



UNIVERSITY  
OF WOLLONGONG  
AUSTRALIA

University of Wollongong  
Research Online

---

Faculty of Health and Behavioural Sciences - Papers  
(Archive)

Faculty of Science, Medicine and Health

---

2009

# Psychophysiological responses to win and loss events during electronic gaming machine (EGM) play: A pilot investigation

Benjamin Wilkes

*University of Sydney*, blw03@uow.edu.au

Craig J. Gonsalvez

*University of Wollongong*, craigg@uow.edu.au

Alex Blaszczynski

*University of Sydney*

---

## Publication Details

Wilkes, B., Gonsalvez, C. J. & Blaszczynski, A. (2009). Psychophysiological responses to win and loss events during electronic gaming machine (EGM) play: A pilot investigation. *Gambling Research*, 21 (2), 22-34.

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library:  
research-pubs@uow.edu.au

---

# Psychophysiological responses to win and loss events during electronic gaming machine (EGM) play: A pilot investigation

## **Abstract**

The pilot study used state-of-the art psychophysiological equipment to monitor, on a second-by-second basis, skin conductance level (SCL) and heart rate (HR) of university students (n = 12) in response to win and loss events while playing an electronic gaming machine (EGM). Each win and loss event was recorded and physiological changes associated with these events sorted and averaged based on event type (win/loss) and time (pre and post events). Compared to pre-event baselines, both SCL and HR increased following the occurrence of a win but not to a loss event. SCL was the more sensitive of the two measures, yielding a robust and reliable response for wins but not for losses. These results have potentially valuable clinical implications and future research should attempt to capture and compare physiological changes to win and loss events in field settings in both problem and non-problem gamblers.

## **Keywords**

events, loss, win, responses, investigation, psychophysiological, pilot, play, egm, machine, gaming, electronic, during

## **Disciplines**

Arts and Humanities | Life Sciences | Medicine and Health Sciences | Social and Behavioral Sciences

## **Publication Details**

Wilkes, B., Gonsalvez, C. J. & Blaszczynski, A. (2009). Psychophysiological responses to win and loss events during electronic gaming machine (EGM) play: A pilot investigation. *Gambling Research*, 21 (2), 22-34.

# Psychophysiological responses to win and loss events during electronic gaming machine (EGM) play: A pilot investigation

**BENJAMIN L. WILKES<sup>1</sup>, CRAIG J. GONSALVEZ<sup>1</sup> & ALEX BLASZCZYNSKI<sup>2</sup>**

<sup>1</sup> School of Psychology, University of Wollongong, Wollongong, NSW, Australia.

Email: blw03@uow.edu.au , wilkesinc@hotmail.com

<sup>2</sup> School of Psychology, University of Sydney, Sydney, NSW, Australia.

## Abstract

The pilot study used state-of-the art psychophysiological equipment to monitor, on a second-by-second basis, skin conductance level (SCL) and heart rate (HR) of university students (n = 12) in response to win and loss events while playing an electronic gaming machine (EGM). Each win and loss event was recorded and physiological changes associated with these events sorted and averaged based on event type (win/loss) and time (pre and post events). Compared to pre-event baselines, both SCL and HR increased following the occurrence of a win but not to a loss event. SCL was the more sensitive of the two measures, yielding a robust and reliable response for wins but not for losses. These results have potentially valuable clinical implications and future research should attempt to capture and compare physiological changes to win and loss events in field settings in both problem and non-problem gamblers.

## Literature Review

Over the past three decades, states of arousal have been identified as potential contributing factors to the development and maintenance of problem gambling behaviour. This “buzz” or excitement generated from gambling has been theorised to operate as a major reinforcer for participation in the activity as a recreational pursuit and also as a contributing factor to the development of problem gambling (e.g., Dickerson, 1993; McConaghy, Blaszczynski & Frankova, 1991; Moodie & Finnigan, 2005).

Cocco, Sharpe and Blaszczynski (1995) reported differences in preferred level of arousal for EGM players as opposed to horse race gamblers. Horse race gamblers were found to prefer heightened levels of arousal while EGM players were found to avoid arousal more frequently. Cocco et al. (1995) suggested that each of these gaming activities allows the participant to attain their preferred arousal state, but the researchers did not objectively measure arousal changes evoked by gambling activity.

Blanchard, Wulfert, Freidenberg and Malta (2000) stated that measuring autonomic arousal in response to gambling activity is perhaps the most direct method of measuring such changes (for a review of psychophysiological research and gambling activity, see Goudriaan, Oosterlaan,

de Beurs & Van den Brink, 2004). Research has suggested that the level of physiological arousal may be related to frequency and duration of gambling sessions (Griffiths, 1993a; 1993b), and that psychophysiological responses, most commonly increased heart rate to gambling activities such as EGM play (Coulombe, Ladouceur, Desharnais & Jobin, 1992), blackjack (Anderson & Brown 1984), and horse racing (Coventry & Norman 1997) have been observed.

In addition, research has shown that winning or losing money influences physiological activity (e.g., Coventry & Constable 1999; Moodie & Finnigan 2005). However, in most studies, separate effects of winning or losing events within the same individual have not been measured. It is important to consistently measure the reactivity of players to both wins and losses since the expectancy of monetary gain (wins) has been identified as possibly the most important factor mediating continued gambling activity (Ladouceur, Sevigny, Blaszczynski et al., 2003; Wulfert, Roland, Hartley, Wang & Franco, 2005). Although there is a general impression from the research that gambling increases arousal in participants, there is limited data as to how the intermittent effects of reinforcement from wins influences physiology following single events.

