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Gambling on electronic machines: psychophysiological differences between 'wins' and 'losses'

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Declaration

In signing this document I declare that this thesis has been entirely my own work and has not been submitted for the purpose of a degree to any other university or institution. The theoretical and research literature discussed has been referred to in the reference section of this thesis.

Benjamin L. Wilkes, 12\textsuperscript{th} December 2009
Abstract

Electronic gambling machines (EGMs) are associated with the highest prevalence rates of problem gambling. The role of arousal in reinforcing gambling activity has been recognised for a long time. It is possible that the many event-types (losses, near-misses, wins, and large wins) generated by EGMs create a psychophysiological roller-coaster that is captivating and possibly addictive for some individuals. However, physiological changes associated with win and loss events on EGMs have not been investigated in a systematic manner.

This area of research is important for several reasons. Converging evidence from several domains indicates that biological factors, especially arousal mechanisms are likely to have an important role to play in the development and maintenance of problem gambling. It is possible that objectively measured physiological characteristics may allow for discrimination between problem and non-problem gamblers. This information may aid early detection of problem gambling and the assessment of treatment progression.

The current program of research was designed to systematically examine the nature and significance of psychophysiological responses to wins and losses on EGMs as they occurred in real time. Study A investigated 12 non-problem gamblers in a laboratory environment and successfully trialled contemporary psychophysiological equipment and methodologies. This study showed that psychophysiological measures [skin conductance level (SCL) and heart rate (HR)] could be captured on a second-by-second basis and that SCL could reliably differentiate between win and loss events on an EGM. Study B replicated and extended the findings of Study A. Losses, wins, fake-wins (where a return is paid, but is less than that has been wagered), and large wins were examined among 24 non-problem gamblers under high- and low-stake conditions.
The results demonstrated significant increases from baseline for SCL, but not HR, following wins but not losses. Study B also revealed that increases in SCL were moderated by the amount won and wagered. Study C was a field study and extended the laboratory findings by monitoring HR and SCL of 6 problem and 6 non-problem gamblers as they experienced wins and losses on EGMs in a licensed club. Both HR and SCL increased relative to baseline in non-problem gamblers following wins but not following losses. More importantly, problem gamblers exhibited significantly fewer changes in HR and SCL to wins during gambling sessions, relative to non-problem gamblers.

Clinical tools based on psychophysiological responses to rewards (wins) may help differentiate between those who develop problem gambling and those who do not, and needs to be further investigated.
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<td>µS</td>
<td>microSiemens</td>
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<tr>
<td>APA</td>
<td>American Psychiatric Association</td>
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<td>AMS</td>
<td>Ambulatory Monitoring System</td>
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<td>ANS</td>
<td>Autonomic Nervous System</td>
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<td>BP</td>
<td>Blood Pressure</td>
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<td>CPGI</td>
<td>Canadian Problem Gambling Index</td>
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<td>DASS-21</td>
<td>Depression Anxiety Stress Scales – short version</td>
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<td>EGM(s)</td>
<td>Electronic Gambling Machine(s)</td>
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<td>EMG</td>
<td>Electromyogram</td>
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<tr>
<td>fMRI</td>
<td>functional Magnetic Resonance Imaging</td>
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<td>GUS</td>
<td>Gambling Urges Scale</td>
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<td>HR</td>
<td>Heart Rate</td>
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<td>I-7</td>
<td>Impulsivity sub-scale</td>
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<td>IGT</td>
<td>Iowa Gambling Task</td>
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<td>IBS</td>
<td>Informational Biases Scale</td>
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<tr>
<td>M</td>
<td>Mean</td>
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<td>MSUGG</td>
<td>Mississippi State University Gambling Group</td>
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<td>Non-PGs</td>
<td>Non-Problem Gamblers</td>
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<td>PG</td>
<td>Problem Gambling</td>
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<td>PGs</td>
<td>Problem Gamblers</td>
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<tr>
<td>SCL</td>
<td>Skin Conductance Level</td>
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<td>Skin Conductance Responses</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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Thesis overview and organisation

While most people have gambled at some point in their life, for some gambling becomes a problematic set of behaviours associated with adverse psychosocial consequences. Problem gambling is a significant physical and mental health issue. It is not only associated with significant financial consequences and loss of time, but also an increased risk of suicide, suffering from mood disorders, and/or abuse of alcohol, nicotine or other drugs (Potenza, Fiellin, Heninger, Rounsaville & Mazure, 2002). From a broader perspective, problem gambling has a negative impact (e.g. crime, financial/relationship distress) on family, friends and the greater community.

Given the potential for large numbers of people to be directly affected by problem gambling, early detection and intervention appears warranted. Several attempts to do this using personality and cognitive measures have not yielded satisfactory results. However, psychophysiological changes have not been investigated in a comprehensive or systematic manner.

One explanation of problem gambling gaining empirical support suggests that rather than money, the reward during gambling is the arousal or “high” produced as a result of participation (Anderson & Brown, 1984). This thesis aims to use state-of-the-art psychophysiological equipment to trace changes in physiological activity on a second-by-second basis during gambling. In particular, a focus is given to changes in physiology (arousal) generated by wins and losses during gambling on electronic machines. This will help determine whether changes in arousal during gambling are generated by the possibility or the actuality of winning. Moreover, it is hoped that an analysis of arousal in response to within session characteristics, such as the amount wagered and won, will help explain differences in gambling behaviour between problem
and non-problem gamblers. This thesis also endeavours to compare psychophysiological profiles of problem and non-problem gamblers in response to wins and losses during gambling on electronic machines. This focus is crucial as it may allow for discrimination between the groups based upon objectively measured physiological characteristics. This information may aid early detection of problem gambling and/or the assessment of treatment progression.

The thesis is organised into seven chapters. Chapters 1, 2, and 3 provide background literature related to gambling, problem gambling, neurobiological and autonomic arousal. The aims of this thesis were addressed by conducting a three-stage program of research. The findings of these three studies are presented in Chapters 4, 5, and 6. Chapter 7 provides an integrated discussion of the results of the research program.

Chapter 1 reviews the literature that identifies electronic gambling machines (‘the pokies’) as the preferred form of gambling for most problem gamblers. The review shows that recent research on both personality and cognitive factors has shown some ability to distinguish problem gamblers from other groups. Although these explanations are seen to provide some promising insights, there is converging evidence that biological factors, especially arousal mechanisms, are likely to have an important role in the development and maintenance of problem gambling. In particular, the arousal or “highs” generated from gambling are considered as potential major reinforcers for participation. It is concluded that an examination of the physiological experience of gambling on electronic machines requires further attention.

Chapter 2 presents a review of neurobiological findings. The neurobiological findings reviewed support suggestions that it is important for research to focus on both tonic arousal changes obtained over long periods of gambling and phasic arousal
responses, which are related to events or stimuli experienced within sessions of gambling.

Chapter 3 provides a review of the literature related to autonomic arousal in response to gambling and winning. In general, gambling has been associated with increases in autonomic arousal. However, researchers have yet to determine what promotes physiological activity, gambling in general or outcomes within gambling sessions (i.e. wins and losses). The distinction is important, as if gambling is inherently arousing to some individuals, desired arousal states may be generated by the possibility rather than the actuality of winning. This may explain why some individuals (problem gamblers) can persist with gambling despite repeated significant monetary losses.

Chapter 3 also outlines several methodological factors, which may have hindered past research into the effects of winning on research. Firstly, most previous research is disadvantaged by a lack of methodological sophistication. Specifically, the ongoing recordings of physiological changes have not been punctuated by a systematic and parallel recording of event-markers (such as wins and losses). Hence, previous research often resorted to computing averages derived following periods of gambling. A key limitation of such measurement is that it does not enable the scrutiny of physiological changes time-locked to win and loss events. Additional limitations associated with averages computed over time segments involving several minutes is that factors, such as physical movement; the context or sequence of wins experienced; or those related to the use of chemical substances prior to or during the gambling session may confound recordings. Hence, physiological data averaged over gambling sessions have not determined how gamblers respond to wins and losses within the gambling session.
A second factor that may have reduced the sensitivity of past findings to the effects of wins and losses on arousal during gambling is the choice of physiological measures used. Physiological changes in response to gambling and winning have most commonly been investigated by monitoring cardiac reactivity (measured by changes in heart rate). A review of the literature indicates that electrodermal activity (as measured by changes in skin conductance) may be a more sensitive and reliable measure of autonomic arousal during gambling. The neglect of research on electrodermal measures appears unjustified.

Chapters 4, 5 and 6 present a program of research that was designed to capture psychophysiological profiles in response to win and loss events during gambling on electronic machines. Three empirical studies were completed. Each of the three experiments utilised state-of-the-art psychophysiological equipment to monitor, on a second-by-second basis, both electrodermal activity and cardiac reactivity of individuals in response to gambling on electronic machines. The first two studies involved the use of a commercially available electronic gambling machine, but were laboratory based. Laboratory studies were chosen as they would allow for a trial of the physiological monitoring equipment in a more controlled setting. The laboratory environment also enabled the researchers to reduce the impact of confounds related to the effects of alcohol, physical movement, or external visual and auditory stimuli, such as that elicited by other machines or other gamblers. Recruitment of large numbers of participants in field studies can be hampered by a lack of cooperation from licensed gambling venues. Moreover, ethical and legal requirements state that participants cannot be encouraged to gamble with their own money for the purposes of research.

Study A (Chapter 4) was a pilot laboratory investigation that monitored heart rate and skin conductance levels in non-problem gamblers (n = 12). It was hypothesised
that wins would be associated with patterns of greater arousal than losses. Compared to losses, significantly increased electrodermal activity was found to immediately follow wins and last for approximately eight seconds. Heart rate showed a similar pattern of increases post wins, although changes were marginal and did not reach significance. Importantly, Study A showed that physiological activity to win and loss events on an EGM can be reliably measured, and that rapid changes occurring in real time (seconds) can be captured by current technology.

Following the promising results of the pilot study, it was decided that it was important to replicate and extend these findings. Study B (Chapter 5) was designed to measure physiological responses to wins and losses, but also the effects of the amounts won and wagered on autonomic arousal. As no changes in heart rate were evident in the pilot study, a larger sample was recruited (n = 24) to increase the power of the statistical analysis. Study B monitored the heart rate and skin conductance levels of non problem gamblers as they were exposed to four event types, namely, losses, fake wins, and big wins. Fake wins, are event outcomes on electronic machines in which the player is awarded a return (above zero credits), but less than what has been wagered, whereas loss events occur when a player receives no credits in return. For example, if an individual bets 20 credits and receives 10 credits in return it is considered a fake win as the machine delivers additional sound and/or visual stimuli, and a portion of the amount wagered, but the individual is actually losing money. Relative to baseline levels, win events in Study B were once again found to produce significant increases in skin conductance levels, whereas loss-events produced no changes. Additionally, the general pattern of results suggested a progressive increase in electrodermal responses based upon the amount won and the amount wagered. The findings of Study B emphasised that arousal achieved during gambling on electronic machines is likely to be moderated
not only by winning, but also by factors controlled by the player, such as the amount staked on each outcome. Again, no significant changes in heart rate were found in response to events during gambling on electronic machines in the laboratory setting. This supported arguments that electrodermal activity may be more sensitive to changes in arousal related to event outcomes when gambling.

The laboratory investigations demonstrated two important outcomes: a) current ambulatory technology could reliably capture physiological changes to win and loss events on EGMs, and b) that healthy controls, responded physiologically more to wins than losses. It was therefore deemed important to transfer the physiological recording methods from the laboratory to a natural field environment.

Study C (Chapter 6) was an investigation of the effects of wins and losses on autonomic arousal during gambling on electronic machines in a club setting. Participants’ (n = 12) heart rate and skin conductance levels were monitored in response to wins and losses during gambling on electronic machines. Both heart rate and skin conductance levels were demonstrated to significantly increase to wins, compared to losses. However, a comparison of the physiological responses of non-problem (n = 6) and problem (n = 6) gamblers demonstrated that problem gamblers exhibited reduced responses to wins compared to non-problem gamblers. Moreover, problem gamblers were found to respond similarly to wins and losses. This finding suggests that problem gamblers may be less responsive to rewards.

Chapter 7 integrates and critiques reported explanations for problem gambling in light of the current findings. In particular, reduced physiological responses to wins may discriminate problem from non-problem gamblers. Further research to determine if these physiological changes can help identify persons at risk of developing problem gambling is supported.
Chapter 1 – Gambling as psychological phenomenon

1.1 – Overview
Chapter 1 introduces the concepts of gambling and problem gambling. Gambling behaviour has the potential to cause significant adverse psychosocial consequences. Research literature that identifies and distinguishes those people suffering harm as a result of problem gambling is reviewed. In the Australian context, electronic gambling machines (EGMs) are highlighted as a primary area of clinical interest. A literature review related to why individuals gamble in general is presented, followed by psychological explanations as to how problem gambling develops and is maintained. Although promising evidence supports the role of psychological factors, it is concluded that the investigation of physiological factors, particularly arousal in response to gambling, is likely to provide complimentary knowledge to the area.

