# Effects of Bet Size and Multi-Line Play on Immersion and Respiratory Sinus Arrhythmia during Electronic Gaming Machine Use

W. Spencer Murch[1] & Luke Clark[1]

1. Centre for Gambling Research at UBC, Department of Psychology, University of British Columbia, Vancouver, British Columbia, Canada

**Citation:**

Murch, W. S., & Clark, L. (2019). Effects of bet size and multi-line play on immersion and respiratory sinus arrhythmia during electronic gaming machine use. *Addictive Behaviors*, 88(August 2018), 67–72. http://doi.org/10.1016/j.addbeh.2018.08.014

**Declarations of Interest:**

Luke Clark is the Director of the Centre for Gambling Research at UBC, which is supported by funding from the Province of British Columbia and the British Columbia Lottery Corporation (BCLC), a Canadian Crown Corporation. The slot machine used in the present study was provided to the Centre by the BCLC. The Province of British Columbia government and BCLC had no further involvement in the research design, methodology, conduct, analysis or write-up of the study, and impose no constraints on publishing.

LC has received a speaker honorarium from Svenska Spel (Sweden) and an award from the National Center for Responsible Gaming (US). He has not received any further direct or indirect payments from the gambling industry or groups substantially funded by gambling. He has provided paid consultancy to, and received royalties from, Cambridge Cognition Ltd. relating to neurocognitive testing. W. Spencer Murch reports no conflicts of interest.

The Centre for Gambling Research at UBC received funding from the Province of British Columbia and the British Columbia Lottery Corporation (BCLC). WSM holds a graduate fellowship from the Natural Sciences and Engineering Research Council of Canada. LC holds a Discovery Award from the Natural Sciences and Engineering Research Council of Canada.

**Contributors:**

WSM and LC designed the study, wrote the protocol and prepared the manuscript. Data collection and analysis was completed by WSM.

**Corresponding Author:**

W. Spencer Murch, Centre for Gambling Research at UBC, Department of Psychology, University of British Columbia, 2136 West Mall, Vancouver, British Columbia, Canada V6T 1Z4. Email: spencer@psych.ubc.ca

**Abstract**

Electronic Gaming Machines (EGMs) are regarded as a relatively harmful gambling product, and are associated with psychological immersion (the 'machine zone') and physiological arousal. Specifically, immersion is a phenomenon of attention manifesting as an intense focus on the game at the expense of peripheral stimuli and goals. Past research has indicated significant levels of immersion in response to modern multi-line EGMs and correlated with risk for problem gambling. The present study sought to separate the effects of multi-line play and bet size on measures of immersion and cardiac activity. Seventy-six male undergraduate students played an authentic EGM on each of 4 pre-defined betting styles while providing electrocardiogram data. The strategies varied the number of paylines and the bet multiplier. From the physiological data, we extracted Respiratory Sinus Arrhythmia (RSA), a marker of task attention derived from heart rate variability. We found that immersion ratings were significantly greater when both paylines and bet-size were high. Importantly, selectively increasing the paylines, but not the bet multiplier, produced significant increases in immersion. RSA change indicated parasympathetic withdrawal, consistent with increases in attention during EGM use, but did not differ across bet styles. These results suggest that multi-line EGMs capture attention across a range of betting styles, and that immersion is amplified by multi-line play.

Keywords: Gambling, Immersion, Flow, Attention, Electronic Gaming Machine, Slot Machine.

## 1. Introduction

Public health approaches to gambling recognize a 'player-product' interaction in which individual factors predispose some gamblers to problematic levels of engagement, but these dispositions interact with game- and venue-level factors to produce or aggravate gambling harms (Korn & Shaffer, 1999; W. Spencer Murch & Clark, 2016). At the venue-level, floor layout (Finlay-Gough, 2015), ambient sound (Noseworthy & Finlay, 2009), prevailing cultural beliefs (Lim & Rogers, 2017), and proximity to other players (Rockloff & Dyer, 2007; Rockloff, Greer, & Evans, 2012; Rockloff, Greer, & Fay, 2011) have been examined in relation to gambling behaviour. In recent years, product features have received increased scrutiny, with modern Electronic Gaming Machines (EGMs, including slot machines and Video Lottery Terminals) bearing the brunt of this research interest. This is due at least in part to these games' links to gambling-related harm (Binde, Romild, & Volberg, 2017; Breen & Zimmerman, 2002; MacLaren, 2015).