Gaming machines are associated with the highest level of problem gambling (Blaszczynski, Sharpe & Walker, 2001) and EGMs have been called the “crack-cocaine” of gambling (Dowling, Smith & Thomas, 2005). Additionally, EGMs have the highest rate of play, frequency and amount of payouts, and are the most accessible form of gambling in Australia (Productivity Commission, 1999). Research indicates that some gamblers find it difficult to stop playing EGMs once a session has commenced (Schellink & Schrans, 2002; Dickerson, Haw & Shepherd, 2003). Because EGMs deliver an intermittent schedule of win and loss events, gamblers can continue to play on the machines in the face of numerous losses. An investigation into the patterns of arousal in response to win and loss events should help determine the presence of physiological reinforcers in the face of net losses and how they are displayed across time.

A notable recent study by Moodie and Finnigan (2005) examined heart rate differences between frequent, infrequent and non-gamblers while playing a gaming machine. The heart rate of participants who won during a session of play was more elevated (on average) during a session (compared to initial baseline recording) than those who lost. However, measures obtained over a long period of play are difficult to interpret as they are affected differentially by the stimuli of different contexts, particularly in a field setting (Moodie & Finnigan, 2005). Averaging responses to wins and losses over a long period of play also averages wins, losses and baseline activity, reducing the sensitivity of such findings to possible clinically relevant physiological markers, and prevents the evaluation of second-by-second timeline responses to gambling events. An additional, serious concern with regard to session-based averages is the confounding effect of alcohol, smoking and medication, all of which may differentially affect these conditions. Capturing responses to individual events (wins/losses) in rapid succession (a few seconds apart) negates this criticism, as state-based changes will affect both event types similarly. Notwithstanding, studies investigating changes in arousal during gambling should control for those taking medications that may act to block physiological responses to stimuli (e.g., beta-blockers). Moodie and Finnigan (2005) used single recordings of anticipation of (pre) and response to outcomes (post) to demonstrate that there were significant increases in HR in response to wins for participants although they did not report on responses to individual loss events. It was also reported that responses to wins were greatest for the group who had played on machines the most regularly (Moodie & Finnigan, 2005).

Gambling on electronic machines is characterised by a rapid frequency of play (Dickerson, 1993), with events occurring in sequences of differing stimuli. The common use of averaged pre and post measures of arousal (e.g., Blanchard et al., 2000; Coventry & Constable, 1999;

Moodie & Finnigan, 2005) bears scrutiny. Further research is warranted to clarify the pattern of physiological changes that are associated with wins (monetary gains) and losses (monetary losses) when gambling on electronic machines. Moreover, the reported differences in responses to gambling activity by high and low frequency players (e.g., Dickerson, Hinchy, England, Fabre & Cunningham, 1992; Moodie & Finnigan, 2005), and between problem and non-problem gamblers (Sharpe, 2004), may not be reflective of patterns of responses across multiple event types commonly experienced during EGM gambling (Griffiths, 1993a). Problem gamblers may respond differently to wins and losses than other players and this differential pattern of responses could be a trait-like factor that predisposes some persons to problem gambling (Sharpe, 2004). If this is the case, the confirmation of psychophysiological differences using contemporary technologies could be applied to predict persons at risk. It is therefore important that researchers investigate patterns of physiological responses taken consistently in response to gambling behaviour and to events during the activity (Blanchard et al., 2000).

Non-psychophysiological explanations also have been posited to explain why individuals continue to gamble despite an overall net loss. These explanations include cognitive processes that result in the gambler overestimating the degree of control they have over the outcome (Coulombe, Ladouceur, Desharnais & Jobin, 1992; Coventry & Norman, 1998), and the “gambler’s fallacy” that after a run of losses, a big win is overdue (Custer, 1984). Another explanation for which there is some evidence is that “selective hypothesis testing” leads gamblers to overestimate the probability of a particular outcome and influences subsequent gambling activity (Gilovich, 1983, 1986; Gibson, Sanbonmatsu & Posavac, 1997). Sharpe and Tarrier’s (1993) cognitive-behavioural model of gambling argues that autonomic arousal is associated with gambling-related stimuli, and that gambling behaviour is cognitively mediated. Research has yet to satisfactorily focus on the association between the presence of such cognitions and arousal associated with events on gambling tasks.

Laboratory settings have commonly allowed researchers to control many aspects of gambling activity, which add to the validity of the findings, while it has been deemed unethical to expose participants to actual real life stressors or behaviour. However, it is unclear whether laboratory gambling tasks are realistic enough to create the same types of responses as gambling in pubs, clubs, or casinos. Early research conducted by Anderson and Brown (1984) revealed large differences in HR between casino and laboratory gambling situations in a group of experienced blackjack players. However, increased electrodermal activity has been evoked without the presence of the possibility of winning money, in response to imagined exposure to gambling stimuli (e.g., Sharpe, 2004). Moreover, laboratory studies into psychophysiological responses to gambling on gaming machines are supported by the findings of Diskin, Hodgins and Skitch (2003) who found no difference in mean skin conductance levels between participants in a laboratory and an in vivo gaming lounge setting. Diskin et al. (2003) found moderately strong correlations between gambling on a gaming machine in natural and laboratory settings for heart rate, electrodermal activity, and subjective ratings of arousal, however, they did observe mean HR and subjective arousal were higher in the lounge situation for all participants. Given that laboratory-based research from settings when money has not been wagered have yielded inconsistent HR findings (e.g., Diskin et al., 2003), the monitoring of multiple measures is warranted.

