Measuring the Slot Machine Zone with Attentional Dual Tasks and Respiratory Sinus Arrhythmia

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Abstract

Recent accounts of problematic electronic gaming machine (EGM) gambling have suggested attentional pathology among at-risk players. A putative 'slot machine zone' is characterized by an intense immersion during game play, causing a neglect of outside events and competing goals. Prior studies of EGM immersion have relied heavily upon retrospective self-report scales. Here, we attempt to identify behavioural and psychophysiological correlates of the immersion experience. In samples of undergraduate students and experienced EGM users from the community, we tested two potential behavioural measures of immersion during EGM use: peripheral target detection and probe-caught mind wandering. During the EGM play sessions, electrocardiogram data were collected for analysis of Respiratory Sinus Arrhythmia (RSA), a measure of calming self-regulation governed by the parasympathetic nervous system. Subjective measures of immersion during the EGM play session were consistently related to risk of problem gambling. Problem gambling score, in turn, significantly predicted decrements in peripheral target detection among experienced EGM users. Both samples showed robust RSA decreases during EGM play, indicating parasympathetic withdrawal, but neither immersion nor gambling risk were related to this change. This study identifies peripheral attention as a candidate for quantifying game immersion and its links with risk of problem gambling, with implications for responsible gambling interventions at both the game and venue levels.

Key words: slot machines, escape, cardiac psychophysiology, flow, addiction.

Introduction

Contemporary research on gambling has increasingly recognized heterogeneity among recreational and pathological gamblers (Blaszczynski & Nower, 2002). One relevant source of variability is the preferred form of gambling. Electronic Gaming Machines (EGMs) are responsible for the greatest proportion of gambling revenue (MacLaren, 2015), and in treatment services, EGMs are often the most commonly preferred game by pathological gamblers (Griffiths, Scarfe, & Bellringer, 1998; Breen & Zimmerman, 2002; Urbanoski & Rush, 2006). In an influential qualitative examination of slot machine gamblers, Schüll (2012) posits that the commercial success of modern EGMs is attributable to their capacity to induce a state of immersion, colloquially termed the 'slot machine zone'. In this state, players may neglect events in the outside world, such as upcoming appointments (e.g. to collect children from school) or bodily cues (e.g. the need to eat or urinate). The state of immersion may provide a means of escape from stress, low mood or boredom (Hopley & Nicki, 2010; Kuley & Jacobs, 1988). In this way, individual differences in the tendency to become immersed during EGM play may contribute to the development of problematic gambling.

The state of immersion is inherently difficult to measure. Any interruptions to the activity, in order to assess immersion, could potentially disrupt the experience. Conversely, retrospective measures acquired after the activity rely on memory and adequate insight into the immersed state. In addition, to enter an immersed state, it is likely that experienced gamblers will require realistic games; most laboratory research on gambling uses simulated games with only limited resemblance to real EGMs (see e.g. Clark et al., 2012; Sharman, Aitken, & Clark, 2015). These features make a rigorous examination of Schüll's hypothesis challenging. The present study sought to quantify the slot machine zone by triangulating three types of candidate measures -- subjective, behavioural and physiological -- while participants played genuine EGMs that were located in a laboratory. This ‘hybrid’ approach aims to balance the realism of an actual gambling venue with the more rigorous control afforded by a lab (Stewart et al., 2002).

The qualitative descriptions of the machine zone by Schüll have parallels with research measuring dissociation-like experiences and the state of flow. According to Jacobs’ General Theory of Addictions (Jacobs, 1986; 1988), dissociation-like experiences occur across all addictive substances and behaviours, and can be assessed with ratings of being in a trance, feeling outside of oneself, or having experienced a memory blackout. Such experiences during gambling have been reported in a variety of samples and different forms of gambling (Cartmill, Slatter, & Wilkie, 2015; Diskin & Hodgins, 1999, 2001; Gupta & Derevensky, 1998), but appear to be most closely related to EGM gambling. In a large Australian survey, 79% of gamblers who reported ever experiencing a trance-like state during play were EGM players (South Australian Department for Families and Communities, 2005). Problem gamblers who played EGMs scored higher on the dissociative experiences scale than problem gamblers with other preferred forms (Kofoed, Morgan, Buchkowski, & Carr, 1997). These experiences are also associated with poor estimations of elapsed time during EGM use (Noseworthy & Finlay, 2009).

This construal of dissociation-like experiences in addictive disorders has much in common with the state of “flow” described in the positive psychology literature (Csikszentmihalyi, 2014). Typically considered in the context of athletic (e.g. running, rock-climbing) or artistic (e.g. painting, writing, playing a musical instrument) pursuits, flow is associated with a decreased sense of the passage of time and an absence of self-conscious thought. In addition, Csikszentmihalyi argues that goal-orientation is critical to flow, relying on a balance between the challenge posed by the task and the level of skill possessed by the performer (Conti, 2001; Stavrou, Psychountaki, Georgiadis, Karteroliotis, & Zervas, 2015). A study by Wanner and colleagues (Wanner, Ladouceur, Auclair, & Vitaro, 2006) assessed both flow and dissociation-like experiences in gamblers (including problem gamblers) and college athletes in response to their favoured activity. While both groups scored highly on both questionnaires, the athletes endorsed significantly higher levels of flow, while the gamblers reported higher levels of dissociation.

Both constructs suggest, as core components: attenuated sense of self, losing track of time and decreased attention to peripheral stimuli. One difference between the theories seems to be that Jacobs' theory casts the dissociative state as clearly maladaptive (by promoting continued substance misuse) while Csikszentmihalyi (2014) has referred to flow as "the highest level of well-being." Dissociation is further distinct from flow in that it emphasizes depersonalization as part of the experience, whereas flow aligns more closely with 'absorption,' a common immersive experience that does not involve altering one's sense of identity and is not inherently maladaptive (Holmes et al., 2005; Waller, Putnam, & Carlson, 1996). Given the similarities between the theories and the paucity of empirical data on their relationship, the present experiment took measures of both constructs as predictors of EGM immersion.