1.2 – Gambling
Gambling is defined as any activity involving an agreement between at least two parties, to exchange an item of value (not necessarily money) on the basis of the result of an uncertain event, and where participation is voluntary (Blaszczynski, Walker, Sagris & Dickerson, 1997). Key to definitions of gambling is that uncertainty (chance) is inevitably involved (Delfabbro & LeCouteur, 2005). Without this distinction, any financial exchange could be considered a form of gambling. Although many investments may be influenced by uncontrollable or unpredictable factors that make them appear to be forms of gambling, chance is not an inevitable feature of these activities (Delfabbro & LeCouteur, 2005). Common forms of gambling that meet the above definition are lotteries, scratch tickets (instant lotteries), EGMs, race betting
(greyhounds, thoroughbred and harness), sports betting, Keno, casino games, internet gambling and Bingo (Productivity Commission, 1999).

Winter (2002) reported that organised gambling in Australia dates back to the first organised race meet in New South Wales in 1809-10 and since then has become an ever-increasing cultural tradition. As a pastime, gambling is uniquely placed, with data suggesting that up to 90 percent of Australian adults gamble at least once per year, and almost every individual has done so at some point in their lives (Dickerson et al., 1996). Moreover, 40 percent of adult Australians are reported to gamble at least once per week (Productivity Commission, 1999). Participation rates in forms of gambling, however, vary considerably. Lottery gambling is the most popular activity with approximately 60 percent of the adult population participating each year, two thirds of whom reporting that they gamble on lotteries at least once per week (Productivity Commission, 1999).

Although lotteries have most participants, gambling expenditure is highest for ‘continuous’ gambling activities (EGMs, race betting or casino games), which offer repeated wagers over short periods of time. One in five Australians is reported to gamble weekly on at least one of these forms of gambling (Abbott & Volberg, 2000). EGMs generate most revenue; accounting for 60 percent ($10.1 billion) of Australia’s gambling expenditure (Office of Economic and Statistical Research, 2006; Productivity Commission, 1999).

1.2.1 – EGMs

The term EGMs has been used for several years to identify mechanical devices designed to offer gambling activity via terminal screens and includes slots machines, video lottery terminals, fruit machines, video blackjack, video poker and electronic roulette (Productivity Commission, 1999). In reference to pieces of research and legislation, the
term EGMs has been widely accepted to represent these gambling activities; however, differences have been made in its explanation. The term, EGMs refers to electronic gaming machines in legislation and within licensed venues in Australia, and to electronic gambling machines by international bodies and research. Given the devices clearly fall within the criteria set out to represent gambling (Blaszczynski et al., 1997) this thesis will use the term EGMs to represent the latter, electronic gambling machines, however, it is understood that both interpretations refer to the same devices.

In Australia, EGMs are sometimes referred to colloquially as ‘poker machines’ or ‘pokies’ (Productivity Commission 1999). Despite perhaps inferring that these are machine-based versions of casino card games, most are multi-line and/or multi-credit EGMs. These devices offer gamblers one or more games involving an initial spin of five virtual reels with symbols across three rows displayed on a video screen (Delfabbro & Winefield, 1999). Combinations of symbols across rows equate to preset return amounts as a function of the amount bet per row. If gamblers bet on multiple lines it is possible to receive a return less than wagered (Griffiths, 1993a). Bets can be wagered every three to five seconds, allowing for hundreds of gambling outcomes to be experienced over short sessions of play (Dickerson, 1993).

EGMs deliver an intermittent ratio of winning and losing events, which are pseudo-randomly programmed so that the “house” wins in the long term (Walker, 2004). Persistence in gambling on electronic machines therefore dictates a higher likelihood of overall financial losses (expenditure). This thesis has chosen to focus primarily on the experience of gambling behaviour as exhibited on EGMs. Each of the following sections will present information relating to gambling in general, and then specific data related to gambling on EGMs.
1.3 – Motivations to gamble

This section will first examine the self-reported gambling motivations among the general population prior to a consideration of gambling motives of PGs later in the chapter (Section 1.7). Given the large financial losses (expenditure) as a result of gambling, the influence of potential financial gain is unlikely to be a dominant motivator for gambling participation. Liu, Maciejewski & Potenza (2009) reviewed data collected during the Gambling Impact and Behaviour Study (GIBS; Gerstein et al., 1999). Liu et al. (2009) collated data from a national representative sample of 1380 individuals whom had recreationally gambled within the past 12 months. These respondents were asked questions about their motivation to gamble. Respondents were provided with a list of reasons to choose from, and were allowed to select as many reasons as they found applicable. The most frequently reported reason for gambling was “to win money” (62.9%) followed by entertainment (39.2%; Liu et al., 2009). The next most commonly reported reason was “for entertainment”.

A previous national telephone survey in the United States conducted by the Mississippi State University Gambling Group (MSUGG; 1995) reported similar findings indicating that “to win money” was the most commonly reported motivator for gambling (50.5% of 1522 recreational adults surveyed). Furthermore, the MSUGG (1995) observed that most individuals are not likely to continue to gamble unless they find it entertaining. The physiological “high” during gambling was identified as contributing to the subjective experience of being entertained (MSUGG, 1995). However, it is the nature of gambling that most gamblers do not “win money”. Thus, of the majority of recreational gamblers who gamble to win money (Liu et al., 2009; MSUGG, 1995), very few of them realise this desired goal.
Similar telephone surveys have been conducted in Australia. 1,737 gamblers in Victoria were interviewed by Roy Morgan Research (1999) and it was found that 59% of respondents gambled because of the lure of winning, while only 13% reported excitement as a motivation to gamble. Regular gamblers were more likely to gamble in order for excitement than non-regular gamblers (Roy Morgan Research, 1999). Similarly, the Centre for Gambling Research (2004) reported regular gamblers were significantly more likely to report they gambled because of the excitement or “the buzz” than non-gamblers. These surveys have found that motivations to gamble vary amongst participants, indicating that gambling is not necessarily driven by the possibility of winning money.

1.3.1 Motivations to gamble on EGMs

The motivations of EGM gamblers have been reported to differ from motivations to pursue gambling activities in general. Two notable Australian surveys have focused on the motivations of regular EGM players. The Australian Institute for Gambling Research (1999) obtained data reporting that only 4% of EGM players are motivated to gamble because of the thrill of winning. Similarly, Hill, Deyell, Lockett and Pederick (1995) reported that 2% of EGM gamblers pursued the activity to win money. In both of these studies social reasons or entertainment accounted for the majority of the reported motivation for regular EGM gamblers.

A desire to win, importantly, is not reported to be an essential motivator for participation in gambling on EGMs. Money lost gambling on electronic machines exceeds all that is lost on other forms of gambling in Australia (Office of Economic and Statistical Research, 2006; Productivity Commission, 1999). EGMs are reported to offer unique arousal-reducing qualities, which may attract gamblers to participate in
preference to other forms of gambling (Delfabbro & LeCouteur, 2005). Investigations of the experiences of gamblers during participation on EGMs may better inform researchers how they maintain motivation to gamble and more importantly, why their gambling behaviour persists despite significant adverse psychosocial consequences.

It should be noted that the reliability and validity of gamblers to report accurately on their motivations to begin gambling and reasons to continue gambling is somewhat unclear. Several studies have cited gambler and collateral agreement as evidence for the validity of self-reports on gambling behaviour, such as money and time spent gambling (Hodgins & Makarchuk, 2003; Taber, McCormick, Russo, Adkins & Ramirez, 1987). Nonetheless, it has been theorised that because of the architecture of mind and personal motives, it may be difficult for people to know themselves and why they act or report on their acts (Nisbett & Wilson, 1977; Wilson & Dunn, 2003). Motivations are less accessible and observable to individuals than actual behaviours.

Wilson and Dunn (2004) proposed the mind as a collection of processing modules that operate efficiently outside of awareness. Therefore some unconscious processes responsible for learning, attention, perception, evaluation, emotion and indeed, motivation are beyond the access of the individual via self-report (Wilson & Dunn, 2004). A focus on measurements not requiring conscious feedback from individuals (e.g. monitoring subtle changes in physiology) may increase access to knowledge as to why gambling is pursued. Ideally, these physiological measurements would not be provided to individuals as these may fabricate self-reports and self-perceptions (Valins, 1966; Wilson, 2002).
1.4 – Problem Gambling

A number of descriptors have been applied in the research literature to describe gambling behaviour, which results in adverse psychosocial consequences; problem and pathological being the most common, however, compulsive, addictive, excessive, disorderly, at-risk, degenerate and potential pathological are also employed (Neal, Delfabbro & O’Neil, 2005). These descriptors usually regard gambling resulting in harm in one of two different ways:

(1) As a mental disorder that is assessed on the basis of individuals meeting diagnostic criteria established by organisations, such as the American Psychiatric Association (APA; 2000).

(2) As a continuum of problem behaviour, with people experiencing one or a small number of minor, transient problems at one end, through to people experiencing a cluster of serious gambling-related problems of prolonged duration at the other.

The term pathological gambling supports the mental disorder conceptualisation, which refers to a repeated pattern of gambling behaviour that leads to actual problems beyond mere financial strain, including marital conflict, accumulated debts, borrowings and impairment in other areas of social and vocational functioning (APA, 2000). Point prevalence rates of pathological gambling in a number of countries are found to be between 1 and 2 percent (Walker & Dickerson, 1996), while investigations of lifetime prevalence rates have ranged from 0.1 to 5.1 percent (Petry & Armentano, 1999). A recent review of prevalence rates obtained between 2000 and 2005 concluded that prevalence rates for pathological gambling are comparable and relatively stable between countries and across survey instruments, and do not differ from earlier reviews (Stucki & Rihs-Middel, 2007).
The concept *problem gambling* is supportive of the continuum approach. It acknowledges that some individuals are involved in gambling activity with adverse consequences, but do not meet diagnostic criteria. The term *problem gambler* tends to include both gamblers who are experiencing problems but who do not meet the diagnostic criteria and those who are clinically diagnosed as problem or pathological gamblers (Neal et al., 2005). As such, *problem* gambling has become the dominant term and reference for clinical study.

“Problem gambling is characterised by difficulties in limiting money and/or time spent on gambling which leads to adverse consequences for the gambler, others, or for the community” (Neal et al., 2005, p. 3).

This thesis will adopt this definition of problem gambling (PG), which will be taken to represent problems experienced as a consequence of gambling behaviour. The negative financial consequences of persistent gambling are indisputable. About one third of gambling expenditure (losses) in Australia is estimated to be attributable to problem gamblers (Productivity Commission, 1999). The Productivity Commission (1999) calculated that each problem gambler spends approximately $12,000 each year on gambling compared to the Australian average of $645.

PG is not only associated with significant financial consequences and loss of time, but also an increased risk of suicide, suffering from mood disorders, and/or abuse of alcohol, nicotine or other drugs (Potenza et al., 2002). Shaffer and LaBrie (2002) compared the prevalence rates of various disorders in the general community and
acknowledged that PG is more prevalent than schizophrenia and anorexia nervosa. PG is therefore a significant physical and mental health issue.

As the definition of PG above suggests, negative consequences are not limited to the problem gambler themselves, but includes their family, friends and the community. About seven additional people are adversely affected by a problem gambler’s behaviour, representing approximately two million Australians or 10 percent of the Australian population (Productivity Commission, 1999). Relationships Australia Inc. (2006) conducted telephone interviews with 1,200 adult respondents from across the states and territories of Australia. More people reported gambling as adversely affecting relationships than affairs or violence (Relationships Australia Inc., 2006). PG has significant negative consequences on marriages, with estimates that PG is the likely cause of approximately 1,600 divorces in Australia each year (Productivity Commission, 1999).

The distribution of negative consequences of problem gambling behaviour on family, friends and surrounding community commonly results in feelings of guilt and attempts to conceal the issue (APA, 2000). Unfortunately, concealment from family members and friends also often results in delays in attempts to seek help. Only about 10 percent of problem gamblers seek treatment (Productivity Commission, 1999). PG therefore is under diagnosed and rarely treated.

1.4.1 – EGMs and problem gambling

EGMs are consistently reported to be mostly associated with PG. The adverse consequences of PG related to EGM use are significant; around 80 percent of treatment-seeking clients identify EGMs as their principle form of gambling (Delfabbro & LeCouteur, 2005; Faunce, 2006). Fifteen to twenty percent of EGM users (or 6% of
adults) contribute 60-80 percent of the revenue generated by EGMs (Doughney, 2007). Specifically, the proportion of expenditure from problem gamblers participating on EGMs is high, and has been calculated at 42 percent in Australia (Productivity Commission, 1999) and 54 percent in Canada (Schellink & Schrans, 1998), of the total EGM expenditure in each of the countries.

Investigations into EGMs have indicated that problem gamblers find it difficult to halt their participation once a session has commenced even if a significant monetary win is experienced (Schellink & Schrans, 2002; Dickerson, Haw & Shepherd, 2003). Whereas, lotteries offer participants the small possibility of winning large grand prizes in the order of millions the majority of EGMs reward players with prizes that are relatively small but frequent; with wins experienced every three to six trials (Delfabbro & Winefield, 1999; 2000). The design of EGMs has been criticised as they allow small, yet frequent winning schedules to induce increased rates of play and the reinvestment of returns (winnings), while lowering the chances for gamblers to leave a session as a net winner (Dickerson, 1993; Dowling, Smith & Thomas, 2005; Schull, 2002).