Fine-grained analyses of specific EGM features have identified a number of ingredients, including near-misses and 'Losses-Disguised-as-Wins,' (a product of modern, multi-line EGMs) that can distort players' perceptions of outcomes and motivate persistent gambling (see Barton et al., 2017). Multi-line games allow players to place concurrent bets across multiple paylines on a single spin. As the many paylines occupy most of the EGM display and often overlap, playing the game on this setting is a perceptually-demanding experience. At the same time, multi-line play is associated with more frequent reinforcement and 'smoother' credit decrement, and experienced slot machine gamblers typically prefer gameplay on the multi-line setting (Dixon et al., 2014; Haw, 2008, 2009; Livingstone & Woolley, 2008; Schull, 2012).

This study addresses game-level predictors of user experience. We aimed to test whether different bet styles on a multi-line EGM affected their immersion (termed "flow," "dissociation," and "the machine zone" by others; Dixon et al., 2017; Jacobs, 1986, 1988; Schull, 2012) in play and their attention to the game. The immersion state is prototypically described as a feeling of amplified attention to the game at the expense of all else, and has been repeatedly related to problem gambling (Cartmill, Slatter, & Wilkie, 2015; Diskin & Hodgins, 1999, 2001; Dixon et al., 2017; Hopley & Nicki, 2010; Kofoed, Morgan, Buchkowski, & Carr, 1997; W. S. Murch, Chu, & Clark, 2017; Noseworthy & Finlay, 2009; Wanner, Ladouceur, Auclair, & Vitaro, 2006). We believe immersion may be related to the attentional demand of play strategies that differ in complexity.

Attention was also measured using a psychophysiological proxy. Heart Rate Variability (HRV) typically decreases in response to tasks or circumstances that demand attention and/or mental effort (Lane et al., 2009; Porges & Raskin, 1969). Duschek and colleagues (2009) observed decreases in HRV related to sustained attention. In an earlier gambling study, we observed significant decreases in Respiratory Sinus Arrhythmia (RSA; an HRV metric) in response to EGM play in separate samples of university students and experienced EGM users (W. S. Murch et al., 2017). Using a driving simulator, Tozman and colleagues (2015) linked self-reported flow experiences with moderate levels of HRV when the task was challenging. As such, immersion and HRV may correlate, and both may be affected by the differing attentional demands of different EGM bet style.

We hypothesized that immersion during EGM play would differ with multi-line versus single-line bet strategies. In a seminal study, Dixon and colleagues (2014) compared regular gamblers playing a simulated EGM on a single-line setting (1 cent on 1 pay-line = $.01 bets) and a multi-line setting (1 cent on each of 20 pay-lines = $.20 bets). Dixon et al., reported greater immersion in the multi-line condition, but the number of pay-lines was confounded by the overall bet size in that experiment. To resolve this, our study added two further conditions: one where the minimum bet is placed on multiple pay-lines, and one where the same overall bet size is achieved by increasing the number of credits bet on a single pay-line, using the bet multiplier options. This approach was also adopted by Dixon et al., (2017), who compared immersion ratings in a game played on either 20 lines at 1 credit ($.01) per line or 1 line at 4 credits ($.05) per line; a $.20 bet in both cases. There, immersion in the multi-line setting more-strongly predicted problem gambling risk. If earlier conclusions are correct, we expect that the multi-line condition will again produce higher immersion. We further hypothesized that changes in RSA across bet conditions would mirror changes in immersion across conditions. In other words, RSA should generally decrease from baseline to task, but should decrease more in blocks where multi-line strategies are employed, where we also expect immersion to be higher.

Finally, we hypothesized that salient game events (wins, ‘bonus rounds’), and self-reported ADHD symptoms (Breyer et al., 2009; Waluk, Youssef, & Dowling, 2016) may also influence immersion and cardiac activity during EGM play.

## 2. Methods

### 2.1 Participants

This study was approved by the host university’s Behavioural Research Ethics Board. We recruited 80 male undergraduate students. This study also investigated impedance cardiography (not presented here). Thus, sampling was restricted to male participants because impedance cardiography involves applying adhesive electrodes to shirtless participants. Inclusion criteria allowed participants: ages 19 years or older (the legal age to gamble in this jurisdiction), with normal or corrected-to-normal eyesight, with no history of allergic reaction to adhesives or gels, and no current or recent use of psychotropic or cardiac medications. Individuals who reported high risk of problem gambling on the PGSI (see below) were not permitted in the slot machine task.