The present study could be viewed as a laboratory adaptation of the previous research into the effects of play characteristics on the autonomic arousal of individuals during gambling. It encompasses analogous ideas, in that it investigates the association between arousal and gambling activity, but looks specifically at differences in responses to wins and losses on an EGM.

An investigation into the association between cognitions and urges has largely been excluded from previous arousal research investigations. Not everyone who gambles excessively responds and thinks the same way, so investigating associations between the mind (cognitions) and body (arousal) across wins and losses is necessary to gain insight into the development, maintenance, and motivations for gambling behaviour (Moodie & Finnigan, 2005). The present study has the advantage over previous studies in that it utilises sophisticated technology that allows for instantaneous changes in autonomic arousal to be monitored and for trends in responses to wins and losses to be delineated across time.

The main aim of the present research was to examine the autonomic arousal in response to wins and loss events on a real (not computer simulated) EGM. It was hypothesised that psychophysiological measures would be sufficiently sensitive to capture differing patterns in responses to wins versus losses and more specifically, that compared to losses, wins would be associated with significantly higher levels of HR and greater SCL increases. It was also hypothesised that cognitions and subjective urges about gambling would be associated with psychophysiological responses to wins and losses during gambling on an EGM.

## **Method**

### *Participants*

Participants were drawn from introductory psychology classes in a university setting. Twelve university students (10 females; 2 males) responded to an intranet-based advertisement to complete the study for research participation credits. The mean age of participants was 20.4 years ( $SD = 4.0$ ). Participants were excluded from the study if they reported a heart condition. All participants reported that they were born in Australia and that English was their first language.

### *Design*

The study followed a 2 (win or lost events)  $\times$  4 (time intervals) repeated measures analysis of variance design. The two dependent measures were SCL and HR.

### *Materials*

*The EGM.* Participants used a real (not computer simulated) EGM named *Alchemy* supplied by Aristocrat Technologies Australia Ltd © 2003. The device is a one-cent EGM featuring a 5  $\times$  3 matrix, which allows players to bet between 1 and 20 credits across 1, 5, 10, 20 or 25 lines. Similar EGMs are currently in use in many clubs in Australia.

*Involvement in gambling behaviour.* The South Oaks Gambling Screen (Lesieur & Blume, 1987; see Appendix A) was used to assess behavioural indices related to excessive gambling behaviour. The SOGS is the most widely used instrument in both clinical and non-clinical populations and has good psychometric properties (Lesieur et al., 1991).

*Gambling cognitions.* The Informational Biases Scale (IBS) developed by Jefferson and Nicki (2003) measures cognitive distortions such the illusion of control and gambler's fallacy in gambling machines similar to the EGMs used in Australia. The IBS has 25 items and has adequate psychometric properties. For the Australian context, the term "fruit machine(s)" was replaced with "electronic gambling machine (EGM)".

*Gambling urges.* The Gambling Urges Scale (GUS; Raylu & Oei, 2004) has six items and is a state measure of the frequency and intensity of gambling urges as experienced by a participant. The measure was chosen for its good validity and reliability and has been used in non-clinical populations (Raylu & Oei, 2004).

*Psychophysiological measures of arousal.* Measures of skin conductance level (SCL) and heart rate were obtained from participants using the ambulatory monitoring system (AMS-3). The AMS-3 (Barry, Moroney, Orlebeke & De Vries (1991) is a sophisticated piece of equipment which has an excellent time resolution, having the capacity to sample physiological changes several times each second, including inter-beat intervals for HR. The AMS-3 device weighs 225g and has dimensions (120 x 65 x 32mm<sup>3</sup>), which allow for unobtrusive recording. Cardiac activity is measured by two electrodes: one placed on the left side of the participant between the ninth and tenth rib, and the other at midsternum. SCL (measured in micro-Siemens at one second intervals) was obtained with a constant voltage of 0.5V from two silver-silver chloride electrodes attached to the palmar surface of the middle phalanx of the second and third fingers of the non-dominant hand using electrode gel composed of sodium chloride in an inert viscous ointment base.