Although the design and structural characteristics of EGMs have been implicated to induce problems, such as loss of time and money, there is no clear picture as to why PGs persist with EGM gambling, displaying low self-regulation, while the majority of players manage to experience relatively fewer problems. Rigorous and systematic analysis of the experience of EGM gambling is required to understand the development and maintenance of PG (Coventry & Hudson, 2001; Dowling et al., 2005). Investigations are required to explore psychological, biological, and social factors mediating the interaction of players with EGMs and more specifically to the unique “winning” experience they deliver.
The principle focus of this thesis is the examination of the psychophysiological experience of gambling on electronic machines. It is envisaged that a greater understanding of this experience may contribute to the development of strategies that limit/relieve harm to the individual, their family, friends and the greater community. A method of identification for those at risk or suffering from problem gambling is crucial to its understanding as a phenomenon. The following section reviews the development and validity of psychometric measures of problem gambling.

1.5 – The measurement of problem gambling

Several measures are available to assist clinicians in the identification of PG. They include the Victorian Gambling Screen [VGS] (Ben-Tovim, Esterman, Tolchard, Battersby, & Flinders Technologies, 2001), the Canadian Problem Gambling Index [CPGI] (Ferris & Wynne, 2001), the Lie/Bet Questionnaire (Johnson et al., 1997), the South Oaks Gambling Questionnaire [SOGS] (Lesieur & Blume, 1987) and those derived from the criteria as stated by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition – Text Revision [DSM-IV-TR] (APA, 2000). The primary gambling screening and diagnostic tools used in survey or clinical research cited in the literature, however, have, in the main, not been evaluated or received minimal psychometric evaluation (Thompson, Walker, Milton, & Djukic, 2005).

From a research perspective, the SOGS is the most commonly used screening instrument, and has been investigated most extensively as to its ability to successfully identify the presence of PG (Stinchfield, 2001). Therefore, this review will focus on the evaluation of this psychometric measure. The SOGS was derived from the official psychiatric definition of pathological gambling as a chronic or chronically relapsing mental disorder (Lesieur & Blume, 1987). People who acknowledge that they have, at
some time in their lives, experienced five or more of 20 symptoms are classified as probable pathological gamblers (PGs).

Use of this term *probable PG* reflects that the people thus classified have been identified on the basis of their score on a screening assessment rather than diagnosed by a clinical interview conducted by a qualified mental health professional (i.e. DSM-IV-TR; Stinchfield, 2001). Screening tools, such as the SOGS, have several cost and convenience advantages over clinical interviews. These advantages allow gambling researchers to sample greater proportions of the general population (including PGs) increasing the validity of their findings (Stinchfield, 2001). It is acknowledged, however, that a clinical diagnosis indicated via a screening tool requires a clinical interview for confirmation.

The SOGS has been applied to samples derived from treatment, Gambler's Anonymous, help-line, and several general population settings (Gambino & Lesieur, 2006). The widespread use of the SOGS in research concerned with population surveys has not occurred without criticism (Gambino, 1997; Battersby, Tolchard, Thomas & Esterman, 2002). The SOGS was developed principally for use in clinical settings and was validated comparing PGs with people who were unlikely to have gambled much at all (Lesieur & Blume, 1987). The consequence is an inflated chance of type I error or false positives (Culleton, 1989). This is particularly an issue for some regular gamblers who are incorrectly classified as PGs despite few problems as a consequence of their gambling (Battersby et al., 2002).

The sensitivity (the proportion of PGs who test positive) and specificity (the proportion of non-PGs who test negative) of the SOGS may be high within a clinical sample, but the measure is most likely not to be as effective in accurately screening for PG among the general population. Sensitivity and specificity influence the predictive
value of a clinical measure and moreover, so does the baseline rate of the disorder being
screened. Pathological gambling is a low base rate disorder in that its prevalence is less
than 10 percent for the general adult population. The SOGS, like most gambling
screens, would therefore be expected to not do very well in classifying as "positive"
those who were PGs, but would do very well in classifying as "negative" those who
were not PGs, since most people are not disordered gamblers (Gambino, 1997).

Critical statistical analysis of the SOGS has revealed the reverse is true. It is
very good at detecting PG, but it also diagnoses a number of people who are not
problem gamblers (Culleton, 1989). In another study, two of four participants classified
as PGs in a general population sample of 803 were found to be false positives
(Stinchfield, 2001). It was acknowledged, however, that these individuals were likely to
be suffering problems as a result of their gambling, but below a clinical level
(Stinchfield, 2001). In the same study, the SOGS had an almost perfect hit rate
(successful identification of PGs) in both general population (.996) and clinical
treatment samples (.96). Moreover, the SOGS had a higher specificity rate in the general
population (.997) compared to the clinical sample (.75). The SOGS is therefore quite
effective at detecting serious gambling problems among people who have been
independently diagnosed as PGs (Stinchfield, 2001).

It has been concluded that falsely identifying people as PGs is a relatively small
cost of utilising the SOGS as a screen (Productivity Commission, 1999). The SOGS
score of 5 therefore remains the best cut-off score in order to maximise the hit rate and
balance the false positive and false negative errors (Productivity Commission, 1999;
Stinchfield, 2001). Moreover, the SOGS is reported as a more powerful screen for
identifying individuals experiencing PG than the newer instruments (see Abbott &
Volberg, 1996; Abbott, 2001; Johnson et al., 1997). Although not adequate for
prevalence research, the SOGS remains a useful screening tool to identify PGs in research projects (Neal et al., 2005).

The SOGS has thus served researchers well in their investigation of PG and should be applied in conditions that support its relevance and usefulness (Gambino & Lesieur, 2006). The majority of gambling studies have used the SOGS or its variants, therefore future studies wishing to replicate or compare findings should hold this as an “important criterion for choice of instrument” (Gambino & Lesieur, 2006, p.9). The SOGS will therefore be utilised as a primary index of PG for the current program of research presented in this thesis.

1.6 – Motivations for problem gambling

This current section will review the motivations of PGs to gamble. While most gamblers report that they gamble to win money and for entertainment (see section 1.3), PGs have reported to gamble for differing reasons. Clarke (2004) compared motivations to gamble amongst 147 university students. Participants with SOGS scores of three or greater were classified as PGs. A lower SOGS cut-off score for PGs was used to compare PGs to non-PGs, as few university students met criteria for pathological gambling, but many had exhibited some signs of problems form gambling (Clarke, 2004). PGs are more likely to be motivated to gamble in order to relieve tension or stress than non-PGs (Clarke, 2004).

Motivations to participate in particular forms of gambling also differ for PGs. Slowo (1997) compared motivations to gamble in treatment seeking PGs. EGM gamblers reported motivations to gamble which more commonly involved escape and reduction of tension, compared to both racing and casino gamblers, who more frequently pursued gambling for excitement reasons (Slowo, 1997).
PGs more frequently report that they gamble on EGMs to win than non-PGs (Hing & Breen, 2002). On the other hand, Loughnan, Pierce and Sagris (1996) reported motivations to gamble amongst male and female EGM gamblers seeking treatment for gambling-related problems. The most important stated reasons for gambling on EGMs were escaping boredom, achieving relaxation, or increasing ‘good feelings’ (Loughnan et al., 1996). PGs may be especially motivated by the principles of negative reinforcement. By gambling, PGs may release tension, and the relief reinforces the gambling behavior, especially on EGMs (Clarke, 2004). Delfabbro and LeCouteur (2005) surmise that EGMs compared to other forms of gambling offer relatively passive, yet continuous involvement. This enables gamblers to use the machines to achieve relaxation or escape boredom.

It should be noted that the reasons people report as to why they gamble may also differ from the reason(s) they continue to gamble. Although PGs may more commonly report that they engage with EGMs to escape or to win than non-PGs, these reported motivations to initiate gambling do not sufficiently explain why some individuals continue to gamble while others do not. There may be other inherent characteristics of PGs that maintain their gambling, such as the experience of, rather than the desire for, positive and negative reinforcement during gambling. As mentioned above, the issue of the extent to which gamblers have conscious access to their motivations is in question. To assume PGs know what motivates their lack of appropriate self-regulation and that they can reliably report it is perhaps less well conceived than research that attempts to objectively measure differences. The following sections review evidence collected for common theoretical explanations for PG.
1.7 – Personality traits and problem gambling

Unlike motivation, which refers to the reason or reasons for engaging in a particular behaviour, personality is proposed to encompass a set of characteristics possessed by a person that predominantly influence cognition, motivation, and behaviour in a variety of situations (Ryckman, 2004). Researchers have attempted to recognise core personality traits of PGs; impulsivity and sensation seeking receiving the greatest attention. A brief review of the findings will now be presented.

1.7.1 – Impulsivity

Impulsivity is characterised by acting without delay to fulfil immediate needs or wants without thought or consideration for long term consequences (McCormick & Taber, 1988). The commencement and persistence with gambling despite adverse consequences may reflect this core dimension of human personality (McCormick, Taber, Krudelbach & Russo, 1987). An early examination of impulsivity’s role in PG compared 10 alcoholics, 10 drug addicts and 25 control subjects with 10 PGs sampled within a hospital setting (Allcock & Grace, 1988). It was revealed that PGs did not differ from controls or alcoholics, while drug addicts scored significantly higher on measures of impulsivity.

Subsequently, a study which has obtained a substantially larger samples has demonstrated that gamblers seeking treatment (n = 115) score higher than healthy controls (n = 235) on impulsivity (Blaszczynski, Steel, & McConaghy, 1997). Moreover, Steel and Blaszczynski (1998) found higher impulsivity among 82 outpatient PGs compared to psychometric norms and that impulsivity is related to the severity of gambling behavior. Furthermore, Breen and Zuckerman (1999) have also demonstrated that high impulsivity is related to increased engagement with behaviours (‘chasing’)
typically associated with PG. However, it is noted that high impulsivity traits are not required for the development and maintenance of PG, but may rather act as a susceptibility factor (Steel & Blaszczynski, 1998). Nonetheless, the findings indicate that the precise role of impulsivity in PG is uncertain and warrants further examination alongside other factors that it may interact with, such as physiology.

1.7.2 – Sensation seeking

Sensation seeking is often depicted as a trait to pursue activities, which provide novel or unknown consequences and provide physical stimulation (Zuckerman, 1999). Research has identified higher sensation-seeking among PGs (Breen & Zuckerman, 1999; Kuley & Jacobs, 1988; Nower, Derevensky, & Gupta, 2004). On the other hand, studies sampling PGs in treatment and controls have found differences in impulsivity but no differences or even lower scores on sensation-seeking (Blaszczynski, Steel, & McConaghy, 1997; Steel & Blaszczynski, 1998).

PGs have been considered as not seeking sensation through gambling, but rather trying to avoid or reduce negative states (Blaszczynski, McConaghy, & Frankova, 1990; Schull, 2002). PGs are prone to boredom and isolation (Blaszczynski et al., 1990). Risk-taking behaviours, such as gambling, have been proposed to mediate how sensitive individuals are to risks and rewards, allowing for regulation of physiological states (Demaree, DeDonno, Burns & Everheart, 2008). Gray (1970) proposed a psychophysiological model in which the likelihood an individual engages with behaviours is balanced by their propensity to avoid negative and approach rewarding stimuli.

The contradictory findings relating to sensation seeking may reflect two groups of PGs, those sensitive to arousal (reward) and those sensitive to punishment (escape).
Zuckerman (1999) indeed suggested that those PGs in treatment may have lower sensation seeking traits than those outside or that treatment in itself may influence sensation-seeking traits.

Bonnaire, Bungener and Varescon (2006) surmised that off-course bettors and EGM players have generally been found to be lower on sensation seeking than the general population, but casino gamblers and racetrack gamblers are higher sensation seekers than the general population. Research has therefore shown that sensation seeking appears to influence not only what form of gambling is pursued (Coventry & Brown, 1993; Dickerson, Hinchy & Fabre, 1987), but also where or how it is used (Bonnaire et al., 2006; Bonnaire, Lejoyeux & Dardennes, 2004; Dickerson et al. 1987; Coventry & Brown 1993; Coventry & Constable, 1999). The distinction between choices of forms of gambling and how it is used has been espoused by several researchers (Bonnaire et al., 2006; Cornish, 1978; Coventry & Brown, 1993) as an avenue of focus for the determinants of PG. The early evidence suggests that it appears unlikely that sensation seeking by itself will provide an adequate explanation of PG, given the disparities in sensation seeking traits for PGs found across forms of gambling. Moreover, the findings suggest that a focus on specific forms of gambling behaviour (such as EGMs) is warranted in order to identify the determinants of PG.