Participants responded to an online advertisement hosted by the school's psychology department, and received partial grade credit. Four participants did not complete the study after providing consent; one reported high risk of problem gambling, one displayed a persistent cardiac arrhythmia, one withdrew citing concerns about adhesive electrode placement on body hair, and one session was halted due to a power outage. Thus, the final sample size was 76 (mean age = 20.55, SD = 2.37).

## 2.2 Procedure

After providing consent, participants completed the Problem Gambling Severity Index (PGSI; Ferris, Wynne, Ladouceur, Stinchfield, & Turner, 2001). Items were scored from 0 to 3 ("never," "sometimes," "most of the time," or "almost always"), for a total of 27 possible points (0 = non-problem gambler, 1-2 = low-risk, 3-7 = moderate risk, 7 or greater = high risk / problem gambler).

Participants completed the Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005). Responses are given on a 5-point Likert scale ("never," "rarely," "sometimes," "often," or "very often,"). For the purpose of these analyses, we chose to treat the scores on the six items as continuous (see Seli, Smallwood, Cheyne, & Smilek, 2015).

Electrodes were connected and a 5-minute, eyes-closed baseline recording was obtained. The game, “Buffalo Spirit,” is a genuine WMS slot machine (Scientific Games Co., Las Vegas, NV) configured on a 1 cent minimum bet with 40 paylines. The bet multiplier buttons allow the player to place 1 to 5 times the minimum bet at each line. The game had a configured hold percentage of 11% (i.e., over thousands of spins the machine would on average keep 11 cents for every dollar wagered). Participants were informed that the game was real, and had not been modified. They were briefed on EGM gameplay. Participants were informed that they would be playing “a number of different betting strategies for a few minutes each.” They were told they would be endowed CAD $40 cash to load into the machine for each block, and that, “depending on how much credit [they had] at the end, [they would] be paid a bonus of up to $12.” The exact nature of these bonus payments (described below) was laid out on the consent form.

The slot machine session was divided into four 5-minute blocks. Each block required players to select a pre-determined betting strategy (Latin square counterbalanced). The ‘Small Bet’ strategy comprised the minimum bet on a single payline (1 line, 1 credit per line, $0.01/bet), ‘Large Bet’ comprised many lines with multiple credits bet on each (20 lines, 5 credits per line, $1.00/bet; made 100x larger than the Small Bet condition in order to emphasize the difference), and two intermediate strategies achieved a $0.05 bet by increasing either the number of paylines (‘Line-Style’, 5 lines at 1 credit, $.05/bet) or the bet multiplier (‘Multiplier-Style’, 1 line at 5 credits, $.05/bet). With these constrained bets, we compared a minimum bet to a much larger bet, as well as two equally-sized intermediate bets which contrast the games’ multi-line and bet-multiplier features. Notably, the Line-Style condition produced wins on 5 different paylines dispersed around the screen, while the Multiplier-Style condition produced wins only on the middle payline. Since multi-line play increases the frequency of wins, and since winning paylines are typically outlined on-screen when triggered by multi-line games, we reasoned that players might expend more attention on the Line-Style condition than the Multiplier-Style condition. Additionally, players may be more vigilant towards multi-line EGMs if they engage in visual searches for matching symbols before the last reel comes to a stop. Such behaviour would also draw upon attentional resources.

For the two multi-line conditions (Large Bet and Line-Style), participants could be exposed to LDWs, and saw a greater likelihood of triggering the 'replicating' bonus feature, which duplicates winning symbols randomly across the reels. All conditions were equally likely to trigger the 'free-spins' bonus feature, as it does not rely on a payline win. Compared to simple wins, bonus features are rare and highly salient, and may be a driving motivator for problem slot machine use (Livingstone & Woolley, 2008; Lole & Gonsalvez, 2017).

Following each block, participants completed a 7-item immersion questionnaire. The scale is a concatenation of two previously-employed measures: the 'Flow' subscale of the Game Experience Questionnaire (IJsselsteijn, de Kort, & Poels, 2013) (e.g. "I felt completely absorbed") and the Diskin and Hodgins (1999) modification of the Dissociation Questionnaire (Jacobs, 1986, 1988) ("I felt like I was in a trance", "I lost track of time"). Each response was obtained on a 5-point Likert scale ("very slightly or not at all," "a little," "moderately," "quite a bit," "extremely,") and divided by 7. We previously used these measures jointly (W. S. Murch et al., 2017), finding that they tend to provide concordant results. Reliability analyses in the present study indicated that these questionnaires were well-suited to concatenation. Cronbach's α for the average rating (across four blocks) participants gave each of the seven items in the immersion questionnaire was .88. Cronbach's α was .82 for the Dissociation Questionnaire and .80 for the Game Experience Questionnaire items.