The common theme across these experiential accounts of the machine zone, dissociation and flow is of a pattern of highly selective attention: a strong, sustained focus on the activity (EGM play), coupled with an attenuation of game-irrelevant processing. Schüll (2012) reports an anecdote where an EGM player was so immersed in EGM play that they failed to notice an adjacent player suffer a cardiac arrest. Broadly speaking, awareness of an event requires some degree of attention to the corresponding area of space where it is about to occur. Even dramatic events such as the appearance of a gorilla on a basketball court can evade conscious perception if attention is directed elsewhere (Simons & Chabris, 1999) or if the central task exerts a high perceptual load (Lavie, 2005). In EGM gamblers, excessive attention to the gambling game can also impact on the detection of stimuli in the peripheral visual field (Diskin & Hodgins, 1999; 2001). In the studies by Diskin & Hodgins, participants responded to unpredictable lights flashing in the peripheral region around the EGM, while concurrently playing the EGM. Problem gamblers were slower to respond to the peripheral targets than recreational gamblers, consistent with an 'attentional narrowing' effect (Lavie, 2005). Such an effect might exert itself disproportionately among individuals with Gambling Disorder, by virtue of their stable attentional bias towards gambling-related stimuli (Brevers et al., 2011). Attentional measures acquired during gameplay offer a major advantage over retrospective, subjective ratings that are prone to memory failure and demand characteristics. The current study modified Diskin & Hodgins' paradigm in a number of ways: we presented fewer peripheral targets, in order to minimize interruption of game immersion experiences, and we obtained state- rather than trait- related subjective measures of immersion.

In addition to tests of visual attention, measures of mind wandering may provide an alternative means of quantifying EGM immersion (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. (This may be a familiar feeling to anyone who reads journal articles regularly). Mind wandering episodes are estimated to occupy about half of all waking activity (Killingsworth & Gilbert, 2010), and often co-occur with negative affect due to their focus on personal issues (Killingsworth & Gilbert, 2010; McVay, Kane, & Kwapil, 2009). The present study tested whether probes assessing the frequency of mind wandering were also sensitive to EGM immersion and risk of problem gambling. In both the peripheral attention session and the mind-wandering session, we collected additional data on the pace and variability with which the EGM was played, which has also been linked to problem gambling risk (Linnet, Rømer

Thomsen, Møller, & Callesen, 2010). Our tentative hypothesis was that immersion may relate to a faster and less variable EGM play.

Physiological measures may provide further markers for the state of immersion. It is well established that heart rate, a coarse measure of cardiac activity, increases during gambling (e.g. Anderson & Brown, 1984; Moodie & Finnigan, 2005). These effects are presumably due to increases in sympathetic nervous activity caused by gambling, although heart rate is influenced by both branches of the autonomic nervous system. Immersion, in contrast, is hypothesized to be associated with a different physiological state: a pleasant *calmness* of the body and mind. Physiologically, the parasympathetic branch is distinct from the 'fight or flight' sympathetic branch, and works to maintain homeostatic balance by inhibiting the heart's sinoatrial node via the Vagus nerve. Tonic parasympathetic activation ('vagal tone') is typically estimated from cardiac data using measures of heart rate variability. Studies of this kind have linked heart rate variability to mental effort and cognitive load (Althaus, Mulder, Mulder, Van Roon, & Minderaa, 1998; Porges & Raskin, 1969), attention (Porges, 1972), and emotional self-regulation (Blascovich & Mendes, 2010; Gramzow, Willard, & Mendes, 2008; Waters, West, & Mendes, 2014). One putative marker of vagal tone, Respiratory Sinus Arrhythmia (RSA, Allen, Chambers, & Towers, 2007) has been related to both sustained attention and immersion experiences. Duschek and colleagues (2009) found that reductions in RSA from baseline predicted stronger performance on an attentional task. Recently, RSA was also linked to flow in a simulated driving task (Tozman, Magdas, MacDougall, and Vollmeyer (2015). Consistent with withdrawal of the parasympathetic brake, RSA decreased in a demanding driving condition (the Monaco Grand Prix), but moderate levels of parasympathetic arousal predicted heightened experience of flow. We hypothesized that RSA would index EGM immersion, with greater RSA during EGM play predicting higher levels of immersion. In contrast, we expected non-immersed participants to show RSA reductions during EGM play, consistent with greater mental effort or attention expended to the task.

We hypothesized that EGM gamblers' myopic focus on the games would be detectable in both diminished peripheral attention and attenuated mind wandering. With the incorporation of additional measures of EGM speed of play, subjective state and psychophysiology, we sought to determine whether these candidate indices of immersion tend to appear together, and whether individual differences in these measures are associated with risk levels of problematic gambling. We test these predictions in two samples: a group of undergraduate students, and a group of regular gamblers recruited from the community.

Methods

Participants

This study was approved by the University of British Columbia Behavioural Research Ethics Board. The student sample was comprised of undergraduate psychology students from the University of British Columbia (N = 59, age M = 20.2, SD = 1.6; 26 males). Participants earned partial class credit for participating. All were at least 19 years old (in accordance with provincial gambling law), and had normal or corrected-to-normal eyesight. Exclusion criteria were: a PGSI score (see Materials) in the high risk range (>7), current use of psychotropic medications and history of allergic skin reactions to the psychophysiology equipment.

Community sample participants reported past-year EGM play (N = 30, age M = 42.0 years, SD = 12.5, 14 male) and were recruited via online advertising (Craigslist.com). Exclusion criteria were a previous attempt to reduce gambling in any way (problem gambling treatment services or voluntary self-exclusion). One participant was excluded due to general non-compliance with task instructions. Upon completion of the study, all participants were debriefed with a full study description and informational resources on EGMs and problem gambling.