1.8 – Cognitive processes in problem gambling

Several cognitive processes have been hypothesised to explain why PGs continue to gamble despite adverse psychosocial consequences. These explanations include cognitive processes that result in the gambler overestimating the degree of control they have over the outcome (Coventry & Norman, 1998; Coulombe, Ladouceur, Desharnais, Jobin, 1992), and the “gambler’s fallacy” that after a run of losses, a big win is overdue
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).

Research has attempted to identify predictors of irrational thinking in regular EGM gamblers (Delfabbro & Winefield, 2000). Delfabbro and Winefield (2000) conceived that irrational gambling cognitions would be influenced by the level of reinforcement (amount won) and risk taking (amount staked) in a study of 20 EGM gamblers. A comparison of high and low staking groups revealed that the high-staking group was more irrational. No relationship was observed between irrational cognitions and winning during gambling on electronic machines. Delfabbro and Winefield (2000) concluded that irrational beliefs could be a mediator for gambling behaviour, and are particularly associated with greater risk taking during gambling on electronic machines.

The influence of cognitive processes on gambling activity has been reported from not only these experimental settings, but also implicated following outcome studies of gambling treatment programs (see Ladouceur & Walker, 1996, for a review of cognitive gambling treatments). Reviews of gambling treatments have concluded that treatments including the remediation of irrational gambling related cognitions produce positive effects (Pallesen, Mitsem, Kvale, Johnsen & Molde, 2005; Walker et al., 2007). Most PGs are found to gamble less often and with less money following cognitive treatments for gambling (Walker et al., 2007). This supports suggestions that irrational cognitions maintain gambling behaviour for at least some PGs.

Theories that postulate that action and behaviour are the result of dual processes (conscious and unconscious) have a long history and stem from the work of Sigmund
Freud (Evans & Coventry, 2006). The following section presents a contemporary dual process theory of cognitive processes (reasoning) during gambling. Later in Section 4.2.4.1, the somatic marker hypothesis is presented, which postulates dual processes for perceived emotion during gambling.

1.8.1 – Dual Process Theories

Theories based upon reasoning biases argue that PG behaviour is produced by a misapplication of decision making strategies that are normally applied without harm outside of gambling situations (Wagenaar, 2002). Evans and Coventry (2006) specifically outline two systems of thinking: System 1 is a product of early evolution, shared with other high order animals and works primarily unconsciously in a rapid, pragmatic fashion, relying upon past events, largely independent of conscious working memory and not influenced by IQ (Evans & Coventry, 2006). Comparatively, Evans and Coventry (2006) describe System 2 as unique to humans, a product of later evolution, and working in a domain of hypothetical, analytical, slow, sequential reasoning that relies heavily upon working memory and thus is affected by levels of IQ.

A key role for System 2 is to reason the behaviours directed unconsciously by System 1 (Evans & Coventry, 2006). System 1 naively attempts to apply identifiable patterns from the past to future behaviour. In the case of gambling, therefore, System 1 may adopt patterns that assume non-randomness. In the case of EGMs, the ability to apply patterns is futile given the application of random number generators which create erratic sequences of numbers which represent the outcomes (Turner & Horbay, 2004). With the real chances of winning beyond the capabilities of System 1, gambling behaviour becomes directed by erroneous implicit accounts of what is actually taking place. According to Evans and Coventry (2006), what makes matters worse is that
System 2 consequentially generates post–hoc conscious beliefs that are in line with the gambling behaviour and participation.

Erroneous cognitions previously have been implicated as causal factors (see Section 1.8). The dual process approach adopted by Evans and Coventry (2006) allows for unconscious processes to initiate gambling behaviour (System 1) and for it to be maintained/explained consciously by collaborative erroneous thoughts (System 2). The success of cognitive treatments, which attempt to enhance the ability of participants to understand the erroneous nature of distorted gambling related thoughts (see Ladouceur & Walker, 1996, for a review of cognitive gambling treatments) supports conclusions that reasoning at the System 2 level is changeable (Evans & Coventry, 2006). A relationship between subtle physiological changes and conscious, verbalised cognitions related to gambling is presented later in Section 3.5.1.

Although cognitive processes manage to partially explain the maintenance of PG, they fail to explain satisfactorily why some individuals more likely to develop gambling, or to predict accurately which factors are associated with the development of irrational cognitions. It is unlikely that beliefs that one can beat the odds or that one will win eventually can develop without exposure to gambling (Dickerson, 1993). Moreover, it is suggested that any individual may be susceptible to develop irrational thoughts about winning when exposed to variable ratios of reinforcement as delivered by EGMs (Dickerson, 1993). Cognitions are probably mediated by not only exposure to financial cues of winning offered by gambling activities, but also the physiological experience of participation (Moodie & Finnigan, 2005). In fact, integrative accounts of PG suggest that cognitions about gambling are probably dependent on how individuals perceive and experience both biological and environmental variables (Blaszczynski & Nower, 2002; Sharpe, 2002). Sharpe’s (2002) biopsychosocial model of PG emphasises that cognitive
accounts of PG are perhaps creating pockets of understating versus integrative accounts where cognitions are investigated alongside and in relation to other factors, such as physiology, behaviour, personal history and stressors.

1.9 – Physiological arousal as reinforcement

Complimentary to the search for personality traits and cognitions associated with gambling are approaches that consider that the development of PG is a consequence of learning. PGs may become conditioned to gambling behaviour as an effect of reinforcement. Given gambling inherently involves losing money; it is proposed that reinforcement may be also be attained via changes in arousal.

There are many definitions of arousal; however, for purpose of this thesis, arousal will be defined as responsiveness to sensory stimuli, measured by levels of physiological activity (Walker, 1968). It is acknowledged that arousal is sometimes considered to have many components (Barry, 2006). However, given the brevity of research into gambling and physiology, it was considered best to examine arousal as a unitary concept. In this way, arousal is conceived to be a measurable physiological characteristic of individuals, the sum of many parts, displayed within multiple physiological systems (Walker, 1968).

Arousal theories suggest that rather than money, the reward during gambling is the arousal or “high” produced as a result of participation (Anderson & Brown, 1984). Essentially, differences in gambling behaviour in PGs are hypothesized to be both a result of the arousal achieved during gambling tasks and that, which is experienced prior to gambling participation. Gambling may therefore be pursued as a relief from adverse arousal or an attempt to seek excitement or arousal “highs”.
Cocco, Sharpe and Blaszczynski (1995) reported on the self-awareness of gamblers and that there are differences in preferred levels of arousal for EGM compared to horse racing gamblers. Problem horse race gamblers were found to prefer heightened levels of arousal (positive reinforcement) and problem EGM gamblers were found to avoid arousal more frequently (negative reinforcement). Cocco et al. (1995) did not measure physiological activity in response to gambling. However, the findings do suggest that EGMs may effect arousal uniquely compared to other forms of gambling.

1.10 – Research literature summary

EGMs are reported that they may motivate gambling behaviour differently compared to other gambling activities. Moreover, compared with other forms of gambling, EGMs account for the most harm in Australia (Productivity Commission, 1999). However, there is limited evidence suggesting why most people can gamble on EGMs without difficulty, yet some develop a lack of self-regulation and suffer significant adverse psychosocial consequences. Although research has differentiated groups of PGs from non-PGs in terms of motivations, cognitions and levels of impulsivity, better accuracy in the prediction of the individual at high risk for problem gambling is required.

The physiological experience of individuals while they gamble appears to be an important factor in each of the explanations of PG reviewed. PGs may respond physiologically differently to non-PGs when gambling. A comprehensive literature review and evaluation of arousal findings in each of these areas will be presented over the next two chapters.
Chapter 2 – Neurobiology of gamblers

2.1 – Overview
This chapter reviews investigations of physiological activity measured within regions of the brain. Neurobiological explanations of PG suggest that there is some physiological condition or tendency, which predisposes individuals to develop PG. Several methods have been applied to illustrate neurobiological differences in PGs. Neurochemical findings are presented initially followed by a review of a recent neuroimaging investigation. Greater coverage is given to studies, which have monitored neurobiological activity in PGs and non-PGs in response to gambling tasks. Collectively, the neurobiological findings support proposals of inherent physiological abnormalities in PGs.

2.2 – Neurochemical findings (Neurotransmitters)
The brain has typically been implicated as the physiological director of human behaviour. It is not surprising then that researchers have proposed three spheres of explanation of PG within particular brains processes; the serotonergic, dopaminergic and noradrenergic systems (Ibáñez, Blanco & Sáiz-Ruiz, 2002). Regarding biochemical research in PG, abnormalities have been found for each of these neurotransmitters.

The findings of these neurotransmitter studies in PG reflect the findings of abnormal brain activation in reward-pathway areas (Potenza, Steinberg & Lacadie, 2000), where dopamine is an important neurotransmitter. Ibáñez et al. (2002) reported that abnormal dopamine and serotonin regulation have also been found in drug and alcohol dependence, indicating similarities between PG and addiction. Moreover, the functioning of the noradrenergic system is important in the arousal system, and
therefore suggests abnormalities in arousal in PG. A more detailed coverage of the research is given below.

Firstly, PG has been hypothesised to be an impulse control disorder resulting from a dysfunction in the serotoninergic system. There is empirical evidence showing that stimulating the serotonin pathway results in lower hormonal responses in PGs as compared to healthy controls (Moreno, Sáiz-Ruiz, & Lopez-Ibor, 1991), and that PGs have a primary serotonin deficit (Blanco, Oresanz-Munez, Blanco-Jerez, & Sáiz-Ruiz, 1996).

Secondly, neurobiologists (Campbell, Stout, & Finn, 2004; Evans et al., 2004; Gschwandtner, Aston, Renaud & Fuhr, 2001) have theorised PGs are addicted to the behaviour and therefore similar mechanisms are implicated as are evident in other addictions (i.e. dopaminergic dysregulation). An urge to gamble has been shown to associate with the same activation of neural pathways in gamblers as a drug craving does in cocaine-dependent participants (Potenza et al., 2000).

Finally, researchers have focused on the possibility of a dysregulation of noradrenergic system increasing the levels of physiological activity and sensation seeking in PGs. PGs have been shown to have higher levels of urinary noradrenergic output, cerebral spinal fluid (CSF) noradrenaline, and CSF 3-methoxy-4 hydroxyphenylglicol than healthy controls (Bergh, Eklund, Sodersten, & Nordin, 1997). Also after stimulating the noradrenergic pathway, elevated levels of hormone response are observed in PGs, indicating higher noradrenergic activity than in controls (DeCaria et al., 1997).

It must be noted that the preceding comparisons, from research into the serotoninergic, dopaminergic and noradrenergic systems, support the notion that PGs possess inherently different levels of neurotransmitter arousal to healthy controls when
measured in non-gaming situations. The findings do not account for arousal in actual gambling situations.

Meyer et al. (2004) monitored the neuroendocrine response pattern of 14 PGs in direct comparison to 15 non-PGs while playing blackjack in a casino setting. Participants gambled with their own money with individual bets limited between 10 and 500 Euros. Physiological recordings were taken 15 minutes before gambling (baseline) and then 30, 60 and 90 minutes into the blackjack session. Measures were also taken 20 minutes after the completion of the blackjack gambling session. Data demonstrated sympathoadrenal activation during gambling, with significantly higher levels of norepinephrine and dopamine in PGs compared to non-PGs (Meyer et al., 2004).

As an initial investigation into neurotransmitter response patterns during gambling activity, the above study provides support for the hypothesis of abnormal physiological mechanisms in PGs whilst gambling. The findings, however, relate to one form of gambling (blackjack), which has differing characteristics to EGM gambling. Therefore, conclusions that can be made as to why PGs continue to gamble on EGMs despite adverse consequences are limited.

2.3 – Neuroimaging research

Neuroimaging studies have provided additional insight into the neurobiological processes that take place when people gamble. Relationships have been identified between these processes and particular areas of the brain during continued gambling behaviour (Reuter et al., 2005). Although few studies on neuroimaging in PG have been published, all studies indicate abnormalities in brain functioning when comparing PGs to control groups (Goudriaan, Oosterlaan, der Beurs & Van den Brink, 2004). Only one
study has utilised neuroimaging during gambling tasks. A review of this study will now be presented.

Reuter et al. (2005) utilised functional magnetic resonance imaging (fMRI) scans focusing on the ventral striatum (previously, decreased activation had been clearly linked to substance use disorders) and the ventromedial prefrontal cortex (previously, decreased activation had been related to reduced impulse control). The researchers presented 12 PGs and 12 normal controls with a novel gambling task involving guessing which of two cards (one red-faced, one green-faced) presented facedown was red. Participants were given 15 Euros as a beginning balance. They gained one Euro for each correct guess and lost one Euro for each wrong guess. The task was controlled so that all participants had won eight Euros at the end of the gambling session.

Reuter et al. (2005) found that both PGs and non-PGs exhibited greater increases in activation in the right ventral striatum following winning versus losing trials. Importantly, PGs showed significantly lower activation in the right ventral striatum and significantly weaker activation in the ventromedial prefrontal cortex, compared to non-PGs. The authors also found a significant negative correlation between severity of PG and responses in both the right ventral striatum and response in the ventromedial prefrontal cortex, which are both proposed to reflect responsiveness to rewards. These findings therefore suggest that PGs experience diminished reward from gambling. This might mean that PGs need to gamble over longer periods or with more money in order to experience the levels of excitement that non-PGs achieve with a lower level of controlled gambling. The findings also imply that PGs might share neurobiological features common to impulse control problems and excessive substance use.