After the fourth and final block, participants were debriefed on the study, the mathematic and statistical rules governing gambling, and hold percentage. They were provided documents describing the functioning of modern, multi-line slot machines and a list of available gambling treatment services in this jurisdiction. Credit losses and gains for each session were totaled; 22 individuals turned a profit overall, each being paid $12. For participants at a net loss, payments decreased by $2 for each 800 credits lost, to a minimum of $2 paid to participants who lost 4000 credits or more (n = 8). Physiological data from a block was discarded if the participant ran out of credits.

**2.3 Heart Rate Variability**

Psychophysiological data were sampled at 1,000 Hz using a wireless BIOPAC MP150 system. Participants wore seven Ag/AgCl electrode patches from Vermed (Buffalo, NY). Three ECG electrodes were affixed to the chest and lower left abdomen. Four patches were applied to the bilateral neck and ribcage for impedance cardiogram measures. Seventeen participants' ECG data was insufficiently clean or complete for use in these analyses. Where correlational analyses were performed with individual task bins and baseline values, all available data was used.

Heart Rate (HR) and RSA were extracted from the ECG traces using QRSTool CMetX (Allen, Chambers, & Towers, 2007). RSA is a marker of cardiac vagal tone, with widespread use in the HRV field (Allen et al., 2007). QRSTool was used for inspection and cleaning of ECG traces. Heart beats' r-wave peaks were automatically marked above visual-inspection threshold, producing a time-series distribution of peak-to-peak latencies (ms). Single missing peaks were linearly interpolated. Consecutive missing peaks triggered the exclusion of that block. Upon export, the generated time-series data were calculated as HR and RSA using CMetX. RSA is defined there as the natural log of the 0.12-0.40 Hz band-limited variance of the time series.

We used a Biopac Respiration Effort Transducer to observe respiration rate for each block (see Grossman & Taylor, 2007). These data were resampled to 62.5 Hz and a 0.05 – 1 Hz band pass was applied. Heart rate is reported alongside RSA as recommended (Grossman & Taylor, 2007).

One-way within-subjects ANOVAs were conducted, and corrected using Greenhouse-Geisser fractional degrees of freedom where the assumption of sphericity was violated under Mauchly's test. Pairwise comparisons were Bonferroni corrected.

## 3. Results

### 3.1 Self-report and Gameplay Data

Participants' PGSI scores were generally low (Mean = 1.22, SD = 1.73); 39 individuals were in the non-problem gambler category (PGSI = 0), 22 individuals were low risk and 15 were moderate risk. The mean ASRS score was 10.64 (SD = 3.15).

Wins and bonus features, as well as the overall number of credits lost, varied by block. For the Small Bet blocks, the median participant encountered 1 win (SD = 0.90), 1 bonus feature (SD = 0.89) and lost 6.88 credits (of 4000, SD = 67.01). For the Large Bet blocks, the median participant encountered 6 wins (SD = 2.56) and 2 bonus features (SD = 1.09), and lost 867.63 credits (SD = 3096.29). The median Line-Style block had 3 wins (SD = 1.81), 1 bonus feature (SD = 0.84), and incurred a loss of 57.71 credits (SD = 296.22). The median Multiplier-Style blocks had 1 win (SD = 1.05), 0 bonus features (SD = 0.68), and 49.21 credits lost (SD = 240.49).

Immersion scores differed significantly between blocks ($F(2.62, 196.21) = 14.24$, $p <$ $.001$ , $\eta^2 = 0.16$, $\varepsilon = .87$, figure 1). The Large Bet condition was more immersive than the Small

Bet condition ($p < .001$), and both intermediate conditions (Line-Style $p = .02$, Multiplier-Style $p < .001$). The Line-Style condition was more immersive than the Small Bet condition ($p = .01$) and did not differ from the Multiplier-Style ($p = .69$). The Multiplier-Style condition did not differ from the Small Bet condition ($p = .18$). To test whether immersion was associated with reinforcement, we ran exploratory correlations of immersion scores with the number of wins and bonus features in each block. The number of bonus features in the Large Bet condition was significantly related to immersion (r(74) = .28, p = .02; all other bonuses p > .10), and we note this would not survive correction for multiple comparisons. The number of wins experienced was not a significant predictor of immersion under any bet style (all p > .20).