Materials

The Problem Gambling Severity Index (PGSI), a 9-item subscale of the Canadian Problem Gambling Inventory (Ferris, Wynne, Ladouceur, Stinchfield, & Turner, 2001) was used to estimate problem gambling risk level (0 = non-problem gambler, 1-2 = low-risk, 3-7 = moderate risk, >7 = high risk).

The Game Experience Questionnaire (GEQ) is a 14-item survey with 7 subscales (Ijsselsteijn, Poels & De Kort, 2008). It was designed to probe various elements of video gaming experiences. Participants report game-related experiences on a 5-point Likert scale (0 = "Did not experience at all," 1 = "Slightly," 2 = "Moderately," 3 = "Fairly," 4 = "Extremely"). The two original Flow items on the GEQ ("I forgot everything around me" and "I felt completely absorbed") relate directly to player immersion as conceptualized here.[1] The GEQ Positive Affect ("I felt content," "I felt good") and Negative Affect ("I felt bored," "I found it tiresome") scales were also of a priori interest. Although the negative affect subscale emphasizes boredom rather than sadness, it is assumed that low mood will also be detected as low scores on the Positive Affect subscale. Preliminary analyses found the two Affect subscales to be collinear, so our analyses combined them into a single variable, 'Affect,' calculated as the average of Positive Affect score and reverse-coded Negative Affect score. The remaining GEQ subscales are reported here for completeness. The GEQ has

[1] The GEQ also includes a scale originally labelled Immersion, comprising 2 items: "I was interested in the game's theme," and "I found the game impressive." In our view, these ideas pertain to interest in the game, and not to absorption in the game as conceptualized within the present framework of the slot machine zone. The GEQ Immersion items are thus reported for completeness but were not included in our correlation matrix.

been employed previously in EGM studies, where the measure was compared to other measures of arousal and affect in student participants (Dixon, Collins, Harrigan, Graydon, & Fugelsang, 2013), as well as in regular EGM users (Dixon et al., 2014; Dixon, Harrigan, et al., 2013).

The Dissociation Questionnaire (DQ) is a 5-item questionnaire that probes gamblers' dissociation-like feelings, using the original 4-items devised by Jacobs (1986) and a time-distortion item added by Diskin and Hodgins (2001) ("I felt like I lost track of time while I played the slot machine.") Instructions were modified to obtain state-related ratings (i.e. of the game just played), rather than trait dissociative tendencies. Participants answered on a 5-point Likert scale ranging from "Not at all," (0) to "Extremely" (4).

Gameplay information was gathered from user input 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, using a wire that contacted the metal facia of the EGM. These signals were registered within the Biopac Acqknowledge software. The time duration between successive spin presses was used to calculate speed of play, limiting latencies to frequencies between 0.1 and 2.0Hz in order to discard delays due to extended EGM bonus features or a contact failure of the Makey Makey wire.

Procedure

The study was completed in our casino laboratory using a genuine EGM. The laboratory room contains a bank of four genuine EGMs along one wall and two data-recording computers against the opposite wall, out of the line of sight of participants seated at the EGMs. Participants were seated on comfortable stools identical to those used in local gambling venues. The room is carpeted and dimly lit using uplighter lamps to recreate the lighting conditions of local gambling venues.

Following consent and confirmation of eligibility via the PGSI, the psychophysiology equipment was attached to the participant and a 5 minute physiology baseline was acquired at rest. Participants were given $40 in cash to load into the EGM, for a play session lasting 30 minutes. Participants used an unmodified “Super Times Pay®” machine (IGT, Las Vegas, Nevada) obtained from the British Columbia Lottery Corporation. The device was a 3 reel, 20 pay-line machine, set on a 1 cent (per line) denomination and an 88.9% return-to-player. We instructed participants to play the game using a ‘maxi-min’ betting strategy: the minimum bet on the maximum number of lines, thus wagering $0.20 per spin. This is the modal strategy of regular EGM players (Livingstone et al., 2008), and ensures a high hit rate with few long losing streaks, by virtue of frequent ‘losses disguised as wins’ (Templeton, Dixon, Harrigan, & Fugelsang, 2014). We constrained participants to play in this way in order to reduce machine volatility and ensure that the $40 endowment would last most players for the intended 30 minutes of play.

Following each 30 minute EGM play session, participants completed the GEQ and DQ. Participants in the student sample’s experimental condition completed the target detection dual task (below) during the EGM play session. Community sample participants completed an additional EGM play session, GEQ and DQ, this time using a mind wandering probe task (below). The average remaining credit after each 30 minute EGM session was $32.85 (SD = $15.45); this was converted to a cash bonus of $2 - $12, in order to balance the need for a monetary incentive (e.g. Anderson & Brown, 1984; Ladouceur, Sevigny, Blaszczynski, O’Connor, & Lavoie, 2003) against the ethical and financial difficulties of honouring high jackpots on real machines. Remaining credit at the end of the session ranged from $6.03 to $72.80 (student sample) and from $9.16 to $69.33 (community sample).

Target Detection Task

Visual stimuli were presented on two panels (20’’ wide by 30’’ tall) mounted on each side of the EGM facade at a 30 degree angle. The task ran on a 64-bit Windows 7 desktop in MatLab 2014b (Mathworks, Natick, Massachusetts) using Psychtoolbox (Brainard, 1997; Pelli, 1997; Kleiner et al, 2007). Participants were told that some white circles and red squares would be moving on the screens beside the EGM. They were told to disregard white circles, and provide a button press whenever they saw a red square. In total, 700 white circles (distractors) and 15 red squares (targets) were presented; stimuli were 2” in diameter and moved from the outer edge of the panel towards the EGM over a 2.5 second display duration, before disappearing at the inner edge. Stimuli thus occupied 5.72 degrees of visual angle at the outer edge and 4.98 degrees at the inner edge. Targets were randomized to appear on either the left or right screen, and were presented semi-randomly with one target in each 2 minute bin of the EGM session. Participants sat themselves at a comfortable distance from the EGM on a casino stool, and responded to the target stimuli using an arcade button mounted on the EGM dashboard adjacent to the play button.