A limitation of the Reuter et al. (2005) study is that the experimental task only offered the participant one choice and one interaction (to turn over one card). EGMs, for
example, offer greater variety of gambling choices including the selection of how many lines to play and how much to bet per line. Additionally, EGMs offer multiple gambling outcomes, such as wins, losses and features. The salience of winning a maximum of one dollar may be reduced for PGs who are likely to have experienced much larger wins throughout their gambling history (Reuter et al., 2005). The above findings therefore might be the consequence of prolonged involvement in gambling rather than the cause of it and might not adequately represent the neurobiology of PGs whilst gambling on EGMs.

2.3.1 – The Iowa Gambling Task

Bechara, Damasio, Damasio and Anderson, (1994) designed the Iowa Gambling Task (IGT) to simulate real-life decision making. The IGT is more complex compared to the task used by Reuter et al. (2005). The IGT involves the participant choosing from one of four decks of cards (two decks that provide high rewards, but also, high losses, and are losing overall; two that provide lower rewards, but also lower losses and result in winning in the long term). Key to this decision making paradigm, is that the participants do not know the properties of the decks prior to the experiment and have to determine which decks are advantageous overall, and become skilled at choosing the winning decks and avoiding the more risky, disadvantageous “losing” decks (Bechara et al., 2004). Performance deficits on the IGT have been associated with Huntington’s Disease (Stout, Rodawalt & Siemers, 2001), brain lesions in the ventromedial prefrontal cortices (Bechara et al., 1994), illicit drugs users (Grant, Contoreggi & London, 2000), schizophrenia (Bark, Dieckmann, Bogerts & Northoff, 2005), and psychopathy (Blair, Colledge & Mitchell, 2001).
When the performance of PGs has been compared to non-PGs, their performance on the IGT has indicated similar deficits to the above clinical groups. PGs have demonstrated an inability to select advantageous decks compared to the non-PGs on the IGT (Cavedini, Riboldi, Keller, D’Annucci & Bellodi, 2002; Goudriaan, Oosterlaan, de Beurs, Van den Brink, 2006). The comparable inability for PGs to select winning scenarios or avoid losing ones may influence the development and maintenance of their gambling behaviour (Goudriaan et al., 2006). A full review of the Goudriaan et al. (2006) study is provided later in Chapter 3.

The association between brain abnormalities and deficits in performance on the IGT supports the notion that physiological processes that aid the perception of risks and rewards may contribute to the development of PG. Researchers are yet to trace performance on the IGT across time in individuals that develop PG, however, some lifespan studies have indicated developmental changes in performance on the IGT. Performance of adults is superior to children (Kerr & Zalazo, 2004), whereas older adults are seen to perform poorly on the IGT (Lamar and Resnick, 2004). Findings that indicate that performance in tasks involving decision making can both improve and decline with age, may also suggest that experience with decision making activities, such as gambling, may contribute to poorer performance on the IGT over time. Similarly, caution should also be made in respect to interpreting results on the IGT as a pure decision making paradigm (Goudriaan et al., 2004). The IGT’s close resemblance to gambling activities is likely to produce arousal states and responses associated with gambling behaviour for PGs and not necessarily decision making behaviour alone (Goudriaan et al., 2004).
2.4 – Research literature summary

Neurotransmitter regulation differences between PGs and non-PGs have been found. PGs have exhibited less activation in brain systems commonly associated with reward response. Unfortunately, only two studies have investigated neurobiological activity in PGs and non-PGs during gambling tasks (Meyer et al., 2004; Reuter et al., 2005). While PGs are found to have heightened neurotransmitter activity during sessions of gambling (Meyer et al., 2004), the reward centres of the brain display less activity (Reuter et al., 2005). This may reflect a fragmentation of arousal responses to components of gambling tasks. PGs, compared to non-PGs, may in general respond more to gambling participation (as indicated by increased dopamine and norepinephrine levels obtained over long periods; Meyer et al, 2004) and be less responsive to wins within sessions of gambling (as measured by neural activity; Reuter et al., 2005). Moreover, PGs may be less responsive to losing, with a propensity to be unable to successfully identify and avoid disadvantageous outcomes compared to non-PGs (as indicated by their performance on the IGT; Cavedini et al., 2002; Goudriaan et al., 2006).

Theoretical conceptualisations are not clear as to whether the reinforcing properties associated with arousal changes stem from specific events within gambling (e.g., wins, near-wins or losses) or whether a potentially heightened arousal state (tonic rather than phasic levels) that lasts during the entire period of gambling may have inherent reinforcing properties. This distinction is relevant in determining whether actual winning is important in sustaining arousal and maintaining gambling behaviours. On the other hand, if elevated tonic levels of arousal are reinforcing by themselves to some individuals (PGs), desired arousal states may be generated by the possibility rather than the actuality of winning.
The neurobiological findings reviewed support suggestions that it is important for research to focus on both tonic arousal changes obtained over long periods of gambling and phasic arousal responses, which are related to events or stimuli experienced within sessions of gambling. The following chapter will review attempts of researchers to monitor phasic and tonic arousal changes exhibited in the autonomic nervous system in response to gambling and winning.
Chapter 3 – Arousal in response to gambling

3.1 - Overview

Chapter 3 reviews the literature related to the reactivity of individuals, as measured by changes in automatic arousal, to gambling and its cues. This review is divided into two major sections. The first provides a critique of research, which has focused on how arousal is experienced in response to gambling. This is followed by an outline of research that has focused on arousal in response to winning during gambling. Research methods and findings are evaluated, including a discussion on what is still unknown. Finally, an outline of the aims for the present program of research is provided.

3.2 – Reactivity to gambling

Autonomic arousal refers to levels of physiological activity exhibited in the autonomic nervous system (ANS), which is part of the body’s peripheral nervous system (Appenzeller & Oribe, 1997). The ANS is a regulatory system and is responsible for the maintenance of heart rate, digestion, respiration rates, pupil dilation, salivation, perspiration, micturition (discharge of urine) and sexual arousal (Appenzeller & Oribe, 1997). Gambling research has focused on varied measures of autonomic arousal, such as heart rate (HR), cortisol level, electromyogram (EMG), skin temperature, blood pressure (BP), skin conductance level (SCL), skin conductance responses (SCRs) and self-report (Goudriaan et al., 2004). These measures of arousal have been taken when participants gambled, after gambling, or during imagined participation in gambling activities.
As discussed in Chapter 2, it is uncertain whether gambling is inherently physiologically rewarding (i.e. produces changes in arousal) or if changes in arousal are the effect of characteristics of gambling sessions (e.g. whether participants have won). Researchers have therefore focused on both of these potential factors in the maintenance of gambling behaviour. Table 1 presents an overview of the research literature. Similar to the forthcoming review presented in this chapter, the findings of 23 studies are presented in two sections: those studies that have focused on arousal in response to gambling in general and those that have investigated the effects of winning. In comparing studies, it is evident that a variety of methodologies have been used. A combination of laboratory and field experiments has been undertaken. Cardiac physiological measures of arousal (HR or BP) are most common, utilised in 90 percent of the studies reviewed. Moreover, single physiological measures are most commonly applied in field studies, while laboratory studies have utilized multiple measures. Electrodermal activity (SCL or SCRs) has been used most commonly alongside HR in laboratory studies.

Eleven studies (Part 1, Table 1) have investigated arousal in response to gambling in general. Results from these studies indicate that gambling is associated with increases in arousal. Twelve studies (Part 2, Table 1), meanwhile, have also concentrated on the effects of winning on arousal. Findings from these studies generally support conclusions that winning produces greater changes in physiological activity than losing. Twelve studies have included a focus on autonomic arousal in response to gambling on electronic machines. Similarly, these studies indicate that autonomic arousal generally increases in response to gambling. Importantly, physiological changes are greater when winning; suggesting that monetary gain may mediate arousal levels during gambling.
PART 1: AROUSAL IN RESPONSE TO GAMBLING

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Sample</th>
<th>n</th>
<th>Study type</th>
<th>Subjective measure</th>
<th>Physiological measure</th>
<th>Key empirical findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson &amp; Brown (1984)</td>
<td>Blackjack gamblers and undergraduates</td>
<td>24</td>
<td>Field &amp; Laboratory (blackjack)</td>
<td>X</td>
<td>HR</td>
<td>Regular gamblers HR increased more in the casino compared to the laboratory setting. No difference in HR between groups when playing blackjack in the laboratory.</td>
</tr>
<tr>
<td>Leary &amp; Dickerson (1985)</td>
<td>Regular and non-regular gamblers</td>
<td>44</td>
<td>Laboratory (EGM)</td>
<td>✓</td>
<td>HR</td>
<td>Subjective arousal only increased for low frequency gamblers. HR during play was higher for the high versus low frequency group during gambling.</td>
</tr>
<tr>
<td>Coulombe et al. (1992)</td>
<td>Regular and non-regular gamblers</td>
<td>24</td>
<td>Field (EGM)</td>
<td></td>
<td>HR</td>
<td>Regular and non-regular players both experienced increased HR during gambling. A significant positive correlation was found between HR and erroneous verbalizations displayed.</td>
</tr>
<tr>
<td>Griffiths (1993b)</td>
<td>Regular and non-regular gamblers</td>
<td>30</td>
<td>Field (EGM)</td>
<td>X</td>
<td>HR</td>
<td>HR increased for both groups during gambling. After gambling, regular gamblers HR started to decrease at once, whereas non-regular gamblers HR did not change significantly.</td>
</tr>
<tr>
<td>Carroll &amp; Huxley (1994)</td>
<td>Dependent and non-dependent gamblers</td>
<td>32</td>
<td>Field (EGM)</td>
<td></td>
<td>BP</td>
<td>For both groups, systolic and diastolic BP rose just before play and during play, and dropped after play. The dependent group had a lower diastolic BP whilst gambling.</td>
</tr>
<tr>
<td>Roby &amp; Lumley (1995)</td>
<td>Regular and non-regular gamblers</td>
<td>70</td>
<td>Laboratory (novel gambling task)</td>
<td>✓</td>
<td>HR, SCL &amp; Skin temperature</td>
<td>Regular gamblers exhibited greater changes in HR, SCL and skin temperature than did non-regular gamblers during the gambling condition.</td>
</tr>
<tr>
<td>Blanchard et al. (2000)</td>
<td>PGs and non-PGs</td>
<td>14</td>
<td>Laboratory (imaginal task)</td>
<td></td>
<td>HR, SCL &amp; BP</td>
<td>HR increases during the task were greater for PGs vs. non-PGs.</td>
</tr>
<tr>
<td>Meyer et al. (2000)</td>
<td>Male regular gamblers</td>
<td>10</td>
<td>Field (blackjack)</td>
<td>X</td>
<td>HR &amp; Cortisol levels</td>
<td>Both HR and cortisol had increased 30 minutes into gambling session and remained elevated for the remainder of the gambling session. Cortisol levels decreased once gambling ceased.</td>
</tr>
<tr>
<td>Diskin et al. (2003)</td>
<td>PGs and non-PGs</td>
<td>64</td>
<td>Field &amp; Laboratory (EGM)</td>
<td>✓</td>
<td>HR &amp; SCL</td>
<td>SCL increased similarly both within laboratory and in vivo gaming lounge settings. HR and subjective arousal, however, were higher in the lounge situation for all participants.</td>
</tr>
<tr>
<td>Meyer et al. (2004)</td>
<td>PGs and non-PGs</td>
<td>29</td>
<td>Field (blackjack)</td>
<td>X</td>
<td>HR</td>
<td>HR levels increased with the onset of gambling in both groups, with PGs showing significantly higher levels across the entire gambling session compared to non-PGs.</td>
</tr>
<tr>
<td>Krueger et al. (2005)</td>
<td>Blackjack gamblers</td>
<td>29</td>
<td>Field (blackjack)</td>
<td>X</td>
<td>HR &amp; Cortisol levels</td>
<td>Both HR and cortisol levels were significantly increased throughout gambling. High impulsivity group had significantly greater cardiac response compared to the low impulsivity group.</td>
</tr>
</tbody>
</table>

Table 1
Reactivity to gambling: Empirical findings and methodologies
## PART 2: AROUSAL IN RESPONSE TO WINNING