Problem gambling risk category (PGSI) was tested as a between-subjects factor on the immersion model. Neither a significant main effect ($F(2, 73) = 2.68$, $p = .08$, $\eta^2 = .07$), nor an interaction were observed ($F(5.27, 192.36) = 0.71$, $p = .62$, $\eta^2 = .02$, $\varepsilon = .88$), though the repeated-measures effect remained ($F(2.64, 192.36) = 14.12$, $p < .001$, $\eta^2 = .16$, $\varepsilon = .88$). We note, however, that the restricted range of PGSI scores in our sample could have impacted these results. ASRS was median-split and tested as a between-subjects factor on the immersion model. A significant main effect ($F(1, 74) = 4.23$, $p = .04$, $\eta^2 = .05$) indicated greater immersion among high-ASRS participants, but there was no interaction by block ($F(2.63, 194.23) = 0.52$, $p = .65$, $\eta^2 < .01$, $\varepsilon = .88$).

**3.2 Psychophysiological Results**

A repeated-measures ANOVA was performed on the RSA data. A significant main effect of baseline/condition was observed ($F(1.64,\ 94.89) = 18.25$, $p < .001$ , $\eta^2 = .24$, $\varepsilon = .41$, figure 2). Pairwise tests indicated that RSA was significantly lower during all EGM conditions relative to the pre-task baseline (all $p < .001$). None of the task conditions differed significantly from one another (all other $p > .99$). Median-split ASRS had a significant between-subjects effect on the RSA model such that high-ASRS participants had lower overall RSA ($F(1, 57) = 6.01$, $p = .02$ , $\eta^2 = .10$), consistent with relative deficits in emotion regulation (Holzman & Bridgett, 2017). The interaction term was not significant ($F(1.63, 92.61) = 0.23$, $p = .75$, $\eta^2 = .004$, $\varepsilon = .41$).

Baseline RSA was subtracted from RSA for each slot machine condition and the change scores were correlated with their associated immersion ratings. RSA change from baseline significantly predicted immersion scores during the Multiplier-Style session type ($r(67) = -.34$, $p = .02$). In this condition, immersion increased as RSA decreased from baseline. All other comparisons were not statistically significant ($p > .99$).

The time-course of RSA was analyzed to determine if RSA changed as the session progressed. Blocks were labelled chronologically, ignoring play condition. Pairwise tests indicated no significant differences between task blocks (all task-related comparisons $p > .50$, figure 3).

Secondary models tested for changes in respiration rate and heart rate. A task-related increase in respiration was observed ($F(1.99, 115.62) = 82.11$, $p < .001$, $\eta^2 = .59$, $\varepsilon = .50$, figure 2), with differences between baseline recording and task blocks (all $p < .001$), but not between task blocks (all $p > .99$). Respiration rate predicted RSA (all $p < .04$). Heart rate also varied by block ($F(2.46, 142.77) = 7.34$, $p < .001$ , $\eta = .11$, $\varepsilon = .62$, figure 2), decreasing from the baseline recording to all EGM conditions (all $p < .03$), but no EGM blocks differed (all $p >.99$).

## 4. Discussion

This study examined differences in RSA and self-reported immersion, which were conceptualized as markers of attention, as a function of different EGM bet style. Our student participants, who were mostly novice gamblers, reported substantially higher immersion scores in the Large Bet condition compared to the Small Bet condition. These results corroborate Dixon and colleagues' (2014) findings, showing that player immersion is maximized when the number of paylines and the overall bet amount are both high. Immersion was also higher in the Large Bet condition compared to the two intermediate conditions, indicating an additive effect of paylines and bet size. In comparing these intermediate conditions against the Small Bet condition, only the Line-Style condition showed a significant increase in immersion; changing the bet by itself in the Multiplier-Style condition did not facilitate immersion.

Some of the relationship between immersion and bet style could be explained by the number of EGM bonus features, which varied in our study due to the use of authentic EGMs. In the Large Bet condition - which produced the highest overall number of bonus features on average - a significant relationship was seen between the number of bonus features and immersion scores. While our participants were generally not experienced EGM users, prior research found that regular players favour games with free spin bonus features (Livingstone & Woolley, 2008). Acknowledging that much EGM work relies on simulators without bonuses, these features certainly merit further research.