--Insert Figure 1 around here--

In order to test whether the target detection task interfered with the EGM experience, 19 students from the student sample acted as a control group who played the EGM for 30 minutes without monitoring for the peripheral visual targets. Forty-two student sample participants played the EGM with the secondary target detection task. Demographically, the group who played the EGM while monitoring for peripheral targets ($n = 42$, age $M = 19.9$, $SD = 1.24$; 15 males) and the control group who only played the EGM ($n = 19$, age $M = 20.7$, $SD = 2.08$; 11 males) did not vary significantly in age ($t(23.94) = 1.77$, $p = .16$) or gender ($t(59) = 1.63$, $p = .11$).

Mind Wandering Task

The sample of EGM users from the community also performed a second 30-minute EGM session (in counterbalanced order) in which the secondary task was a mind wandering test (see Smallwood and Schooler 2006; Handy and Kam 2015). Twenty identical probe statements "Just now, were you thinking about the game, or were you mind wandering?" were presented, at durations of 60 - 120 seconds (mean 90 seconds) between probes. Participants were instructed to respond based on the few seconds before the probe appeared, to answer honestly, and that there was no penalty for mind wandering. No time limit was imposed on responding. A 'beep' tone accompanied the appearance of probes to ensure that they were not missed.

Psychophysiological Measures

Heart rate was collected using a BIOPAC systems MP150, sampling at a rate of 1,000Hz. Adhesive Ag/AgCl electrodes (Vermed, Buffalo, New York) were affixed to the chest and abdomen. A 5 minute baseline recording (in which participants sat quietly with their eyes closed) was performed prior to the slot machine session. Electrocardiogram data was extracted in six 5-minute bins through the slot machine session. For the community sample who played the EGM twice, only the first EGM session was used in the physiological analysis; we did not acquire a second baseline recording before the second task, and some participants requested rest or bathroom breaks between sessions, so that the two EGM sessions were separated by a variable time window. As a result, a change from baseline calculations could not be performed for session 2. In cases where the recording became badly artefactual, bin values were discarded, and a value was imputed as the average of adjacent bins (see Ivory & Kalyanaraman, 2007). By imputing the average of adjacent bins, we avoid losing that participant's entire data from the repeated-measures analyses and we minimize the possibility of introducing spurious trends in the individual-level data. Cases were included in the analysis if data was available for the baseline and at least four of six EGM blocks. Three individuals in the student sample and two individuals in the community sample had a single bin imputed. One individual in the community sample had two bins imputed. Thus 1.4% of the total data points were imputed. Non-spherous within-subjects data were treated with the Greenhouse-Geisser correction using fractional degrees of freedom. For the analyses of psychophysiology and speed of play, to improve the power of these analyses to detect real effects, student participants in the dual task and control conditions were combined in a single group.

RSA was obtained from the ECG traces using CMetX and QRSTool (Allen, 2002; Allen et al., 2007). QRSTool was used for manual cleaning of ECG traces, marking of the R-wave peak in each beat and conversion of the data into a time series of inter-beat-intervals. CMetX then used those time series to calculate RSA, which is defined as the natural log of the 0.12-0.40 Hz band-limited variance of inter-beat-intervals in a time series (Allen et al., 2007). In further cleaning the RSA data, respiration rate was estimated from the ECG trace using the WFDB Toolbox for Matlab (Goldberger et al., 2000; Silva & Moody, 2014). As recommended by Grossman and Taylor (2007), variance associated with respiration rate was removed from the RSA dependent variable, using semi-partial correlation.

Electrodermal data were also acquired using the BIOPAC EDA module. Preliminary analyses determined that the typical pace of play on the EGM (one spin every 3-4 seconds) was too swift to isolate reliable skin conductance responses (SCRs) (which typically peak 4-6 seconds post-stimulus) and for this reason, the electrodermal data were not analyzed further.

Results

Self-Report Results

The student sample reported few gambling harms, comprising 38 (62%) non-problem gamblers, 11 (18%) low-risk gamblers and 12 (20%) moderate-risk gamblers, with an overall mean PGSI score of 1.05 (SD = 1.78, Table 1). By contrast, the community gamblers had a wider range of problematic gambling behaviour, with the group comprising 5 (17%) non-problem gamblers, 3 (10%) low-risk gamblers, 15 (50%) moderately-at-risk gamblers and 7 (23%) high-risk gamblers, with an overall mean PGSI score of 5.57 (SD = 6.14). In the community sample, the modal value for frequency of EGM use was 2-6 times per week.

Among student sample participants, the control group reported significantly higher GEQ Flow ratings compared to the dual-task group (see Table 1). There were no reliable differences between groups on the DQ or GEQ Affect scale following EGM play.

Subsequent analyses focussed on the dual-task group. PGSI score was associated with significantly higher dissociation-like experiences on the DQ in both the student sample (see Table 2) and in the community sample (Table 3, Figure 2A). GEQ Flow and DQ scores were both associated with significantly higher scores on the GEQ Affect scale. Greater risk of problem gambling (PGSI) was associated with a higher GEQ Affect score in the student sample, but not in the community sample.

Behavioral Results

The community sample and student sample detected a similar number of peripheral targets on average (see Table 1). In fact, both samples detected over 80% of targets on average, thus near to ceiling levels, but performance in the community sample was nearly 50% more variable than the student sample. PGSI score significantly predicted poorer peripheral task performance only in the community sample (Figure 2B*)*. DQ score, GEQ Flow and GEQ Affect were not significantly correlated with responding to peripheral targets.

--Insert Figure 2 around here--

The community sample reported mind wandering on 35.0% (SD = 26.7%) of probes overall (Table 1). Mind wandering frequency was not significantly related to PGSI (Figure 2C) or DQ score, but was negatively correlated with GEQ Flow and Affect subscales (Table 3, Figure 2D*)*.