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Sample Description</th>
<th>Sample Size</th>
<th>Study Type</th>
<th>Subjective measure</th>
<th>Physiological measure</th>
<th>Key Empirical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dickerson et al. (1992)</td>
<td>Regular gamblers</td>
<td>10</td>
<td>Field (EGM)</td>
<td>✓</td>
<td>HR</td>
<td>Increased HR in minutes with exposure to small wins and more so for big wins, compared to no wins.</td>
</tr>
<tr>
<td>Sharpe, Tarrier, Schotte, &amp; Spence (1995)</td>
<td>Regular and non-regular gamblers social gamblers and PGs</td>
<td>38</td>
<td>Laboratory (five experimental tasks)</td>
<td>✓</td>
<td>HR, SCL, EMG &amp; BP</td>
<td>SCL was significantly higher for PGs than the control groups when watching videos of gambling stimuli. There was a trend for PGs to have increased EMG responses to imagined personally relevant winning situations than the two control groups. No significant differences between groups on HR to any tasks.</td>
</tr>
<tr>
<td>Coventry &amp; Norman (1997)</td>
<td>Regular and non-regular gamblers</td>
<td>32</td>
<td>Field (off-course)</td>
<td>X</td>
<td>HR</td>
<td>No significant group differences in HR. Gamblers who bet on horses that won had significantly higher HR levels in the last 30 seconds of a race than those who backed horses that lost the race.</td>
</tr>
<tr>
<td>Coventry &amp; Norman (1998)</td>
<td>Non-PGs (undergraduates)</td>
<td>54</td>
<td>Laboratory (gambling task)</td>
<td>X</td>
<td>HR</td>
<td>Small increases in HR following early trials. Wins were associated with greater increases in HR than losses.</td>
</tr>
<tr>
<td>Coventry &amp; Constable (1999)</td>
<td>Regular and non-regular gamblers</td>
<td>32</td>
<td>Field (EGM)</td>
<td>✓</td>
<td>HR</td>
<td>No significant difference in HR changes based upon gambling frequency. HR was higher for those who won during and after play than for those who lost.</td>
</tr>
<tr>
<td>Coventry &amp; Hudson (2001)</td>
<td>Male and female gamblers</td>
<td>42</td>
<td>Field (EGM)</td>
<td>✓</td>
<td>HR</td>
<td>Significant increases in HR during gambling. However, “losers” exhibited slight changes compared to the increases found when participants won during play.</td>
</tr>
<tr>
<td>Ladouceur et al. (2003)</td>
<td>Regular and non-regular gamblers</td>
<td>24</td>
<td>Laboratory (EGM)</td>
<td>X</td>
<td>HR</td>
<td>HR increased when gambling to win either money or credits on an electronic machine. However, arousal when gambling was greater when informed of the possibility of monetary gain.</td>
</tr>
<tr>
<td>Diskin &amp; Hodgins (2003)</td>
<td>PGs and non-PGs</td>
<td>64</td>
<td>Laboratory (EGM &amp; Imaginal task)</td>
<td>✓</td>
<td>HR, SCL &amp; EMG</td>
<td>Both groups experienced significant increases in EMG and SCL when thinking about personally relevant wins, and increases in SCL and HR when thinking about personally relevant losses.</td>
</tr>
<tr>
<td>Sharpe (2004)</td>
<td>PGs and non-PGs</td>
<td>33</td>
<td>Laboratory (Imaginal task)</td>
<td>X</td>
<td>SCL</td>
<td>PGs exhibited similar SCL responses to wins and losses. Non-PGs had greater responses to wins than losses.</td>
</tr>
<tr>
<td>Gee et al. (2005)</td>
<td>Regular gamblers</td>
<td>17</td>
<td>Field (gambling episodes)</td>
<td>✓</td>
<td>X</td>
<td>Wins were followed by a large decrease in self reported arousal levels, while losses were followed by a small increase.</td>
</tr>
<tr>
<td>Moodie &amp; Finnigan (2005)</td>
<td>Frequent, infrequent and non-gamblers</td>
<td>63</td>
<td>Field (EGM)</td>
<td>X</td>
<td>HR</td>
<td>HR increases were greater for frequent gamblers (PGs) than the other groups. Responses to specialist play characteristics (bonuses) were mediated by the amount won.</td>
</tr>
<tr>
<td>Goudriaan et al. (2006)</td>
<td>PGs and non-PGs</td>
<td>93</td>
<td>Laboratory (Gambling task)</td>
<td>X</td>
<td>HR &amp; SCRs</td>
<td>Non-PGs were observed to exhibit greater increases in HR immediately following winning events than PGs.</td>
</tr>
</tbody>
</table>
Group differences are less consistent. Researchers have compared the arousal of various groups in response to gambling. Seven of the 23 studies reviewed (Blanchard, Wulfert, Freidenberg & Malta, 2000; Diskin & Hodgins, 2003; Diskin, Hodgins & Skitch, 2003; Goudriaan, Oosterlaan, de Beurs, & Van den Brink, 2006; Meyer et al., 2004; Sharpe, 2004; Sharpe, Tarrier, Schotte & Spence, 1995) have compared the arousal of PGs to non-PGs, while the remaining studies have mostly sampled regular and non-regular gamblers or undergraduates. PGs are commonly found to respond differently to non-PGs, however, the direction of differences is not consistent. Moreover, inconclusive results have been obtained when comparing groups based on gambling frequency (i.e. regular vs. non-regular gamblers).

The following review will attempt to synthesize the findings and evaluate the evidence for physiological differences in PGs in response to gambling. As highlighted above, the review is divided into two major sections: those studies that have focused on arousal in response to gambling in general and those that have investigated the effects of winning. Some studies have investigated both issues; these are presented in the second section of the review. Given the methodological differences amongst studies, each of the two sections of the review is divided into subsections, which present field and laboratory investigations, separately. Each of the studies is reviewed in chronological order within the subsections.

3.3 – Arousal in response to gambling

The more objective methods of assessing reactivity of individuals to behaviour expose them to it (i.e. observe them gambling) and measure their reactivity consistently throughout the task. Blanchard et al. (2000) declared that measuring autonomic arousal
in response to gambling activity is perhaps the most direct method of measuring such changes, and it is on this body of research that this literature review will now focus.

3.3.1 – Field studies

Ecological validity is an important aspect of gambling research. To address this issue researchers have investigated physiological responses of gamblers in their natural environment. Results from five field studies will be reviewed, of which, two have concentrated on gambling on electronic machines. The findings from Coulombe et al’s (1992) study are presented later in the chapter.

Anderson and Brown (1984) monitored HR of 12 regular gamblers during blackjack in a real and a laboratory casino. Twelve students were also monitored playing blackjack in the laboratory. HR was obtained during gambling, in three different stages, however; only overall HR differences were analyzed. HR increased when gambling in both settings, however, greater HR increases were found in regular gamblers in the casino compared to the laboratory settings. Physiological responses in the laboratory were weaker than in the real world task. This suggests that laboratory findings may not be fully generalized to the natural environment (Anderson & Brown, 1984).

In the laboratory, participants could win £10 if they had won the largest amount of chips at the end of the game, compared to the two other participants. No significant difference was found between the students and regular gamblers in HR exhibited in the laboratory. No group comparisons of responses to gambling in the casino setting were possible as the students only gambled in the laboratory. Importantly, bet size was positively correlated to HR increases in the regular gamblers when playing blackjack in
the casino. This suggests that player behaviour can moderate arousal during gambling (Anderson & Brown, 1984).

Griffiths (1993b) monitored HR of 15 regular and 15 non-regular gamblers when gambling on a fruit machine of their choice in a field setting. Participants were given £5 to gamble. Mean HR was obtained before, during and after the gambling session. HR increased for both groups during the gambling session and remained higher after gambling, compared to before play. HR of regular gamblers dropped quickly after ceasing gambling compared to the non-regular gamblers. This finding is suggested to represent tolerance in regular gamblers (Griffiths, 1993b).

Caroll and Huxley (1994) measured diastolic and systolic BP in 14 dependent and 18 non-dependent gamblers (dependence was judged on amount of money and time spent gambling). Participants were given £5 to gamble with on a familiar slot machine and one chosen by the researcher. Recordings were taken before, during, and after gambling. Systolic and diastolic BP rose just before play and during play, and dropped after play for both dependent and non-dependent gambling groups. There was no significant group difference in systolic BP; however, the dependent group had a significantly lower diastolic BP whilst gambling. It should be acknowledged that the dependent group also had lower baseline diastolic BP. Therefore, lower baseline diastolic BP may discriminate PGs from non-PGs rather than diastolic BP in response to gambling (Carroll & Huxley, 1994).

Meyer et al (2000) traced HR and salivary cortisol levels in 10 male blackjack gamblers in a casino setting. Participants in the experimental condition gambled using their own money. No money was wagered in the control condition in which the participants played cards. Heart rate and endocrine parameters were recorded at baseline, 30 min, and 60 min following commencement of each session, and again at
completion of the sessions. Compared to the control condition, both HR and cortisol levels had significantly increased at 30 minutes and remained elevated for the remainder of the gambling session. Cortisol levels decreased once gambling ceased. Meyer et al. (2000) concluded that gambling in real life environments increases cardiovascular activity and is accompanied by increased salivary cortisol levels.

As a follow-up study, Meyer et al. (2004) compared the HR and endocrine response patterns in PGs and non-PGs. The methodology and endocrine response pattern results were reviewed in Chapter 2. Both groups’ HR increased in response to gambling. PGs, however, had significantly higher HR during casino gambling than non-PGs. This finding supports suggestions that cardiac responses during gambling may discriminate PGs from non-PGs. PGs may be more aroused to gambling in general than non-PGs.

3.3.2 – Laboratory studies

In vivo assessment of autonomic arousal during gambling is hampered by ethical considerations. There is the risk that some gamblers who may be in treatment may be struggling to refrain from gambling and may not wish to be exposed to the natural setting. Imaginal studies and those conducted in a laboratory are considered an extension of previous research used with Post Traumatic Stress Disorder clients, where it is commonly deemed unethical to expose them to actual real life stressors or behaviour. Four studies (Blanchard et al., 2000; Diskin et al., 2003; Leary & Dickerson; 1985; Roby & Lumley, 1995) have studied autonomic arousal in response to gambling in general in the laboratory. A further five laboratory studies have included a focus on the effects of winning on autonomic arousal (Diskin & Hodgins, 2003; Goudriaan et al.,
2006; Sharp, 2004; Sharpe et al., 1995; Ladouceur, Sevigny, Blaszczynski, O’Connor, & Lavoie, 2003) and these are presented later in the chapter.

Leary and Dickerson (1985) monitored HR before, during, and after playing on a non-EGM poker machine in a laboratory setting. Changes in HR were compared between regular gamblers (n = 22) and non-regular gamblers (n = 22). Participants gambled a minimum of $3 of their own money, and received their wins at completion of the study. Before the gambling session, HR did not differ between the groups; however, during the gambling session the increase in HR was higher for the regular gamblers compared to the non-gamblers. HR after play was not analyzed, since the regular gamblers gambled longer and lost more money, which hindered comparison between these groups. Leary and Dickerson (1985) reported that the HR increases for both groups were small compared to those obtained by Anderson and Brown (1984) in response to casino blackjack. This may be due to the comparably smaller stake size when gambling on electronic machines (Leary & Dickerson, 1985). This study’s findings indicated that it is possible to measure HR increases in response to gambling on electronic machines in a laboratory environment.

Researchers in the laboratory have also utilised novel gambling tasks to investigate the importance of feedback regarding prediction accuracy without monetary gain or loss versus accuracy feedback combined with monetary contingency (Roby & Lumley, 1995). HR, SCL and skin temperature were monitored in 35 regular and 35 non-regular gamblers as they responded to a gambling task, which consisted of a panel with lights and buttons beneath the lights. Participants had to choose which light would be lit next. The task was experienced in two conditions. In the first task, participants gambled $20 on their predictions about a sequence of events and received both feedback and monetary outcome. Each trial involved a $2 wager. In the other condition, only
feedback about accuracy was provided, with no money wagered. During each condition, physiological recordings were obtained twice over 30-second periods. HR and SCL were greater, while skin temperature was lower, for both groups during actual gambling than in the feedback only condition, (Roby & Lumley, 1995). Regular gamblers exhibited greater changes in HR, SCL and skin temperature than did non-regular gamblers during the gambling condition. These results suggested that the possibility of monetary gain was an important motivating feature of gambling tasks and that it was associated with greater physiological changes than tasks simply involving feedback on accuracy (Roby & Lumley, 1995).

Autonomic arousal has also been monitored in response to imaginal gambling tasks in laboratory environments. Blanchard et al. (2000) measured differences in automatic arousal, as indicated by HR, BP and SCL between a group of seven PGs and seven age and sex matched non-regular gamblers to individualized audiotapes of the gamblers’ preferred form of gambling (sports betting, blackjack, craps, or horse races) along with some other control tasks (e.g. mental arithmetic). During the auditory simulation task, HR was significantly greater for PGs compared to the matched controls when listening to the gambling audiotapes. There were no significant differences between the groups in BP or SCL.

Blanchard et al. (2000) suggested that their findings confirmed that there is some degree of cue-specific autonomic arousal in PGs which is not displayed in non-PGs. Freidenberg, Blanchard, Wulfert and Malta (2002) subsequently have found that PGs with lowered SOGS scores following treatment have reduced reactions to gambling cue scenarios. The proposal that abnormal arousal levels may motivate abnormal gambling behaviour (PG) is collectively supported by these preliminary uncontrolled results.
(Freidenberg et al., 2002). Further examination of the proposed abnormal autonomic arousal responses of PGs to gambling is therefore warranted.