We observed significant relationships with self-reported ADHD symptoms between both immersion and RSA. Participants with higher ASRS scores reported greater slot machine immersion, and had lower RSA across all bet styles. This effect on RSA indicates poorer top-down self-regulation among individuals with ADHD traits (Holzman & Bridgett, 2017), consistent with prior research where lower RSA was associated with emotion regulation deficits in children treated for ADHD (Beauchaine et al., 2013). Since no consistent relationship between immersion and RSA was observed, these relationships are not likely to confound our interpretation of the immersion data.

We further hypothesized that different bet styles would produce in-kind reductions in RSA, since multi-line and large bet strategies should impose greater attentional demands. This hypothesis was not supported. Rather, we saw significant and uniform decreases in RSA compared to baseline levels. There are a number of possible explanations for this null result. Perhaps EGMs at any setting are sufficiently demanding of attention to trigger parasympathetic withdrawal even in the Small Bet condition, creating a floor effect. This interpretation would help to explain why some participants show marked decreases in the ability to perform simple peripheral target-detection tasks while playing EGMs (Diskin & Hodgins, 1999, 2001; W. S. Murch et al., 2017). Alternatively, outlining winning paylines with salient colours could nullify, or at least attenuate, the increased attentional demands of multi-line play by allowing wins to be pre-attentively processed regardless of the number of paylines played.

Another likely factor is the relationship with respiration rate, which showed a similar response pattern to RSA. Indeed, one frequency-domain examination of RSA suggests that its covariation with attention is due to changes in respiration (Althaus, Mulder, Mulder, Van Roon, & Minderaa, 1998). If so, why does EGM use increase respiration? Perhaps our resting baseline led to a conscious control of breathing rate by some participants. Future studies could establish multiple baselines (e.g. one during a paced breathing instruction) to capture this effect. Certainly, future research on cardiac function during gambling, and particularly HRV measurement, would benefit from direct recording of respiration.

Several limitations should be acknowledged. Our student sample registered low levels of gambling involvement and PGSI scores, and thus our results do not speak to disordered gambling. Indeed, the makeup of our sample (younger adults, all male) does not match the demographic makeup of EGM patrons in most jurisdictions. The use of a hybrid casino laboratory allows us to study genuine EGMs in a highly-controlled environment, however some concern exists with respect to ecological validity (Anderson & Brown, 1984; Stewart, McWilliams, Blackburn, & Klein, 2002). It is notable, for example, that heart rate decreased during EGM play in our experiment; a number of studies have reported HR increases during EGM use in naturalistic environments (Coventry & Constable, 1999; Coventry & Hudson, 2001; Diskin & Hodgins, 2003; Griffiths, 1993). We aimed to examine attentional differences using heart rate variability, though its close ties to respiration suggest it may not be the best tool for research on EGM users. We note also that the cleaning of the cardiac data resulted in a smaller subsample of participants compared to the immersion analyses, reducing statistical power. A clear avenue for future research lies in applying eye tracking to monitor attentional allocation during EGM play, and relationships with immersion.