Gameplay Results

Gameplay data were analyzed jointly for the dual task and control conditions in the student sample. The students pressed the spin button every 3.69 seconds (SD = 1.36) and in that sample, PGSI score predicted a faster pace of play ($r(59) = -.33$, $p = .01$). The correlation between PGSI and *variability* in pace of play was not statistically reliable ($r(59) = .23$, $p = .08$). In the community sample, the average pace of play was 3.78 seconds (SD = 1.02), with no significant correlation with PGSI score ($r(28) = -.29$, $p = .12$). Pace of play was not significantly related to DQ score, GEQ Affect, GEQ Flow or peripheral target detection in either sample (all $p > .26$). Variability in pace of play was not significantly correlated with PGSI, DQ, GEQ Flow or Affect scores in the community sample (all $p > .08$).

Psychophysiology

In the student sample, 48 participants provided both baseline and EGM data. There was no significant change in heart rate from baseline (baseline M = 79.3 bpm, SD = 10.8) to the EGM session (M = 77.7 bpm, SD = 9.2, $F(2.16, 101.71) = 0.26$, $p = .79$, $\varepsilon = 0.36$). In contrast, RSA decreased significantly from baseline to EGM play ($F(3.08,144.92) = 13.22$, $p < .001$, $\varepsilon = .51$,

Figure 3), with the average value collapsed across the 6 bins indicating a 7.7% decrease in RSA from baseline.

--Insert Figure 3 around here--

An RSA change score was calculated from the difference between the baseline 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, GEQ Flow and GEQ Affect, controlling for RSA variance associated with baseline respiration rate[2]. RSA change was not significantly related to PGSI ($r(45) = -.18$, $p = .20$), DQ ($r(45) = -.14$, $p = .34$), GEQ Flow ($r(45) = -.03$, $p = .84$) or Affect ($r(45) = -.18$, $p = .19$) in the student sample.

In the community sample, complete cardiac data was available for 26 participants. Mean HR again showed minimal change from baseline (M = 75.0 bpm, SD = 16.0) to EGM play (M = 75.4 bpm, SD = 16.0, $F(2.16,53.88) = 0.67$, $p = .53$, $\varepsilon = .36$). As in the student sample, significant vagal withdrawal was observed on RSA (main effect of block: $F(6,150) = .4.14$, $p = .001$, see Figure 3), with an 11.5% decrease from baseline (M = 5.45, SD = 1.94) to EGM play (M = 4.83, SD = 1.28). In the semi-partial correlations of the self-report variables against the RSA change, controlling for the respiratory influences on the RSA variable, GEQ Affect significantly predicted the RSA change ($r(23) = .48$, $p = .02$) such that greater RSA decreases from baseline were associated with lower Affect scores following play. Significant correlations were not observed for PGSI ($r(24) = -.02$, $p = .94$), DQ ($r(23) = .09$, $p = .66$) or GEQ Flow ($r(22) = .27$, $p = .21$).

[2] This inclusion of respiration as a covariate was carried out following recommendations by Grossman & Taylor (2007), who note that respiratory influences confound cardiac RSA. Removal of the covariate did not qualitatively alter any effects.

Discussion

This study sought to characterize the state of immersion in EGM gambling, looking at the relationships between candidate variables reflecting the player's subjective experience, behavioral measures (of attention and mind wandering), and cardiac psychophysiology. In undergraduate students and a sample of community EGM gamblers, we examined the associations between these measures and problem gambling risk scores. In both samples, we found significant relationships between PGSI scores and flow or dissociation-like experiences in response to the EGM session in the Casino Lab. These data show that in a semi-controlled laboratory environment, there is variability in the extent to which both novice gamblers and regular EGM gamblers endorse being 'in a trance' or 'completely absorbed' in the game, and second, that this tendency to become immersed in the EGM is correlated with measures of disordered gambling. This result extends previous studies linking problem gambling to a lifetime history of dissociation-like experiences while gambling (Diskin & Hodgins, 1999, 2001; Cartmill, Slatter & Wilkie, 2015), by capturing subjective immersion in relation to a specific gambling session.

Some further relationships were seen in the student sample, but were not corroborated in the community EGM players. In the students, elevated PGSI scores were related to higher Affect scores following EGM play, but this relationship was not borne out in the more experienced community sample. The student sample also pointed to some associations between pace of EGM play and risk of problem gambling. In that group, participants at low-to-moderate risk of gambling harms played faster than those in the non-problem gambling group (i.e. scoring zero). The community sample, however, failed to show this relationship. Thus, these effects in the students may represent a type 1 error or may only be visible in groups with minimal prior EGM experience.

Using a classic dual task design where participants monitored the peripheral visual field for occasional targets while playing the EGM, we observed a significant relationship between target detection performance and problem gambling risk scores in the community sample. This relationship did not reach statistical significance in the students, although that sample showed less variability both in their PGSI distribution and target detection performance. Our results in the community sample corroborate a finding by Diskin & Hodgins (1999, 2001) that peripheral attention was impaired in EGM gamblers at increased risk of problem gambling. Notably, our result replicated Diskin & Hodgins' effect on peripheral attention using many fewer peripheral targets, and showed a further relationship between risk of problem gambling and subjective measures of immersion during that testing session specifically.

Our other behavioural measure, of mind wandering, was not associated with problem gambling risk scores and was inconsistently related to subjective immersion. This procedure was only administered in the community sample, and mind wandering frequency was significantly related to GEQ Flow scores, but was not significantly related to dissociation-like experiences on the DQ (p = .14); a measure that otherwise tended to converge with GEQ Flow in these analyses. Mind wandering frequency seemed to more strongly predict a more negative emotional response to the EGM, rather than immersion. The relationship between negative affect and frequent mind wandering has been noted previously (Killingsworth & Gilbert, 2010).

