or ‘completely absorbed’ in the game, and these experiences were correlated with their risk of problem gambling.

Two follow-up studies in undergraduate (novice) samples (Studies 3 and 4) failed to replicate this association. This should certainly raise some doubt as to the robustness of the effect in the undergraduate students in study 1, although it must be noted that the PGSI scores were generally very low among the undergraduate groups, creating a range restriction problem. The PGSI scores in the three undergraduate groups were each similar (all approximately equal to a mean score of 1 out of 27), whereas the PGSI scores for regular EGM gamblers recruited through community advertising in study 2, varied widely and averaged in the moderate risk range, which was higher than anticipated. It is reasonable to postulate that the effect in Study 1 may represent a small effect size, and replication is likely to require larger samples and better distributions of the independent variable than was available in Study 3 or 4. In future investigations, community sampling is likely to provide a diverse, continuous distribution of
problem gambling risk that is more representative than student sampling and easier to assemble than populations of severe problem gamblers.

6.1.1. Peripheral Target Detection

Studies 1, 2 and 3 employed a classic dual task design to measuring EGM immersion, where participants monitored the peripheral visual field for occasional targets while playing the EGM for 30 minutes. The target detection data in those experiments supports its potential for delineating regular EGM gamblers at varying risk of problem gambling. Though we found no evidence of a relationship between PGSI score and peripheral target detection in the undergraduates in studies 1 or 3, such an effect was present in the experienced EGM gamblers of study 2. This result replicates Diskin & Hodgins’ observation that problem EGM gamblers tend to be slower to respond to peripheral events while playing EGMs, lending credence to the notion that the world beyond the game seems to ‘fall away’ as players enter the zone.

Target detection was not found in Study 3 to be sensitive to the presence of adult ADHD symptoms, which is an established risk factor for problem gambling. This null finding adds some strength to the assertion that EGM gamblers who are ‘in the zone’ appear disinterested in the world beyond the machine because of the specific gambling activity and are not simply expressing a pre-existing deficit in executive attention.

6.1.2. Mind Wandering

Study 2 also examined whether the effects of problem gambling risk on peripheral attention may also be seen as a decrease in spontaneous thought. Although the regular EGM gamblers at risk of problem gambling in Study 2 tended to miss peripheral events, and while mind wandering was seen to strongly predict the affective response during gambling, I did not
discern any relationships between the mind wandering frequency and EGM immersion. Accounts of immersion typically emphasize that thought is focused solely on the activity, this seems to have not been the case for regular EGM gamblers. It may alternatively be the case that participants at elevated risk of gambling were so engrossed in the activity that they lacked insight into their ongoing mental state, but such a hypothesis would be exceedingly difficult to test without employing more covert (e.g. electrophysiological) methods.

6.1.3. Time Estimation

Across all four studies, I examined whether participants’ impressions of how long they had just been playing the EGM were related to immersion and gambling risk. Based on Noseworthy & Finlay (2009), I predicted that those participants who experienced “losing all track of time” would show inaccurate estimated of the time spent playing the game. Across each of the four experiments, I found no evidence for this prediction: in fact, their actual appraisals of elapsed time were essentially very accurate. Two caveats qualify this interpretation. First, Study 1 showed a significant difference in time estimations between the control group who played the EGM and the dual-task group who also performed the peripheral visual detection task. Only the control group reliably underestimated the time spent gambling, whereas the estimations in the dual-task condition were fairly accurate. It is possible that the temporal component of EGM immersion is more sensitive to distraction and is easily attenuated if other things are invading attention. For this reason, some alternatives to dual-task measures of immersion are discussed in section 6.3. Against this interpretation, the solitary condition of Study 4 was similar in design to the control group in Study 1, but these participants reliably over-estimated the amount of time spent playing. This group also showed no significant difference in time estimation from the social condition in Study 4.
It is also possible that the time estimation measure was compromised by the use of a consistent ‘round number’ for the session length for all participants. Each study used an EGM session length of either 20 or 30 minutes, in order that cardiac measures could be summarized across 5-minute bins. Combined with the fact that participants in studies 1, 3 and 4 knew that they had signed up for exactly one hour of experimentation, some portion of participants may have used reasoning or rough estimation rather than their subjective sense to estimate elapsed time.

6.1.4. Speed and Variability of Play

Studies 1 and 4 pointed to some associations between pace or variability of EGM play and risk of problem gambling. In Study 1 in the undergraduate group, participants at elevated risk of gambling harms played faster than those with lower risk. Studies 2 and 4 failed to replicate this relationship, suggesting that the effect may represent a type 1 error or may be related to the range restriction issues with the PGSI in undergraduate samples. The absence of the effect in the community study in Study 2 is thus notable. The play-button variability effect in Study 4 showed greater variability in solitary gambling scenarios and suggested that attentiveness to the game might be captured without the use of a dual task as individual differences in post-trial pauses. This line of inquiry may warrant independent study.