### *Procedure*

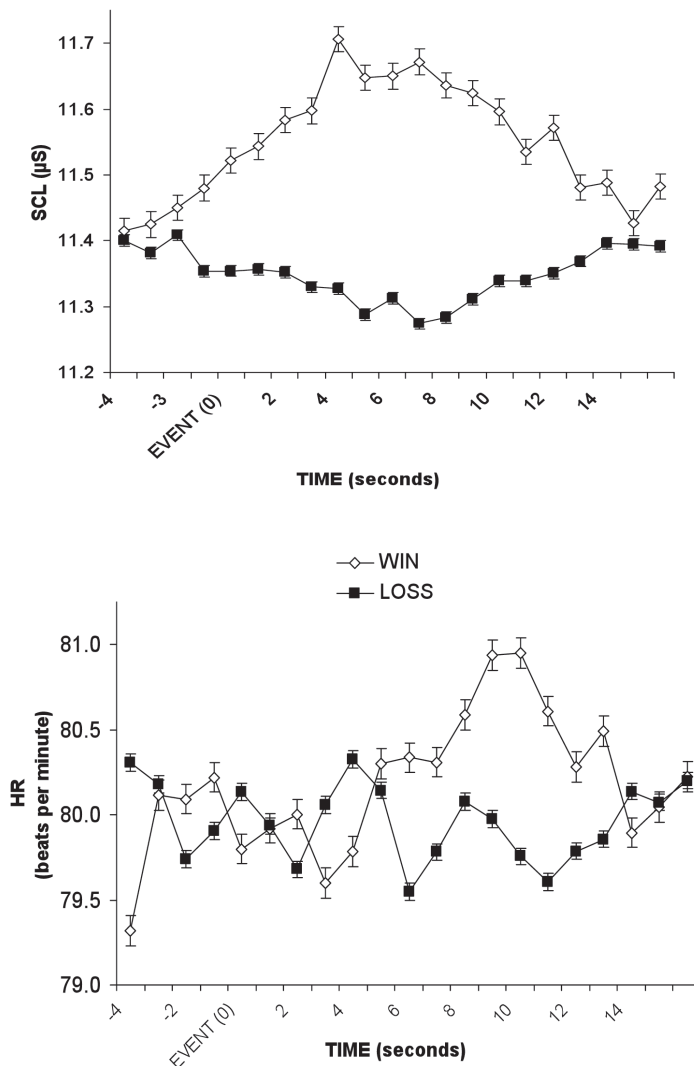
Approval for the research project (HE06/054) was granted by the Ethics Committee of the University of Wollongong and written informed consent was obtained from each participant before the study commenced. Experimental sessions were conducted individually in a university-based laboratory setting. Participants who were mostly inexperienced gamblers played on the EGM in three betting conditions (low stakes, high stakes, and free stakes). The low stakes condition restricted the amount of lines the participant could choose to play to 1, 5 and 10 lines, and the high stakes condition restricted choices to 20 or 25 lines. The betting conditions were counterbalanced; half the participants played in the low and then the high stakes conditions, while the remainder played in the high stakes condition first. The free stakes condition was always completed as the final schedule of testing. Participants had two-minute rest breaks between conditions. The free stakes condition mimicked in vivo EGM playing, but due to regulatory and ethical requirements, participants were prevented from gambling with their own money. The participant was free to vary bets from trial to trial, with bets ranging from 2 to 50 credits. Each participant was provided with 5,000 credits (\$50) at the beginning of the session and was informed that they would win an entertainment voucher (valued at \$11.70) if they had more than 7,000 credits (\$70) at the end of a 15-minute block. No participant ran out of credits during the course of the 15 minutes of play. Three participants in the free stakes condition had more than 7,000 credits at the completion of play and won an entertainment voucher. As in real life, participants were able to gamble or “double-up” their wins by predicting the colour or suit of the next card. Participants were given a demonstration to ensure they were completely familiar with their response requirements and the equipment before the experiment commenced.

A camera focused on the EGM's screen allowed the researcher to monitor trial-by-trial choices made by the participant. During their play, the experimenter seated in an adjoining section of the laboratory marked events with button presses on a computer keyboard. An event was marked as a “win” if the outcome of the bet resulted in an increase of credits (prominently displayed on the screen) and as a “loss” if no return was paid to the player. No participants reported smoking, alcohol and medication use in the two hours prior to physiological testing and consumption was not permitted throughout the testing procedure.

On completion of the gambling task participants were given the questionnaires (SOGS, IBS, and GUS) to complete. To preserve the anonymity of participants, all questionnaires were de-identified, coded by number and matched to the physiological data at a later date. At the completion of the laboratory session, participants were debriefed and offered contact numbers for problem gambling counselling services.

## Data Analysis and Results

A 20-second epoch for each win and loss, commencing 5 seconds before to 15 seconds following events, was captured and averaged. The averaging procedure that time-locks physiological



**Figure 1** Skin conductance levels (SCL; top panel) and heart rate activity (HR; bottom panel) pre and post win/loss events during EGM play. Error bars are the standard errors of the means.



changes to an event, is used routinely in event-related brain potential recording to neutralise effects of random physiological fluctuations. A similar procedure was employed here. The results are depicted in Figure 1. For the purposes of this study, therefore, only the data from the free stakes condition, which was always administered after the low and high stakes conditions, were analysed. This ensured all participants were familiar with their response requirements in this final block of testing.

For statistical analyses, the data were collapsed to four time intervals. Participants' HR and SCL were averaged across 5 to 2 seconds prior to the event (baseline; B) and three post-event periods (1 to 4 seconds post-event; PE1), 5 to 8 seconds (PE2), and 9 to 12 seconds (PE3). The physiological activity associated from 1 second (-1s) prior to the event and at the event's occurrence (time 0) was excluded to compensate for the latency delays associated with the sluggish skin conductance responses (skin conductance responses have a latency between 1 and 3 seconds) and the reaction time of the researcher to mark the events (approximately 1 second).

*Psychophysiological responses to EGM play.* Two event types (win/loss)  $\times$  4 Time (B, PE1, PE2, PE3) repeated measures ANOVA were computed separately for the electrodermal and cardiac data. To determine differences relative to baseline, planned contrasts between the baseline (B) and post-event segments (PE1, PE2 and PE3) were also conducted. Because the hypotheses were specific contrasts, not all possible comparisons were relevant and examined. As the planned contrasts met the degrees of freedom for effect criteria, no Bonferroni-type adjustments for probability levels ( $\alpha$  levels) were required (Tabachnick & Fidell, 1989). Also, because all contrasts were based on a single degree of freedom, no corrections for sphericity violations that may affect repeated measures ANOVAs were required (Tabachnick & Fidell, 1989). Mean and standard deviations for win and loss events during these time segments are presented in Table 1.

**Table 1** Means (M) and standard deviations (SD) for skin conductance levels ( $\mu$ S) and heart rate (beats per minute) at baseline (B) and post-event times (PE1, PE2 and PE3) for win and loss events.