Notably, the differences in HR between groups found by Blanchard et al. (2000) were modest compared to those found in previous in vivo studies (Anderson & Brown, 1984; Griffiths, 1993b). Diskin et al. (2003) recently systematically compared arousal recorded in both laboratory and field environments. Fourteen PGs and 16 non-PGs gambled on electronic machines in both lounge and laboratory conditions. Diskin et al. (2003) found no difference in SCL between participants in laboratory and an in vivo gaming lounge setting. For all participants, HR and ratings of subjective arousal were higher in the lounge situation, while SCL did not differ between locations. SCL increased over baseline when gambling in both situations. The results initially suggested that increases in HR over baseline would only be recorded in the lounge situation, but by the end of gambling sessions, increases in the participants’ HR were also observed in the laboratory. These findings suggest that there is some justification for laboratory studies, the changes observed very specific and sensitive and thus of potential importance (Diskin et al., 2003).

3.3.3 – Summary and discussion

Autonomic arousal has consistently been found to increase in response to gambling in both field and laboratory environments. Moreover, changes in autonomic arousal have been greater when more money has been wagered (Anderson & Brown, 1984). Field studies (Anderson & Brown, 1984; Griffiths, 1993b; Meyer et al., 2000; 2004) have measured greater changes in HR than gambling in the laboratory (Leary & Dickerson, 1985; Roby & Lumley, 1995); and imaginal tasks (Blanchard et al., 2000). Due to limited studies, a comparison of other physiological measures is limited. However,
Diskin et al. (2003) demonstrated equivalent SCL changes in field and laboratory settings.

In regards to the four studies examining gambling on electronic machines (Diskin et al., 2003; Griffiths, 1993b; Carroll & Huxley, 1994; Leary & Dickerson, 1985), all studies indicated that gambling increases physiological activity. No studies have investigated the effects of wager size on autonomic arousal during gambling on electronic machines, however, physiological activity is less than in other forms of gambling, which involve larger individual bets (Leary & Dickerson, 1985). Only one EGM study (Diskin et al., 2003) has compared arousal in PGs and non-PGs. In this study, no significant differences were found between groups, HR and SCL increasing for both groups similarly. The preliminary findings therefore indicate that most players are aroused in response to gambling on electronic machines. Patterns of general changes in automatic arousal in response to sessions of gambling have thus far been unable to discriminate PGs from non-PGs. The following sections will evaluate the importance of winning on autonomic arousal experienced in response to gambling.

3.4 – Arousal in response to winning

The harms caused by gambling are most commonly observed where the individual persists with play despite net monetary losses (APA, 2000). Moreover, PGs when gambling on electronic machines rarely leave a session as a winner, as they have a proclivity to “reinvest” their wins (Schellink & Schrans, 2002; Dickerson et al. 2003). Given the consequences of gambling are more times than not negative (in monetary terms) for PGs, their remains doubt as to what is reinforcing about gambling activity. Recently, Wulfert, Roland, Hartley, Wang and Franco (2005) suggested that gambling activity may intrinsically produce heightened arousal (excitement) and that monetary
gain (i.e. winning) may be a secondary factor. The reactivity of individuals to winning and losing has therefore been examined. The review will once again be divided into field and laboratory investigations, with studies presented in chronological order within each section.

3.4.1 – Field studies

An early attempt to examine the effects of winning on arousal was conducted by Dickerson, Hinchy, England, Fabre and Cunningham (1992). Dickerson et al. (1992) monitored HR, play rate, winnings, subjective excitement and the expectation of winning for 10 regular EGM gamblers during play in a club setting. When cardiac activity, averaged for one-minute periods, was compared for no wins, small wins and big wins, no significant differences occurred. However, there was an observed trend for increased HR to small wins and more so for big wins. Notably, it was demonstrated that minutes in which small wins were present were associated with increased rates of play compared to no wins and big wins. Because of poor temporal resolution (averages over minutes rather than seconds) and differential physical activity following the event types, the observed changes in HR could be explained by factors other than monetary gains, somewhat limiting the value of the study (Dickerson et al., 1992). Nonetheless, the findings of this preliminary study indicated an importance of winning and the amount won, which subsequent studies have been able to replicate.

Coventry and Norman (1997) examined HR before, during and after horse races in 16 regular and 16 non-regular off-course gamblers. Coventry & Norman (1997) found that, across groups, HR for both winners and losers increased during races, however, gamblers who wagered on horses that won had significantly higher HR levels in the final 30 seconds of a race than those who had lost. No significant differences in
HR were found between the regular and non-regular gambling groups. Gambling was therefore found to be arousing, even when betting on losing horses, however, more so when backing winners (Coventry & Norman, 1997).

Coventry and Constable (1999) recruited 14 regular and 18 non-regular female gamblers and tested them in a bingo or leisure hall. Participants gambled with their own money on a specific slot machine. HR before, during and after play was recorded. In general, HR was higher during play than before or after play. There were no differences in HR between regular and non-regular gamblers. Coventry and Constable (1999) also compared the HR of participants who had won (n = 14) and lost (n = 18) overall. HR was greater during and after play for those who won, compared to those who had lost.

Similar to the above study, Coventry and Hudson (2001) examined HR before, during and after sessions of gambling on electronic machines in a field setting. Comparing responses of 22 male and 20 female gamblers, HR was again recorded to be higher during compared to before and after play for both groups. Winners were defined as participants who had experienced a win during a 3-minute gambling session. Although increases in HR were common for all participants, significantly larger changes in HR were found for those participants who had won (n = 9) than those who had lost (n = 9). People who had won had played significantly fewer trials than those who had lost. Coventry and Hudson (2001) suggested that this was particularly indicative that winning was important, as the winners would have experienced less of a HR increase as a result of motor activity alone than those who lost.

While Coventry and Hudson (2001) demonstrated an importance of having experienced a win, many of the participants who had won subsequently were losing by the end of the session. The results therefore indicated that overall financial gain was not necessary to increase arousal at the completion of the session. The experience of series
of small wins or big wins during play may maintain arousal for prolonged periods (Coventry & Hudson, 2001). Increased autonomic arousal captured following sessions of gambling could be a function of individual wins that deliver monetary gain over short periods or even in response to winning combinations of symbols that deliver no monetary gain. The findings highlight the importance of studying the effects of within-session wins and losses in the same individual.

Gee, Coventry and Birkenhead (2005) measured the subjective arousal of 17 gamblers (more than once per week) using an interactive voice response system via mobile phones, before, during and following a gambling episode. Eleven of the 17 participants called before, during and following sessions where they had won and lost. This therefore enabled a comparison of winning and losing sessions within individuals. During sessions of gambling, both winning and losing sessions were associated with increases in subjective arousal. Interestingly, gamblers following losing sessions reported more physiological arousal compared to winning sessions, which were followed by a large significant decrease in subjective arousal. This is contradictory to findings of previous field studies (e.g. Coventry & Constable, 1999; Coventry & Norman, 1997). However, it must be noted that Gee et al. (2005) measured subjective arousal within individuals, whilst the previous studies had compared changes in HR between winning and losing groups.

Moodie and Finnigan (2005) examined HR differences between frequent (used machines more than three times a week), infrequent (about two times a month) and non-gamblers (no gambling history whatsoever) while playing a fruit machine. The three groups also completed a SOGS Questionnaire (Lesieur & Blume, 1987) prior to being allocated to the groups. The three groups had significant differences based on their SOGS scores and all frequent gamblers met the cut off score for PG (i.e. 5 and above).
Frequent gamblers were found to have significantly higher autonomic arousal (HR) than infrequent and non-gamblers, with frequent gamblers HR continuing to rise after play, unlike the other two groups. Moodie and Finnigan (2005) also examined responses to within session win trials. There were significant increases in HR in response to wins. SOGS scores were observed not to be a significant predictor of a reaction to wins; however, amount won was a significant predictor. Greater HR increases were found with larger wins. The effect of SOGS scores on reactivity to losses was not reported. The researchers also analysed their data for the effect of wins by comparing between the groups. Frequent gamblers exhibited larger HR increases to wins than non-gamblers; however, there was no significant difference when comparing frequent to infrequent gamblers. It should be noted that the infrequent gamblers group did have some participants with SOGS scores above five, suggesting that it may have included some PGs. It is possible that PGs in the infrequent gambling group inflated the overall group means, reducing the differences between the frequent and infrequent gambling groups.

The Moodie and Finngan (2005) study showed that HR changes in response to individual wins during sessions of electronic gambling can be measured. As outlined in Chapter 2, these event-related HR changes can be considered examples of phasic recordings. Unlike previous field studies, which had sampled responses to winning over long periods (tonic recordings); Moodie and Finnigan (2005) measured HR changes across several seconds between each bet on the electronic machine. This methodological development reduced the possible influence of confounds, such as motor activity and losing trials, on arousal recorded in response to wins (e.g. Dickerson et al., 1992), hence the study’s findings are valuable. However, because gambling was interrupted between trials for recordings to take place the results could be confounded by the effects of these interruptions and the potential frustration caused. Also effects of losses were not
studied, so a comparison of physiological responses to wins and losses during gambling on electronic machines is likely to complement these findings.

3.4.2 – Laboratory studies

Sharpe et al. (1995) compared SCL, EMG and HR in 13 PGs, 12 regular and 13 non-regular gamblers in response to five laboratory tasks. All PGs stated a preference for gambling on poker machines. Two tasks monitored participants as they watched a poker machine video. The third involved watching a video taped horse race, while the fourth asked participants to imagine a personally relevant win. A control task (counting the alphabet) was also included. SCL was significantly higher for PGs than the control groups when watching videos of gambling stimuli. Regular and non-regular gamblers did not differ on measures of SCL to the gambling video tasks. In fact, the regular and non-regular gambler groups did not differ on any physiological measure. There was a trend for PGs to have increased EMG responses to imagined personally relevant winning situations than the two control groups. No significant differences in HR were found between groups for any of the five tasks. These findings indicate that PGs had higher autonomic arousal levels as measured by SCL compared to both control groups, and that gambling stimuli, particularly winning cues, are more arousing to PGs. Notably, the PGs, all who had a stated preference for gambling on electronic machines, responded significantly more to the poker machine videos than the other gambling cues (horse race video). This supports arguments that arousal needs to be measured in response to individual forms of gambling (Griffiths & Delfabbro, 2001).

Coventry and Norman (1998) assessed arousal of 54 undergraduate students during a laboratory gambling task in which win and loss contingencies were presented in ascending (winning more as the task continued), descending (winning less as the task
continued) or random order. The task consisted of a computer screen in which four turtles in a circle were presented. Prior to the task beginning, participants had to choose the turtle that they thought would win a race. The schedule of wins and losses (ascending, descending, or random) was unknown to the participants. Participants were encouraged to influence the outcome of the race, without making contact with the machine and to say their thoughts aloud. Coventry and Norman (1998) observed no effect of ascending, descending, or random win/loss contingencies on HR. Small HR increases were observed in the early trials for all three groups. Winning trials resulted in a higher HR than losing trials. An interaction was found between the win/loss trials and the schedule of wins and losses; in the descending contingency wins produced a lower HR than losses and in the random condition wins produced a higher HR than losses, while in the ascending condition there was no difference in HR during wins or losses. This study demonstrated that arousal in response to wins was influenced by the sequence of wins experienced each group. This highlights the importance of studying changes in arousal to wins and losses within individuals across time. Moreover, studies that sample arousal in response to only one win or loss may be limited in their ability to be generalised.

The importance of the outcomes of gambling tasks having expected value to participants has been replicated in recent research (Ladouceur et al., 2003). Ladouceur et al. (2003) examined the relationship between the anticipation of monetary gain and HR in 34 occasional and regular gamblers, who were non-PGs according to their SOGS scores (Lesieur & Blume, 1987). The authors randomly assigned participants to two experimental groups (nine males and eight females in each): high winning expectations or low winning expectations. Each group started at rest, then listened to instructions and familiarized themselves with the electronic machines by playing 50 games set at a 92
percent return. The investigators then informed participants that the machines would now yield a 200 percent payout and told the high winning expectation group they could win up to $40, while the low expectation group could only win valueless “credits”. Controlling for participants prior gambling experience and baseline HR, Ladouceur et al. (2003) found that participants in the high expectancy group were significantly more likely to have an increased HR than those in the low expectancy group when informed of potential winnings. The differences between groups were evident following instructions that they could win. During the gambling episode, the differences between groups were significant, but less than in response to the instructions. It should be noted that the instructions presented participants with an unusual and perhaps unrealistic gambling condition in which they would win double their bet with no possibility of loss. Participants’ responses, then, might represent anticipated monetary gain rather than gambling-related monetary gain and loss. Despite these concerns, this research suggests that instead of the common report that people gamble primarily for the excitement of the game in general, the effect of monetary gain, or expectancy there of, might be an important factor increasing arousal among gamblers and in particular PGs. Moreover, the physiological findings support previous findings that arousal responses during gambling are likely to be greater when tasks involve the possibility of monetary gain (Roby & Lumley, 1995).