6.1.5. Psychophysiological Markers of Immersion

Studies 1, 2 and 4 sought to characterize a psychophysiological basis for EGM immersion by examining changes in mean HR and RSA in response to EGM gambling relative to a resting baseline. Each study found a robust and statistically significant decrease in RSA from baseline to EGM play, consistent with the exertion of mental effort via the withdrawal of the ‘vagal brake’
constraining the heart’s natural rhythm. Unfortunately, this marker of vagal withdrawal was not related to the risk of problem gambling, immersion state, affective state or social context. Mean HR provided somewhat inconsistent results, with significant HR deceleration from baseline to task only observed in Study 4, where it is described in more detail.

As a final comparison of the studies in this thesis, a mixed-model analysis was performed on the resting RSA and the first four EGM task blocks across studies 1, 2 and 4. In this analysis, experiment number was treated as a grouping variable and respiration rate as a covariate. The analysis showed a significant effect of block ($F(2.57, 298.55) = 14.55, p < .001$), and a significant effect of group ($F(2,116) = 9.21, p < .001$), but no block x group interaction ($F(5.15, 298.55) = 0.26, p = .35$, figure 6.1.5.1). The associated figure clearly shows that the regular EGM users in Study 2 had lower mean RSA levels across all comparable blocks.
Figure 6.1 RSA values from baseline through the first twenty minutes of EGM play for undergraduate participants in studies 1 and 4 and regular EGM users in study 2. Bars represent SEM.

It should be noted that this effect is partially confounded by age, which was higher in the community-recruited regular gamblers, and has previously been shown to correlate negatively with heart rate variability (Umetani, Singer, McCraty, & Atkinson, 1998). This potential confound cannot be tested here because the age difference between students and community groups cannot be considered incidental, and hence analysis of covariance is inappropriate as a means of adjusting for this variable (Miller & Chapman, 2001). To my knowledge, there are no existing studies that characterise heart rate variability as a marker of physiological self-regulation ability in disordered gambling. Such future work should examined both baseline RSA differences and RSA reactivity (e.g. in response to gambling or an alternative appetitive task) (Blascovich & Mendes, 2010; Rottenberg, Salomon, Gross, & Gotlib, 2005).
Together, the results of these studies suggest that there is some veracity to the often-reported experience of the EGM ‘zone.’ These experiments provide support for the hypothesis that feelings of immersion and markers of peripheral inattention are clinically-relevant factors in identifying individuals at risk of problematic EGM gambling. In the final sections of this thesis, I point out the key limitations of these works and outline a number of potential new directions for this line of inquiry.

6.2 Limitations

The research design across 3 of the 4 experiments in the thesis was correlational in nature. As such, these studies cannot indicate causal influences, for example that immersion causes problematic EGM gambling. Other sources of individual differences might alternatively explain the relationship between these variables. Similarly, behavioural effects reported in study 2 are subject to the same caveats.

Another major limitation in these works is the sampling frame of for studies 1, 3 and 4. Ideally, I would have had the time, resources and assistance to conduct all studies on regular EGM gamblers, but this simply was not the case. A number of problems exist with sampling regular EGM gamblers from the local community. First, reimbursement costs are greater. Second, they are often unwilling to travel to our lab for any testing session shorter than two hours. Third, and most importantly, they are a finite community and are easily exhausted. By using undergraduate students for early examination of gambling-related hypotheses, some threads can be followed to a sensible conclusion without having to exhaust a portion of the EGM-gambling population in Metro Vancouver.
Finally, the realism of the gambling scenario that we have created in our hybrid casino laboratory likely still falls short of emulating real casino gambling. While genuine EGMs offer several advantages in improving ecological validity beyond a ‘simulated’ slot machine running on a desktop or laptop computer, other features of the laboratory environment may nonetheless interfere with a participant’s ‘normal’ experience of casino gambling and EGM immersion. Such factors include the size and shape of our laboratory room, which is about 150 square feet, compared to Vancouver’s local casinos which range from 60,000 to 100,000 square feet in open gaming space. Naturally, participants arrive to an appointment in a Psychology department, and the wider location does not resemble the casino foyer in any way. This may be of particular relevance to those who consider the broader ethos of the gambling environment (Schüll, 2012). Additionally, immersion in EGM gambling seemed to be attenuated by different cognitive demands. The EGM-only control condition in Study 1 and the solitary gambling condition in Study 4 showed significantly higher self-reported immersion experiences. These findings imply that 1) the magnitude of immersion is sensitive to the situational context and 2) our estimates of immersion in dual-task or social conditions could be conservative compared to immersion in genuine casino environments. While I achieved, in these studies, a degree of situational control that would not be possible in naturalistic or observational experiments, that control came at a cost for the study’s ecological validity.