We also tested for psychophysiological correlates of EGM immersion, focussing specifically on RSA, firstly as a marker of vagal tone at rest and secondly to index parasympathetic withdrawal in response to EGM play. In both samples, we observed a robust decrease in RSA from baseline to EGM play, consistent with the concept of vagal withdrawal (Porges & Raskin, 1969). This is, to our knowledge, the first study to examine markers of parasympathetic activity in relation to gambling engagement, with prior psychophysiology research predominantly reporting heart rate (a complex variable under both sympathetic and parasympathetic control) and skin conductance (primarily a sympathetic measure; Bradley & Lang, 2000). In our data, RSA reliably decreased during EGM play with no corresponding fluctuation in heart rate. Notably, neither resting RSA nor the vagal withdrawal response to the EGM were associated with measures of immersion or problem gambling risk. The only psychological variable that predicted RSA withdrawal was the GEQ Affect score in the community sample, where those participants showing greater RSA decrease provided lower Affect scores for the session. Vagal withdrawal is reliably observed following mental effort (e.g. Porges & Raskin, 1969), and we note that EGM immersion scores were actually correlated with a more positive game experience. Thus, if EGM immersion has a psychophysiological signature, it may instead be related to the sympathetic branch of the autonomic nervous system.

We note that RSA levels appear somewhat lower in the community sample compared to the undergraduate students (see Figure 3). However, our two samples were not demographically matched and were not intended for group comparisons. In particular, the community sample was significantly older, and heart rate variability is associated with age (Umetani, Singer, McCraty, & Atkinson, 1998), meaning that this group difference may be entirely due to an extraneous third variable such as age or health. Nevertheless, an intriguing hypothesis for future research is that regular EGM gamblers may display stable impairments in parasympathetic activity – an effect that may further contribute to the established comorbidity between depression and pathological gambling (Lorains, Cowlishaw, & Thomas, 2011) and data linking RSA to depression recovery (Rottenberg, Salomon, Gross, & Gotlib, 2005).

Limitations and Conclusion

A number of limitations should be noted. Correlational effects do not indicate causal influences, and thus the directional link between immersion and the level of problem gambling is unclear. Additional third variables such as low mood may also contribute to these relationships. For example, one alternative explanation for the correlation observed between target-task performance and risk of problem gambling in the community sample is the established comorbidity between problem gambling and more general deficits in attention (Breyer et al., 2009; Waluk, Youssef, & Dowling, 2016). Future studies should account for this possibility.

Informed consent required that participants be made aware they were about to play an EGM. As such, an expectancy effect may have skewed baseline physiological recordings to some extent. Further, PGSI scores were low on average in the student sample, restricting the range and shape of the distribution of PGSI scores. This, along with the somewhat small sample size of both participant groups, limits the conclusions that can be drawn from the results reported here.

One inherent challenge with measuring immersion is that probes may interrupt the state itself. This was apparent in our student sample when we compared our dual task condition (participants who played the EGM while monitoring for peripheral targets) against a control group who only played the EGM. Scores on the GEQ Flow scale were lower in the dual-task group, suggesting that the additional cognitive load may have interfered somewhat with EGM engagement. Nevertheless, the dual-task condition captured sufficient variation in immersive experience to detect relationships with PGSI, and the difference between the dual-task and single-task groups did not transfer to the conceptually-similar DQ.

One advantage of this study is that it made use of real EGMs housed in a laboratory environment, offering several advantages to ecological validity over ‘simulated’ slot machines that run on a desktop or laptop computer. Nevertheless, the realism of our Casino Lab still falls short of emulating real casino gambling in several respects, including the size and design of our laboratory room, which is in many ways distinct from the large gambling venues typical for British Columbia. This may be of particular relevance to those who consider the broader gambling environment (Ladouceur, Jacques, Sevigny, & Cantinotti, 2005; Schüll, 2012). Similarly, our decision to constrain participants to play using the maxi-min betting strategy may reduce ecological validity and physiological arousal, at least for some participants. It is an empirical question to what extent these effects diminish the degree of EGM immersion experienced.

Together, these results lend empirical credence to qualitative descriptions of the ‘slot machine zone’ (Schüll, 2012). This experiment provides 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. These findings carry implications for gambling policy in terms of the design of responsible gambling tools. It is vital to consider human attentional processes when designing game- or venue-level interventions. For example if messages are presented in the visual space peripheral to the game, immersed gamblers may be unlikely to register this information, and such effects may scale with those at greatest risk of problem gambling. Rather, responsible gambling messages should be salient and directly capture attention, or else be presented during pauses in EGM play.

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Table 1

Descriptive Statistics and Means Comparisons within Student Sample

	Regular EGM Players	Students Dual-Task Condition	Students EGM Only Condition	*t*	*df*	*p*
N	30	42	19	-	-	-
PGSI	5.57 (6.14)	1.14 (1.78)	0.84 (1.77)	0.61	59	.54
DQ	5.05 (4.69)	5.26 (4.86)	4.95 (3.91)	0.25	59	.81
GEQ FLOW	2.81 (2.02)	1.88 (1.66)	3.26 (2.38)	2.62	59	.01
GEQ AFFECT	4.30 (1.86)	3.32 (1.92)	2.92 (1.58)	0.79	59	.43
GEQ GAME INTEREST†	3.19 (2.15)	2.71 (1.88)	2.95 (4.88)	0.27	59	.79
GEQ COMPETENCE	2.66 (1.99)	2.29 (1.85)	1.58 (1.46)	1.47	59	.15
GEQ CHALLENGE	1.71 (2.06)	1.17 (1.51)	1.21 (1.62)	0.10	59	.92
GEQ TENSION	1.74 (1.96)	1.93 (1.47)	2.89 (1.82)	2.20	59	.03
TARGET DETECTION	12.43 (3.21)	12.90 (2.22)	-	-	-	-
MIND WANDERING	.350 (.267)	-	-	-	-	-

Note. Mean values are provided with standard deviation in parentheses. Community sample items are averaged across two play sessions. Inference tests are relevant to self-report comparisons of treatment and non-treatment conditions in the student sample. List of acronyms: DQ = Dissociation Questionnaire, GEQ = Game Experience Questionnaire (divided into subscales), PGSI = Problem Gambling Severity Index. † While this subscale is actually termed “immersion” by Ijsselsteijn and colleagues (2008), we believe the name is inappropriate;

that items do not reflect the type of immersion described in this study. Here, we refer to the subscale by a name we believe more fitting, “Game Interest.”