Skin conductance levels								
	B		PE1		PE2		PE3	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)
<b>Wins</b>	11.44	(4.68)	11.63	(4.77)	11.65	(4.80)	11.55	(4.74)
<b>Losses</b>	11.39	(4.66)	11.32	(4.65)	11.30	(4.61)	11.35	(4.61)

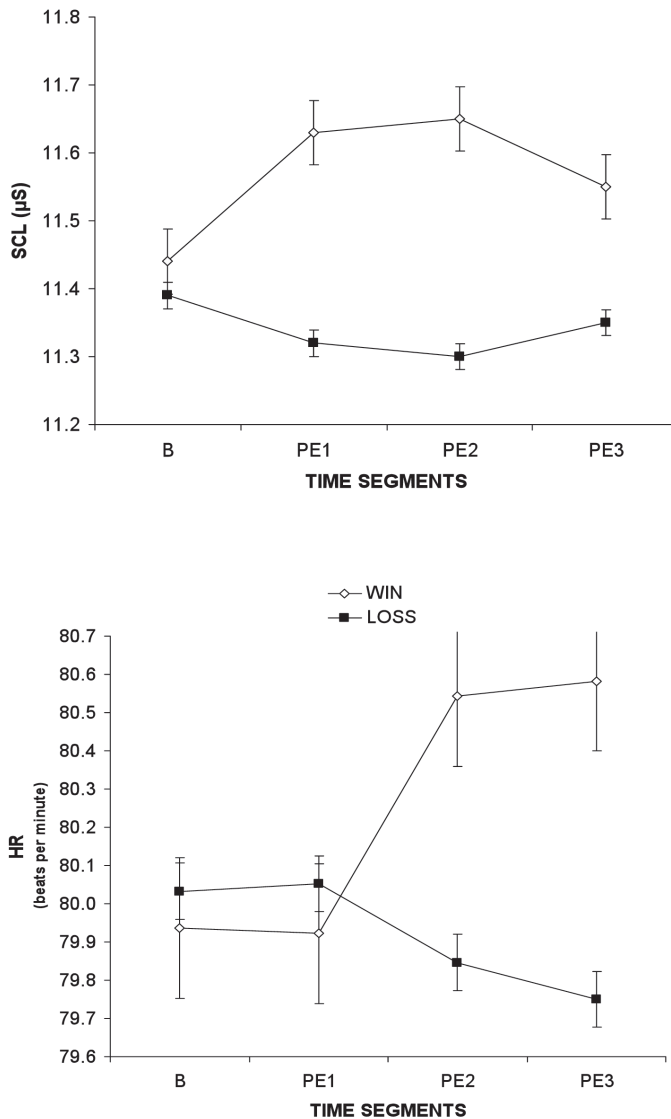
  

Heart rate								
	B		PE1		PE2		PE3	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)
<b>Wins</b>	79.94	(11.82)	79.02	(12.04)	80.54	(10.72)	80.58	(11.18)
<b>Losses</b>	80.03	(11.55)	80.05	(11.37)	79.85	(11.57)	75.79	(11.79)

The data for the four time points are presented in Figure 2. For SCL, the effect for Event was significant,  $F(1, 11) = 9.29, p < .05, \eta_p^2 = .46$ ; demonstrating larger amplitudes for wins ( $M = 11.57, SD = 4.60$ ) than losses ( $M = 11.34, SD = 4.48$ ). Across events, the three contrasts for Time (B vs. PE1, B vs. PE2, and B vs. PE3) were not significant. However, Event  $\times$  Time interactions were

significant: for B vs. PE1,  $F(1,11) = 6.63$ ,  $p < .05$ ,  $\eta_p^2 = .38$ ; and for B vs. PE2,  $F(1,11) = 5.14$ ,  $p < .05$ ,  $\eta_p^2 = .32$ . The B vs. PE3 contrast was not significant. Overall, the results indicate that win events produced significant elevations of SCL whereas losses did not. The pattern of increased SCL applied at PE1 and PE2 (1–8 seconds post-event), but SCL dropped at PE3 (9–12 seconds post-event) yielding levels comparable to baseline,  $F(1,11) = 2.56$ ,  $p > .05$ . This pattern of results is observable in Figure 2.

None of the main or interaction effects were significant for the HR data.



**Figure 2** Skin conductance levels (SCL; top panel) and heart rate activity (HR; bottom panel) at baseline (B) and post event times (PE1, PE2 and PE3) for win/loss events during EGM play. Error bars are the standard errors of the means.

*Relationship between physiological measures.* Baseline levels for HR and SCL were not correlated. This finding applied to results when data for event types were averaged together,  $r(12) = .33$ ,  $p = 0.30$ , and when wins and losses were considered separately: for wins,  $r(12) = .33$ ,  $p = .30$ ; for losses,  $r(12) = .33$ ,  $p = .29$ . To investigate relationships between changes on the physiological measures, PE1 was chosen to best represent the period in which arousal would have changed as a result of the events marked. Time segments PE2 and PE3 are likely to have been compromised by arousal changes prompted by subsequent win or loss events, which can occur within four to five seconds (Dowling, Smith & Thomas, 2005), and were therefore not correlated. The correlations between the SCL and HR changes (B to PE1) were also not significant. This finding applied when win and loss events were averaged together,  $r(12) = .45$ ,  $p = .15$ , and when wins and losses were considered separately: for wins,  $r(12) = .45$ ,  $p = .15$ ; for losses,  $r(12) = .46$ ,  $p = .14$ .