6.3 Future Directions

The first potential follow-up project to these works involves expanding the search for behavioural indices of EGM immersion and risk of problem gambling. In light of the fact that our estimate of the utility of peripheral dual tasks in measuring EGM immersion may be undercut by the distraction that the method might introduce, I may attempt to identify a less
intrusive measure of peripheral attention. First, I intend to investigate the use of eye-tracking in a genuine EGM gambling session. If it is the true that, in immersed gambling, “the object is not to win but simply to continue” (Schüll, 2012, p. 12), then we hypothesize that gamblers who score highly on immersion self-report scales will spend less time looking at the ‘credits remaining’ window and relatively more time fixated on the spinning reels. If true, this finding would carry practical implications for responsible gambling policy. For example, such a study could spur on legislature which requires messaging to be presented centrally on the device, where it is most likely to be seen, rather than peripherally, where it may be missed by individuals in an immersed state. This study may also help to disambiguate the various, competing accounts of gambling motivation. If the eye-tracking hypothesis is supported, it may counter the argument put forward in the influential ‘pathways model’ (Blaszczynski & Nower, 2002) of problem gambling which allows for the possibility that some may be motivated to gamble by pre-existing mood or stress conditions, but which holds that the principles of reinforcement learning and reward seeking are common among all problem gamblers.

If Blaszczynski and Nower’s model is correct, however, problem gamblers should show no difference in attention to the EGM credit window. If that is the case, a separate line of inquiry concerns whether the eye movement of immersed players tracks game-irrelevant, peripheral stimuli to which they have not be instructed to provide a behavioural response. Further, we may investigate whether these markers of immersion among regular EGM gamblers are associated with low mood or stress. If this kind of factor indeed drives people toward electronic gambling, then mood or stress-specific treatment or prevention measures could be proposed to tackle the phenomenon head-on.
Another point of interest in the follow-up to these works involves determining whether this kind of immersion state is specific to machine gambling, or if it represents a more stable trait (i.e. a predisposition towards escapism or a tendency to become immersed in activities). If some problem gamblers seek out activities for the express purpose of immersion in them, then perhaps psychological treatments may harness alternative activities with less dire social and financial consequences. Such a study might seek to examine behavioural and subjective immersion experiences during electronic activities that inherently lay on a continuum from passive/uncontrollable to active/controllable. On this continuum, television might be proposed to lie at one end and open-world, role-playing video games at the other, with gambling situated somewhere in between.

One final area of interest for these works is focused on applying immersion as a predictor of gambling risk and sculpting the electronic gambling experience. This involves both working to reduce harmful, excessive play among problem gamblers and avoiding serious detriment to the games’ playability for the majority of gamblers who do not experience problems with gambling. The broadest of these considerations comes on the heels of the solitude-immersion effect in Study 4. An observational, human geography study could be carried out using overhead footage of casinos; looking at the persistence of patrons in high-traffic areas versus secluded, dark or otherwise out-of-the-way parts of the casino. With such footage, one could code the time spent on each gambling session, the number and type of breaks in play and simple measures of peripheral or somatic attention such as head-turns, interactions with staff or other patrons or stretching one’s arms or back. Results of such a study would have implications for casino design and for venue staff who oversee the well-being of casino patrons.
In this thesis, I have put forward the argument that EGMs have developed to be more inherently harmful or able to propagate gambling problems than various other forms of gambling. The final avenue for follow-up would try to ‘unsramble the egg’ of problem gambling. Using sophisticated EGM simulations programmed in-house, we can begin to strip away different features present in modern slot machines to see which are preferred by problem gamblers and which are most highly associated with immersion and persistent gambling behaviour. A recent study has previously argued that multiple paylines on modern EGMs, by virtue of the highly continuous feel they create in the game, produce more feelings of flow during the game (Dixon et al., 2014). Such findings may be extended and clarified by mathematically disambiguating the number of paylines from the games’ hit rate (the proportion of spins which win any amount). One might also have some success by comparing different EGMs on the basis of popularity; trying to answer the industry-plaguing question of why two mathematically-identical games could be vastly different in their average generated revenue. This would involve investigating the games’ intuitive play-speeds, their symbols and animations and expanding our understanding of the role of game sounds as reinforcement (Barrus & Winstanley, 2016; Dixon, Collins, et al., 2013; Dixon, Harrigan, et al., 2013). By understanding the features that target or appeal most to problem gamblers, I can begin to design an electronic gaming platform that minimizes the potential for abuse while maintaining end-user playability.
Bibliography


doi:10.1080/09652140020050997


doi:10.1348/000712699161503


Lole, L., Gonsalvez, C. J., Barry, R. J., & Blaszczynski, A. (2014). Problem gamblers are


Reinforcement Rate by Playing the Maximum Lines in Multi-line Slot Machine Play.