Table 2

Correlations between Behavioural and Self-report Variables in the Student Sample Dual Task Condition

	PGSI	DQ	GEQ FLOW	GEQ AFFECT
TARGET RESPONSE	r(40) = -.17 *p* = .28	r(40) = -.27 *p* = .08	r(40) = .07 *p* = .67	r(40) = -.06 *p* = .69
GEQ AFFECT	r(40) = .51 *p* = .001	r(40) = .49 *p* = .001	r(40) = .50 *p* = .001	
GEQ FLOW	r(40) = .36 *p* = .02	r(40) = .66 *p* < .001		
DQ	r(40) = .65 *p* < .001			

Note. DQ = Dissociation Questionnaire, GEQ = Game Experience Questionnaire, PGSI = Problem Gambling Severity Index.

Table 3

Correlations between Behavioural and Self-report Variables in the Community Sample

	PGSI	DQ	GEQ FLOW	GEQ AFFECT	TARGET RESPONSE
MIND WANDERING	r(26) = .05 *p* = .80	r(26) = -.29 *p* = .14	r(26) = -.39 *p* = .04	r(26) = -.61 *p* = .001	r(25) = -.32 *p* = .11
TARGET RESPONSE	r(26) = -.49 *p* = .01	r(26) = .15 *p* = .46	r(26) = .16 *p* = .42	r(26) = .21 *p* = .29	
GEQ AFFECT	r(27) = .10 *p* = .59	r(27) = .43 *p* = .02	r(27) = .60 *p* = .001		
GEQ FLOW	r(27) = .35 *p* = .07	r(29) = .78 *p* < .001			
DQ	r(27) = .45 *p* = .02				

Note. DQ and GEQ items are averaged across both EGM play sessions. List of acronyms: DQ = Dissociation Questionnaire, GEQ = Game Experience Questionnaire, PGSI = Problem Gambling Severity Index.

Figure 1

Representation of the target detection task.

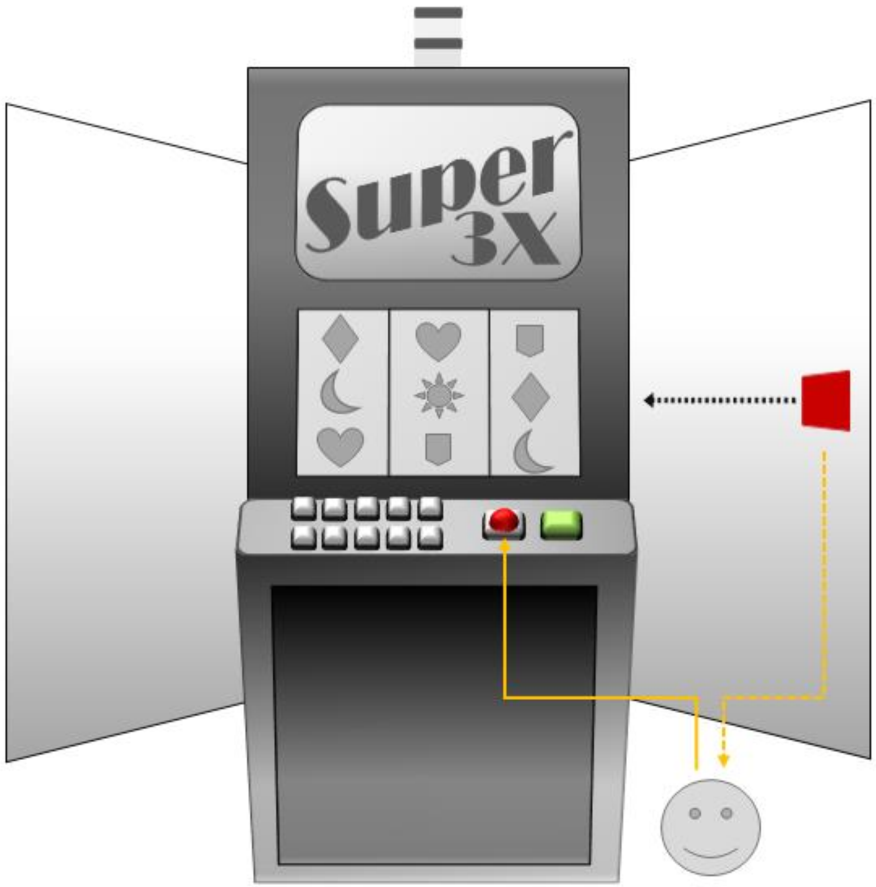


Figure 2

Correlational analyses for behavioral and self-report data in both samples.