*Relationship between autonomic arousal and self-report measures.* Participants had a mean SOGS score of 0.5 ( $SD = 0.80$ , range: 0–2), suggesting that all members of the group were likely to be non-problem gamblers. As the range of scores was restricted, this variable was not analysed further. To conduct a preliminary investigation of relationships between physiological reactivity to gambling with gambling related cognitions and urges, scores on the other self-report measures were correlated with the difference between time baseline (B) and post (PE1). PE1 was again chosen as the best time segment in which physiological changes would be representative of the event marked, without the possible contamination from following events. The results indicate that: (i) the correlation between cognitive distortion scores and increased responses to win events approached significance  $r(12) = .55$ ,  $p = .06$ ; (ii) changes in electrodermal activity following wins were positively related to scores on gambling urges  $r(12) = .68$ ,  $p < .05$ ; and, (iii) there was no significant relationship between SCRs following loss events and cognitions associated with gambling  $r(12) = -.08$ ,  $p = 0.81$ , or between SCRs following loss events and gambling urges  $r(12) = .32$ ,  $p = .31$ . There were no significant relationships between HR and the self-report measures for participants.

## Discussion

The data generated by this pilot laboratory study contributes significantly to the available literature on autonomic psychophysiology during gambling activity. The study utilised state-of-the-art technology, which for the first time allowed recording of a combination of psychophysiological responses to EGM play to be captured on a second- by-second basis. The results indicate that in a healthy control population, wins evoke a significant increase in electrodermal activity, while losses evoke a marginal decrease in arousal levels (Figure 1). Despite not wagering their own money, SCL was shown to be a robust and sensitive measure of change associated with event types experienced on an EGM in a laboratory setting. In real life situations when the participant's money is wagered these responses are likely to be amplified and the responses may last even longer.

Physiological models of gambling (e.g., addiction models) include tolerance as an aspect of gambling behaviour (Griffiths, 1993b). It is worth investigating whether arousal levels dissipate faster in problem gamblers than shown here in healthy controls. With regular gamblers becoming more tolerant to arousal elicited by gaming machines (Griffiths, 1993b), they would need to play longer and/or bet larger amounts to achieve similar arousal levels. It would therefore be beneficial

to replicate this study with a clinical sample, because a differing pattern of arousal could be a significant contributing factor to the maintenance of gambling behaviour by these individuals.

With regard to HR, the present laboratory study revealed a trend towards higher HR to wins as compared to losses (Figure 2). However, the difference was not statistically significant. These findings are consistent with HR results from laboratory-based studies (Anderson & Brown, 1984; Diskin et al., 2003). It is possible that the small sample compromised statistical power. Alternatively, HR may be less sensitive to subtle changes that occur when gambling occurs in the laboratory but may capture larger changes when gambling occurs in the field (e.g., Moodie & Finnigan, 2005).

The differential results observed for HR and SCL in this study may be associated with factors related to the nature of arousal mechanisms. Some authors argue that electrodermal activity may be a more reliable measure of arousal and that, at least in certain circumstances, HR may not reflect arousal changes (Barry & Sokolov, 1993; Croft, Gonsalvez, Gander, Lechem & Barry, 2004). The continued utilisation of devices and methodologies which allow for simultaneous, continuous, objective measurement of electrodermal activity is strongly supported by the current data.

Exploratory analyses were conducted on the data obtained to investigate the relationships between the physiological measures obtained and also their relationships with the self-report data. Higher gambling urges were associated with greater increases in arousal following wins, albeit on a small sample. Sharpe (2002) identified that gambling urges are a mind-body interaction, and are seen as physical, psychological, or emotional motivational states that involve desire to gamble. Although this relationship may be interpreted as being consistent with conceptualisations of gambling behaviour (e.g., Sharpe, 2002), the sample of the current study was restricted to non-problem gamblers. Hence larger studies will be needed to determine whether these conclusions are corroborated and apply to the clinical population.

This experiment also investigated associations between changes in electrodermal and cardiac activity in response to events in a gambling activity and cognitions related to gambling. An inspection of the data related to win events revealed mean differences in the expected direction, although not reaching statistical significance. The small sample and the low level of gambling-related cognitive distortions endorsed by the non-clinical sample in the current study may have contributed to this negative finding. Future research with larger numbers that include clinical and non-clinical samples appear justified.

The study revealed significantly greater electrodermal activity following wins than losses, though it remains unclear whether these small differences (approximately 0.3  $\mu$ S) are perceptible or of clinical significance. The magnitudes of these phasic electrodermal responses to wins, however, were similar in latency to target stimuli in continuous performance tasks in healthy adults (e.g., Barry & Sokolov, 1993; Vaez-Mousavi, Barry, Rushby & Clarke, 2007). The results therefore suggest that during gambling on EGMs, non-problem gamblers exhibit subtle electrodermal changes, which may be triggered by target stimuli with inherent meaning (i.e., wins which deliver monetary gain) and not losses.

The effects of the sound and visual stimuli associated with wins and losses were not controlled for by this study as a commercially available EGM was used, and it was intended to mimic real play conditions. Investigations that manipulate these characteristics for both win and loss events, could identify whether the arousal evoked by wins is, in fact, a function of the presence of the “bells and whistles” produced by EGMs following wins or because of value and attention for monetary gain.

Although the findings indicate a persistence of arousal to wins across time, it is observed that the arousal created by following events may have contaminated the epoch of interest. The current study employed the averaging procedure to reduce the effect of these contaminating events. Because these events are likely to affect both wins and losses and occur at various points during the post-event epoch, the effects are likely to be averaged out. Similar averaging procedures are employed routinely in electroencephalography (EEG) and event-related potential experiments to enhance signal-to-noise ratios (Picton et al., 2000). The results suggest that the averaging method produced the desired results, with the time-locked waveforms that were derived (Figure 1) suggesting both reliable and meaningful effects. Nevertheless, a replication of these data and procedures is warranted.