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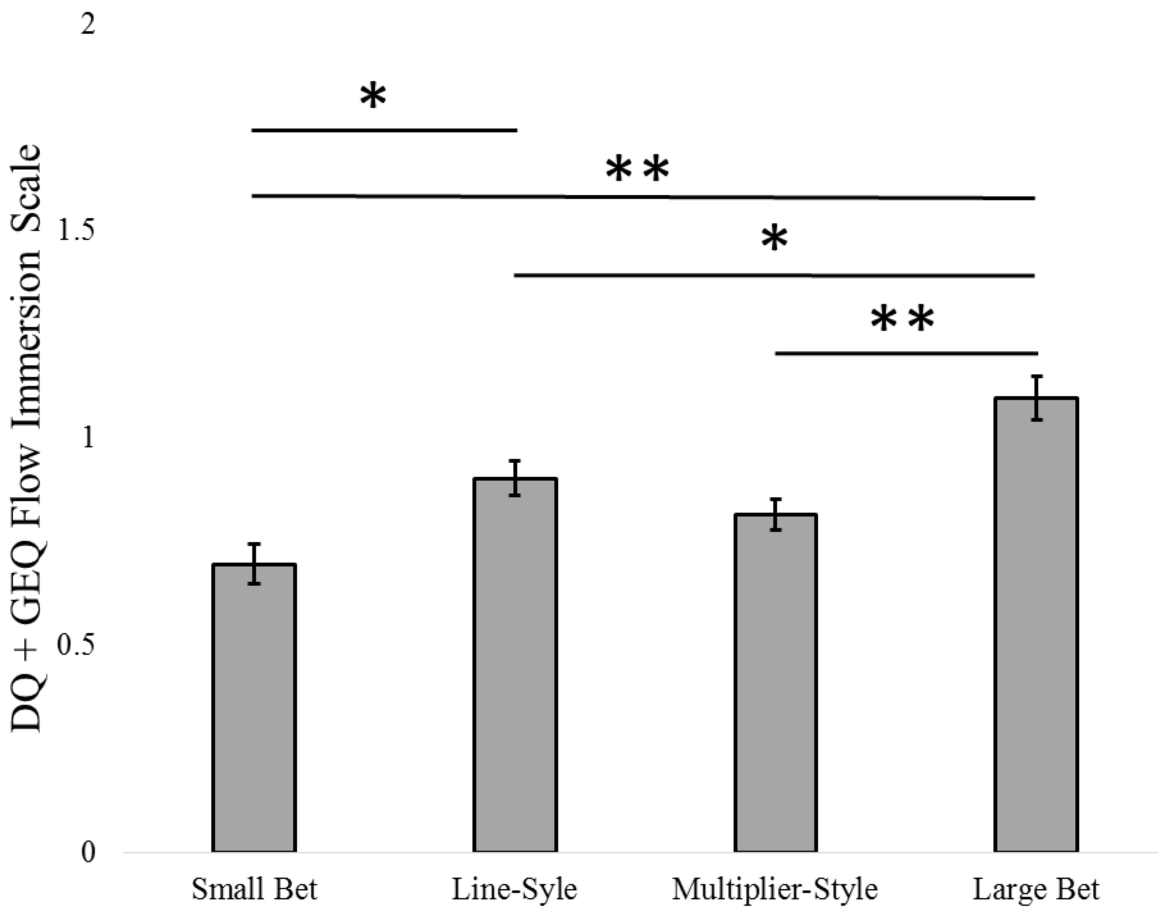
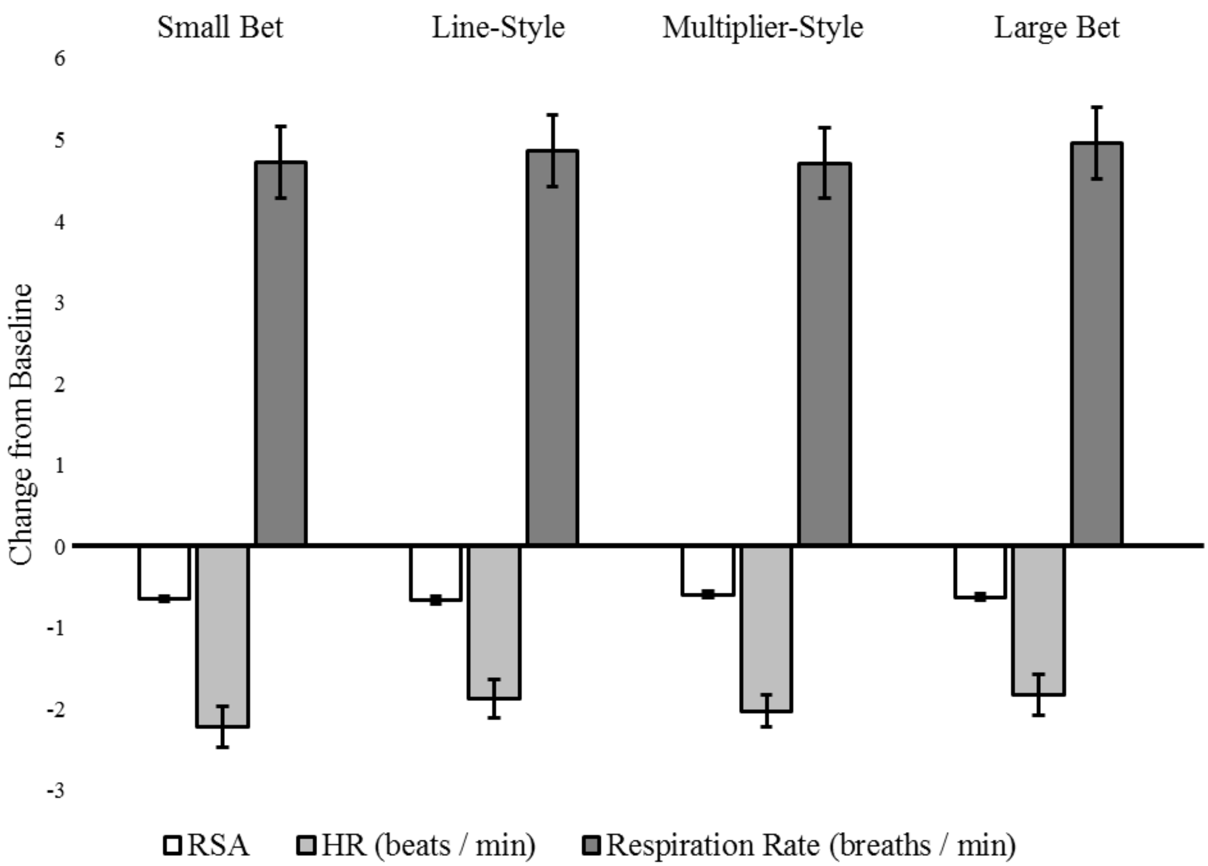
Figure 1: Immersion ratings (out of 4) by bet condition