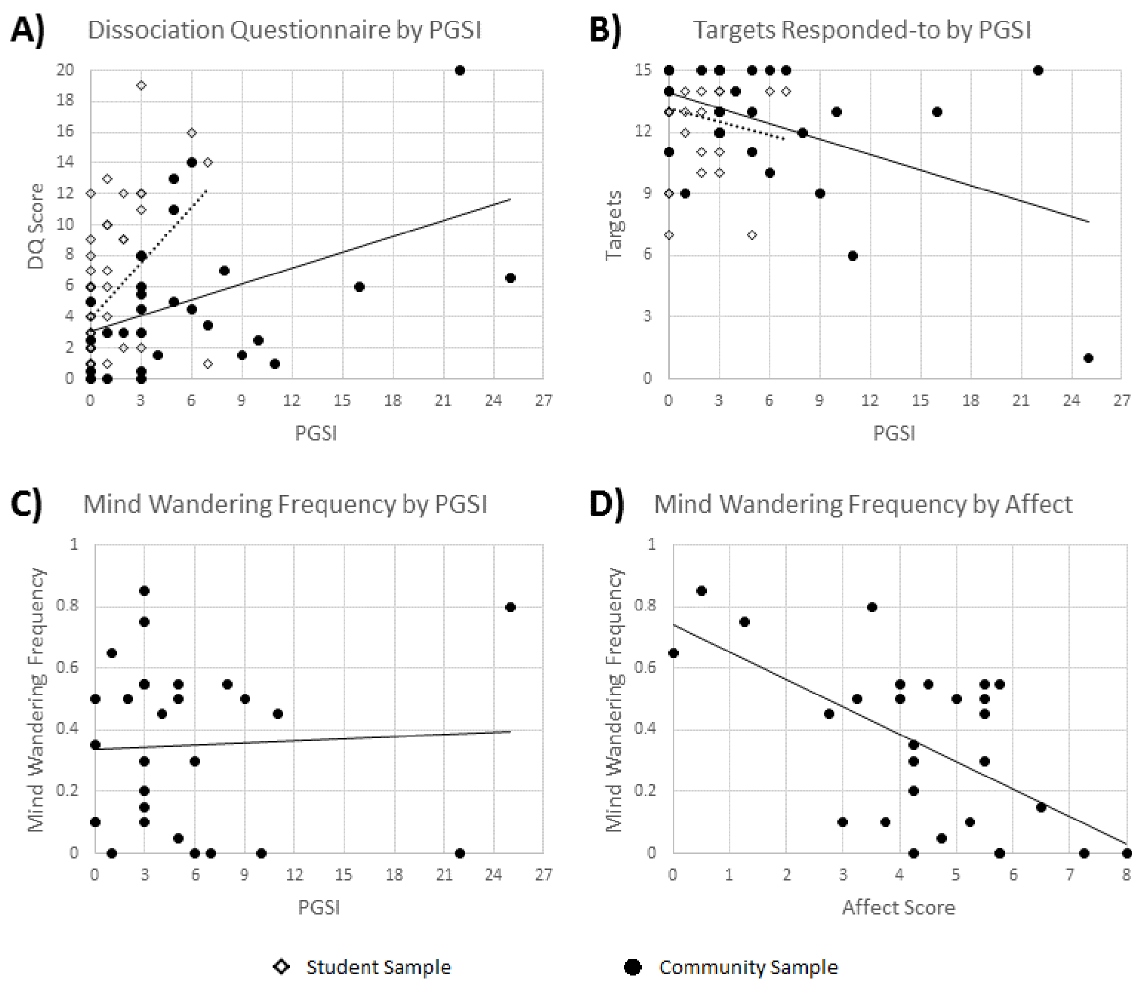
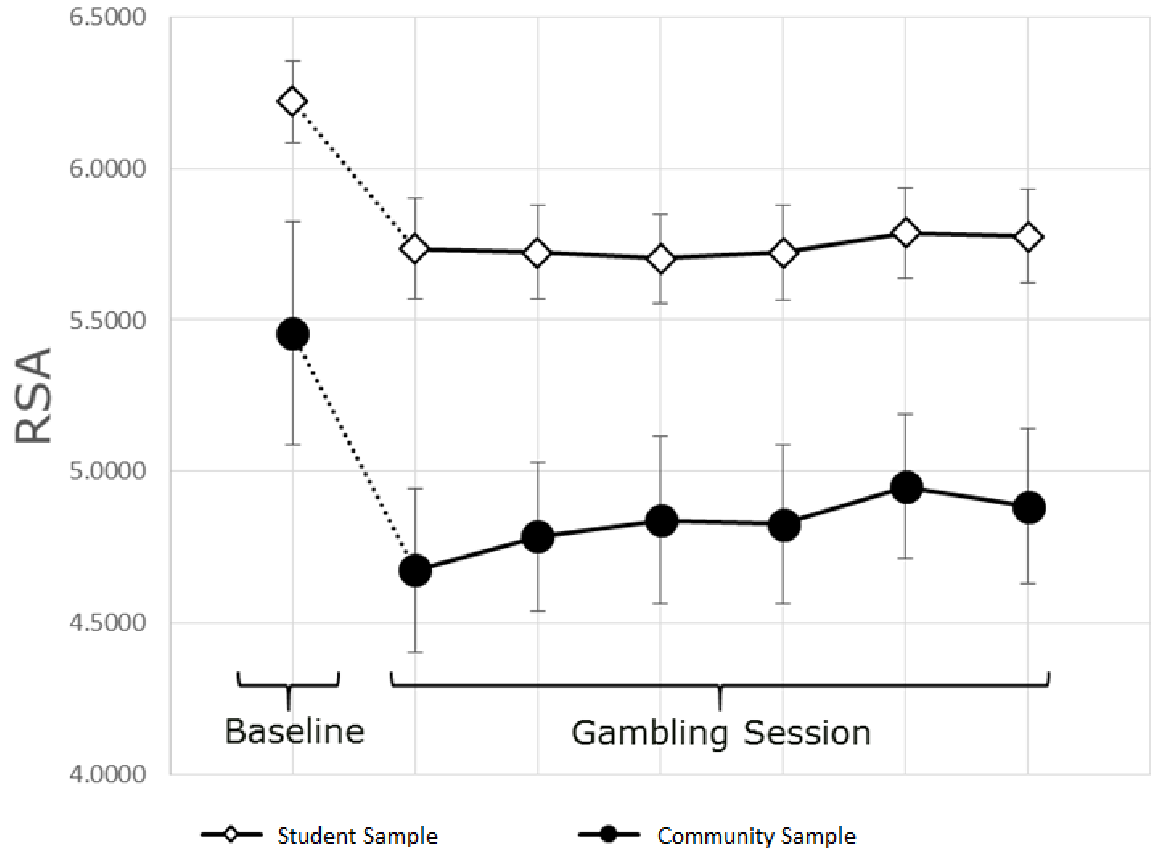


Figure 3

Respiratory Sinus Arrhythmia (RSA) Values from Baseline through the First Thirty Minutes of EGM Play.



Note. Bars represent SEM. Gambling session data is presented in 5-minute blocks.