The experimenter was also required to press win versus loss buttons to code the events, resulting in an inaccuracy with regard to identifying the exact occurrence of the win/loss. However, this is a minor issue given that the researcher's response time may be expected to affect timing of both wins and losses in a relatively uniform way. As response time variations are in the order of milliseconds, this inaccuracy is unlikely to affect the direction and pattern of the results obtained. Nevertheless, the researcher's response time could be monitored and event times corrected to ensure accurate tagging of events.

Finally, it should be acknowledged that the participants in this pilot study were university students who were mostly inexperienced players of EGMs. Differences between psychophysiological responses of problem versus low frequency or novice gamblers when playing an EGM were not examinable by the study and remain a further field of inquiry. Future studies should endeavour to sample a more heterogeneous population, of a wider age range, education level and income. Additional projects are currently ongoing to address some of the limitations mentioned above and to confirm, clarify and extend these findings by studying non-problem and problem gamblers in both field and laboratory settings.

### *Summary*

The current pilot study used state-of-the art psychophysiological equipment to monitor, on a second-by-second basis, physiological responses to win and loss events. SCL and HR activity were recorded continually while 12 university students gambled on an EGM in a laboratory setting. The main contribution of the study is to demonstrate that SCL, but not HR, was sufficiently sensitive to physiological changes associated with win events during gambling on an EGM. Loss events produced no observable changes. In terms of the time course, SCL increased immediately after wins, reached a peak 4 to 8 seconds after the event and returned to approximate baseline levels after about 15 seconds. No significant changes in electrodermal activity were observed to losses.

The findings demonstrate that rapid changes occurring in real time can be captured by current technology. The finding that responses to wins persist for a prolonged period post event also suggests that the physiological reinforcers in EGM play occur and are maintained even in the absence of monetary reinforcers. An association between gambling urges and cognitions on the one hand and increased SCL to wins on the other were also observed. The study has applications for future research and paves the way for similar procedures to be used in real life gambling contexts. Although differences in the pattern of responses to wins and losses have been demonstrated, similar studies in natural field settings, using clinical populations would likely provide greater insight into the development and maintenance of problem gambling or potential risk factors.

## References

- Anderson, G., & Brown, R. I. F. (1984). Real and laboratory gambling, sensation seeking and arousal. *British Journal of Psychology*, *75*, 401–410.
- Barry, R. J., Moroney, R., Orlebeke, J. F., & De Vries, J. (1991). A research orientated portable heart rate and galvanic skin response monitor. *International Journal of Psychophysiology*, *11*, 161–165.
- Barry, R. J., & Sokolov, E. N. (1993). Habituation of phasic and tonic components of the orienting reflex. *International Journal of Psychophysiology*, *15*, 39–42.
- Blanchard, E. B., Wulfert, E., Freidenberg, B. M., & Malta, L. S. (2000). Psychophysiological assessment of compulsive gamblers' arousal to gambling cues: A pilot study. *Applied Psychophysiology and Biofeedback*, *25*(3), 155–165.
- Blaszczynski, A., Sharpe, L., & Walker, M. (2001). *The Assessment of the Impact of the Reconfiguration on Electronic Gaming Machines as Harm Minimisation Strategies for Problem Gambling*. Report for the Gaming Industry Operators Group. Retrieved 21 November, 2007. Available from [http://www.psych.usyd.edu.au/gambling/GIO\\_report.pdf](http://www.psych.usyd.edu.au/gambling/GIO_report.pdf)
- Cocco, N., Sharpe, L., & Blaszczynski, A. P. (1995). Differences in preferred level of arousal in two subgroups of problem gamblers: A preliminary report. *Journal of Gambling Studies*, *11*(2), 221–229.
- Coulombe, A., Ladouceur, R., Desharnais, R., & Jobin, J. (1992). Erroneous perceptions and arousal among regular and occasional video poker players. *Journal of Gambling Studies*, *8*(3), 235–244.
- Coventry, K. R., & Constable, B. (1999). Physiological arousal and sensation-seeking in female fruit machine gamblers. *Addiction*, *94*, 425–430.
- Coventry, K. R., & Norman, A. C. (1997). Arousal, sensation-seeking and frequency of gambling in off-course horse racing. *British Journal of Psychology*, *88*, 671–681.
- Coventry, K. R., & Norman, A. C. (1998) Arousal, erroneous verbalisations and the illusion of control during a computer-generated gambling task. *British Journal of Psychology*, *89*, 629–634.
- Croft, R. J., Gonsalvez, C. J., Gander, J., Lechem, L., & Barry, R. J. (2004). Differential relations between heart rate and skin conductance, and public speaking anxiety. *Journal of Behaviour Therapy and Experimental Psychiatry*, *35*, 259–271.
- Custer, R. L. (1984). Profile of the pathological gambler. *Journal of Clinical Psychology*, *45*, 35–38.
- Dickerson, M. G. (1993). Internal and external determinants of persistent gambling: Problems in generalising from one form of gambling to another. *Journal of Gambling Studies*, *9*, 225–245.
- Dickerson, M. G. (2003). Exploring the limits of “responsible gambling”: Harm minimisation or consumer protection? *Gambling Research*, *15*, 29–44.
- Dickerson, M. G., Haw, J., & Shepherd, L. (2003). The psychological causes of problem gambling: A longitudinal study of at risk recreational EGM players. Unpublished manuscript, University of Western Sydney, Sydney.
- Dickerson, M.G., Hinchy, J., England, S.L., Fabre, J., & Cunningham, R. (1992). On the determinants of persistent gambling behaviour. I. High-frequency poker machine players. *British Journal of Psychology*, *83*, 237–248.
- Diskin, K. M., Hodgins, D. C., & Skitch, S. A. (2003). Psychophysiological and subjective responses of a community sample of video lottery gamblers in gambling venues and laboratory situations. *International Gambling Studies*, *3*(2), 133–148.
- Dowling, N., Smith, D., & Thomas, T. (2005). Electronic gaming machines: Are they the “crack-cocaine” of gambling? *Addiction*, *1*, 33–45.
- Gibson, B., Sanbonmatsu, D. M., & Posavac, S. S. (1997). The effects of selective hypothesis testing on gambling. *Journal of Experimental Psychology: Applied*, *3*(2), 126–142.
- Gilovich, T. (1983). Biased evaluation and persistence in gambling. *Journal of Personality and Social Psychology*, *44*(6), 1110–1126.
- Gilovich, T. (1986). Biased evaluations of randomly determined gambling outcomes. *Journal of Experimental Social Psychology*, *22*, 228–241.