*Note:* Bars represent one standard error within-subjects (Cousineau, 2005; Morey, 2008). Lines indicate statistical significance of the pairwise comparisons.

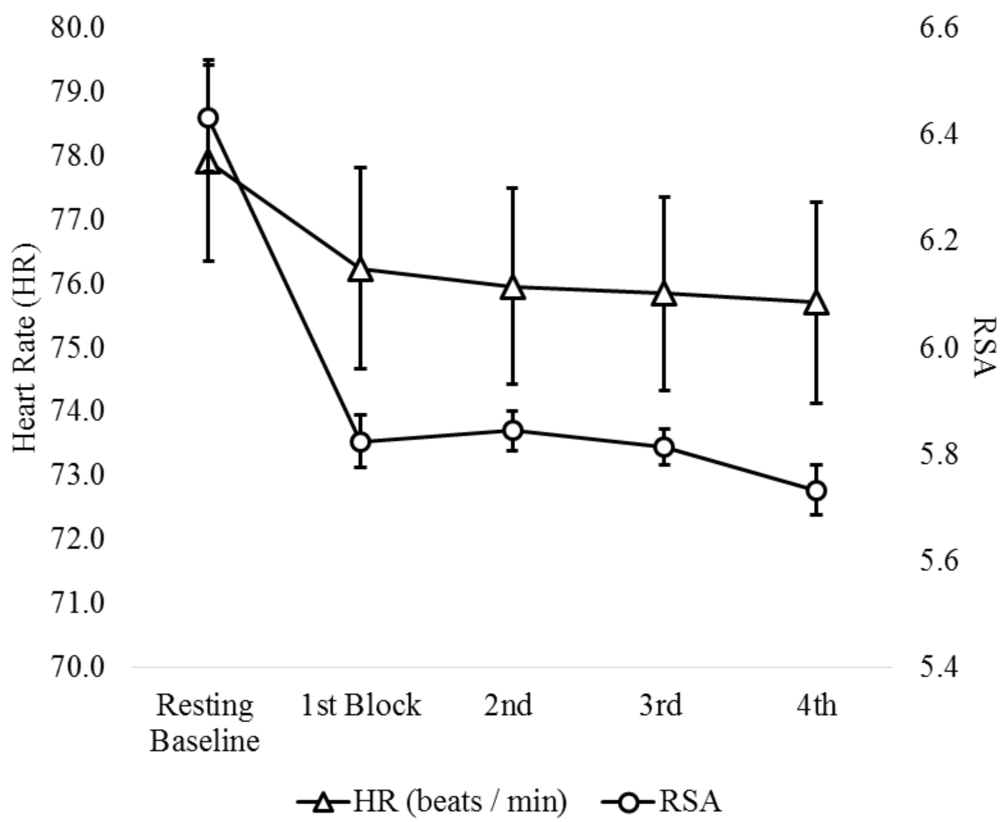
* $p$ < .05, ** $p$ < .01

Figure 2: RSA, HR and Respiration Rate change from baseline by bet condition.




*Note:* Bars represent one standard error for the within-subjects effects.

Figure 3: Time-course graphs of HR and RSA.




*Note:* Bars represent one standard error for the within-subjects effects.