- Goudriaan, A. E., Oosterlaan, J., de Beurs, E., & Van den Brink, W. (2004). Pathological gambling: A comprehensive review of biobehavioural findings. *Neuroscience and Biobehavioural Review*, 28(2), 123–141.
- Griffiths, M. D. (1993a). Fruit machine gambling: The importance of structural characteristics. *Journal of Gambling Studies*, 9, 101–120.
- Griffiths, M. D. (1993b). Tolerance in gambling: An objective measure using the psychophysiological analysis of male fruit machine gamblers. *Addictive Behaviours*, 18, 365–372.
- Jefferson, S., & Nicki, R. (2003). A new instrument to measure cognitive distortions in video lottery terminal users: The Informational Biases Scale (IBS). *Journal of Gambling Studies*, 19(4), 387–403.
- Ladouceur, R., Sevigny, S., Blaszczynski, A., O'Connor, K., & Lavoie, M. E. (2003). Video lottery: Winning expectancies and arousal. *Addiction*, 98, 733–738.
- Lesieur H. R., Cross J., Frank M., Welch M., White C. M., Rubenstein G., Moseley K., & Mark, M. (1991). Gambling and pathological gambling among university students. *Addictive Behaviors*, 16, 517–527.
- Lesieur, H. & Blume, S. B. (1987). The South Oaks Gambling Screen (SOGS): A new instrument for the identification of pathological gamblers. *American Journal of Psychiatry*, 144, 1184–1188.
- McConaghy, N., Blaszczynski, A., & Frankova, A. (1991). Comparison of imaginal desensitisation with other behavioural treatments of pathological gambling. A two to nine year follow up. *British Journal of Psychiatry*, 159, 390–393.
- Moodie, C., & Finnigan, F. (2005). A comparison of the autonomic arousal of frequent, infrequent and non-gamblers while playing fruit machines. *Addiction*, 100, 51–59.
- Picton, T.W., van Roon, P., Armilio, M.L., Berg, P., Ille, N., & Scherg, M. (2000). The correction of ocular artifacts: A topographic perspective. *Clinical Neurophysiology*, 111, 53–65.
- Productivity Commission (1999). *Australia's Gambling Industries*. Report no. 10. Canberra, Australia: AusInfo.
- Raylu, N., & Oei, T. P. S. (2004). The Gambling Urge Scale: Development, confirmatory factor validation and psychometric properties. *Psychological Addiction and Behavior*, 18(2), 100–105.
- Schellinck, T., & Schrans, T. (2002). *Video Lottery Responsible Gaming Feature Research, Final Report*. Atlantic Lottery Corporation.
- Sharpe, L. (2002). A reformulated cognitive-behavioural model of problem gambling: A biopsychological perspective. *Clinical Psychology Review*, 22, 1–25.
- Sharpe, L. (2004). Patterns of autonomic arousal in imaginal situations of winning and losing in problem gambling. *Journal of Gambling Studies*, 20(1), 95–104.
- Sharpe, L. & Tarrier, N. (1993). Towards a cognitive-behavioural theory of problem gambling. *British Journal of Psychiatry*, 162, 407–412.
- Tabachnick, B. G., & Fidell, L. S. (1989). *Using multivariate statistics* (2<sup>nd</sup> ed.). New York: Harper & Row.
- VaezMousavi, S. M., Barry, R. J., Rushby, J. A., & Clarke, A. R. (2007). Evidence for differentiation of arousal and activation in normal adults. *Acta Neurobiologiae Experimentalis*, 67, 179–182.
- Walker, M. (2004). The seductiveness of poker machines. *Proceedings of the 13th National Association for Gambling Studies Conference*, Canberra, Australia pp. 12–27. Melbourne: National Association for Gambling Studies. Retrieved 10 November 2007. Available from <http://www.nags.org.au>
- Wulfert, E., Roland, B. D., Hartley, J., Wang, N., & Franco, C. (2005). Heart rate arousal and excitement in gambling: Winners versus losers. *Psychology of Addictive Behaviors*, 19(3), 311–316.

## Acknowledgements

The researchers would like to thank Aristocrat Leisure Limited who loaned to the University of Wollongong a commercially available, electronic gaming machine for use in this research project.