Diskin and Hodgins (2003) measured SCL, HR, EMG and subjective excitement of 30 PGs and 34 non-PGs who played on a commercially available EGM in a laboratory setting. Participants did not use their own money to gamble, but were able to win a maximum cash payout of $50.00 on the machines. All participants demonstrated significant increases on all three physiological measures of arousal during the first two minutes of gambling. There were no significant differences between groups on HR,
SCL, or EMG, but, the HR of PGs was generally higher than non-PGs. Because physiological changes were not time-locked to win and loss event markers, it was unclear whether the changes observed were related to factors associated with gambling in general (e.g., expectation and engagement) or whether they were event-related (e.g., win or loss). Diskin and Hodgin (2003) also asked participants to imagine a personally relevant win and loss in a separate experimental task. Both groups experienced significant increases in EMG and SCL when thinking about personally relevant wins, and increases in SCL and HR when thinking about personally relevant losses. PGs may perceive their physiological responses to gambling and gambling cues differently than non-PGs, since PGs rated their levels of subjective excitement higher than non-PGs despite having similar physiological recordings to non-PGs (Diskin & Hodgins, 2003). These findings also highlighted that multiple physiological measures may be necessary to examine autonomic arousal in a comprehensive manner.

Sharpe (2004) compared the reactivity of 13 PGs as indicated by SOGS scores (Lesieur & Blume, 1987) and 20 non-PGs in imaginal situations of winning and losing. Participants were directed to describe a situation where they had won and lost during a period of gambling. Before and during the imaginal recalls, SCLs of participants were recorded. Sharpe (2004) reported that the non-PGs became more aroused in response to winning than losing, whereas, the PGs reacted equally to both scenarios. Sharpe (2004) indicated that this means that any outcome whilst playing for PGs may have the same physiological impact (i.e. promote continued play). Moreover, it is suggested that a lack of discerning responses to losses may support the notion that gamblers think they are on the verge of a big win, or that every loss is a “near miss” therefore they feel the same regardless (Custer, 1984; Griffiths, 1991). This research infers that the unwarranted expectancy of wins might be the most important factor increasing arousal among PGs.
during gambling activity. Therefore, investigations focusing on the interactions between cognitions and physiological reactivity to gambling tasks are again supported.

Specifically, investigations into the separate effects of winning or losing events during gambling within the same individual have rarely been obtained (Goudriaan, et al., 2004). A recent laboratory investigation of psychophysiological differences between PGs and non-PGs highlights the need to focus on these differences (Goudriaan et al., 2006). Goudriaan et al. (2006) used contemporary psychophysiological equipment to consistently monitor HR and SCRs, which were synchronised to the nearest millisecond with wins and losses experienced during a computer simulated task (IGT; Bechara et al., 1994). Monitoring physiological responses to wins and losses in rapid succession ensured phasic changes in physiology were obtained. Physiological activity (both HR and SCRs) in anticipation of events that carried greater risk were observed to be significantly higher for the non-PGs than PGs. PGs performed worse on these trials and Goudriaan et al. (2006) suggested that this may reflect lowered risk assessment abilities as a consequence of lowered arousal compared to non-PGs. Goudriaan et al. (2006) reported that non-PGs exhibited greater increases in HR immediately following winning events than the PGs. No differences in HR or SCRs in response to loss events were observed. The absence of a response to wins in problem gamblers during the gambling task was theorised to represent decreased physiological reward sensitivity in the clinical group (Goudriaan et al., 2006).

It should be noted that the degree to which the IGT reflects gambling activities, particularly EGM gambling is uncertain. Nonetheless, the Goudriaan et al. (2006) study demonstrated that phasic changes in autonomic arousal could be rapidly monitored in response to advantageous (win) and disadvantageous (loss) events in a gambling task within a laboratory environment. Moreover, the group differences obtained support a
priority for research to focus on phasic arousal changes within gambling activities in addition to tonic arousal changes associated with gambling in general.

3.4.2.1 – Somatic marker hypothesis

As highlighted in Chapter 2, the IGT, which was utilised by the Goudriaan et al. (2006) study, was designed to simulate real-life decision making in the way it factors in uncertainty, reward and punishment (Bechara et al., 1994). Empirical evidence gained via the use of the IGT has formed a major piece of the underpinnings for what Damasio (1994) termed the somatic marker hypothesis. The somatic marker hypothesis asserts that when making decisions physiological signals, known as a ‘somatic markers’, help inform individuals of their emotions in response to a choice (Damasio, Tranel &. Damasio, 1991). A somatic state is therefore generated following every response option considered, together with sensations in the bones, muscles, internal organs and neural anatomy (Damasio, 2004). Somatic markers assist individuals in the registering of the value of experiences, choices and outcomes; directing working memory and what the individual gives attention to (Damasio, 2004). Damasio (1994) theorised that only those options marked as promising are fully attended to and processed in a cognitive fashion.

Dunn, Dalgleish and Lawrence (2006) surmised that how an individual evaluates the somatic state information determines if they are more likely to approach or withdraw from choices, behaviours and situations. Somatic markers operate at a conscious and unconscious level. Some are overt and allow individuals to link physiological and emotional changes within themselves to particular choices and response options, and others are covert, where individuals are unaware of how their emotions and physiology interact (Dunn et al., 2006).
The distinction between overt and covert physiological changes in response to emotions was highlighted by the investigations of Rainville, Bechara, Naqvi and Damasio (2006). Rainville et al. (2006) identified distinctive patterns of cardio-respiratory activity to four basic human emotions (anger, fear, happiness and sadness). Notably, recall of all four emotions was associated with an overt increase in HR for participants; however, what differentiated exposure to the emotional cues were less perceptible (covert) changes in the frequencies of HR and respiration (Rainville et al., 2006). The findings from the Rainville et al. (2006) study emphasise that a focus on physiological measures, which are easily perceptible and/or accessible via self-report by the individual, may not accurately represent all the physiological processes involved in a behavioural response. Accordingly, gambling behaviour, and for that matter, behaviour in general, is proposed to be experienced and pursued at a conscious level (including physiological changes perceived by participants) and unconscious level (including physiological changes not perceived by participants).

In line with the somatic marker hypothesis, Goudriaan et al. (2006) investigated subtle psychophysiological changes, believed to be quite imperceptible. PGs, in fact, were found to have diminished somatic responses (as measured by small changes in cardiac and electrodermal responses) prior to disadvantageous deck choices (losses). The lack of or deficits in somatic markers to risky situations could be associated with behavioural deficits observed in PGs including not focusing on or heeding the warning signals that losses potentially offer (Damasio, 1994). With some physiological changes being less perceptible than others, research that focuses on objective measurement of bodily changes (somatic markers) may result in better understanding of the determinants of PG (Goudriaan et al., 2006).
Based upon studies using the IGT, Damasio (1996) proposed three possibilities as to why target patients (e.g. PGs) pursue immediate rewards over delayed, and commonly more severe punishments:

1. That PGs are so sensitive to immediate reward that the prospect of future (delayed) punishment is outweighed by that of immediate gain.
2. That PGs are insensitive to punishment, therefore the possibility of winning always prevails in directing gambling behaviour, even if they are not abnormally sensitive to rewards.
3. That PGs are generally insensitive to outcomes, positive or negative.

In order to investigate Damasio's (1996) three theoretical explanations of PG (above), researchers will have to closely monitor physiological activity during gambling tasks in real time. Paradigms will need to include the indexation of events and outcomes within gambling tasks as rewards (i.e. wins) and punishment (i.e. losses). Furthermore, between-groups designs that allow for comparison of the physiological responses of PGs vs. non-PGs will be essential to the testing of the proposals.

Importantly, somatic markers are conceived to merely assist in decision making and are not deterministic, nor involved in every decision (Damasio, Bechara & Damasio, 2002). For this reason, some PGs can, at points throughout their gambling history, end their participation prior to experiencing significant monetary losses. Likewise, some individuals may have strong non-physiological aids (e.g. rational gambling related cognitions), which help inhibit their development of PG. It is therefore pertinent that researchers investigate both physiological and non-physiological determinants of the behaviours (see Sections 1.7 and 1.8).
3.4.3 – Summary and discussion

Physiological measures have consistently demonstrated that winning is associated with increases in autonomic arousal. Three field studies (Coventry & Hudson, 2001; Coventry & Norman, 1997; Dickerson et al., 1992) and three laboratory studies (Coventry & Norman, 1998; Goudriaan et al., 2006; Sharpe, 2004) compared the effects of winning versus losing. The findings from these studies indicate that winning is associated with greater increases in autonomic arousal than losing. Moreover, increases in HR are greater when winning more money on EGMs (Dickerson et al., 1992; Moodie & Finnigan, 2005).

The results of studies when PGs and non-PGs are asked to imagine wins are inconsistent. Two studies have indicated differences in responding between PGs and non-PGs (Sharpe et al., 1995; Sharpe, 2004), however, one study found no significant differences between groups (Diskin & Hodgins, 2003).

Only one study compared the effects of winning and losing between groups of PGs and non-PGs (Goudriaan et al., 2006). This laboratory study focused on event-related phasic changes and demonstrated that PGs exhibited less autonomic arousal than non-PGs immediately following wins. PGs were also shown to have lower autonomic arousal prior to risky outcomes.

However, in one study that only obtained a subjective measure of arousal, winning was associated with reductions in physiological activity, while losing was followed by slight increases (Gee et al., 2005). These subjective recordings included measures of agitation; therefore, the study may have measured anxiety in response to winning and losing rather than excitement achieved. This may explain the contradictory findings. Alternatively, an explanation of the mismatch between objective and subjective measures of arousal during gambling is supported by empirical evidence that
gamblers selectively attend to stimuli (Gilovich, 1983, 1986; Gibson, Sanbonmatsu, & Posavac, 1997) and hold differing beliefs about winning (Jefferson & Nicki, 2003). Positive arousal states (i.e. excitement following wins) may be perceived less than negative arousal states (i.e. agitation following losers) and may be moderated by erroneous beliefs that wins are inevitable (Weatherly, Sauter, & King, 2004).

In regards to the five studies examining gambling on electronic machines, only one study (Moodie & Finnigan, 2005) focused on event related phasic changes in autonomic arousal. HR in response to wins was increased for all gamblers. Frequent gamblers (PGs) responded more to wins than infrequent and non-gamblers. No analyses of phasic responses to individual losses were reported. Responses to wins were independent of SOGS scores.

Findings from the studies reviewed indicate that winning increases autonomic arousal. Notably, participants who have experienced wins display greater changes in autonomic arousal than those only experiencing losses, despite not obtaining financial gains at the conclusion of gambling sessions (Coventry & Hudson, 2001). Moreover, autonomic arousal has been found to increase at the onset of the possibility of monetary gain (Ladouceur et al., 2003). These findings both support theories that gambling is inherently arousing and that actual monetary gain may act as a secondary reinforcer (Wulfert et al., 2005). Preliminary investigations have indicated that phasic arousal changes during gambling differ between PGs and non-PGs (Goudriaan et al., 2006; Moodie & Finnigan, 2005). Systematic analyses of the autonomic arousal of gamblers prior to, during and following win and loss events during sessions of electronic gambling should help determine the significance of monetary gain.
3.5 Factors affecting arousal during gambling

The following sections review research, which has investigated arousal in response to gambling and the influence of other variables on the levels of arousal demonstrated. Although limited studies have investigated these relationships, there is evidence that cognitions, personality (impulsivity) and alcohol may mediate arousal associated with gambling behaviours.

3.5.1 Cognitions

Griffiths (1991) suggested that a gambler’s cognitions might work together with physiological factors such as arousal to help explain the maintenance of PG. When a PG wins or nearly wins, they may get physiologically aroused and their cognitions suggest that they are not constantly losing but constantly “nearly winning” and, thus, this stimulates further play (Griffiths, 1991). Coulombe et al. (1992) investigated the relationship between levels of arousal during gambling and erroneous perceptions during gambling on electronic machines. Twelve regular and 12 non-regular gamblers were asked to “think-aloud” whilst playing, stating their thoughts as they gambled. During the gambling session HR was monitored. Regular and non-regular gamblers showed similar increases in HR during play, compared to baseline recordings. Additionally, frequency of irrational verbalisations was found to correlate significantly with HR during gambling. Coulombe et al. (1992) did not measure changes in HR related to winning, however, the findings did support proposals that both cognitions and arousal may maintain PG.

In support of these experimental findings, clinical interventions for PG have focused on both the reduction of cognitions and physiological responses to EGMs.
These studies have reported promising clinical improvements over the medium (Tolchard et al., 2006) and long term (Oakes et al., 2008). These cognitive treatments have included exposure sessions that do not involve actual gambling participation, but rather restraint in lieu of strong physiological urges to gamble that are prompted by gambling stimuli. Oakes et al. (2008) stated that increased awareness of both cognitive distortions and physiological reactions weakens associations between gambling triggers (cognitions), arousal and gambling behaviours.

Townshend (2005) reported on the use of providing biofeedback during in-vivo exposure tasks in which PGs in treatment actually gambled. BP and HR tended to increase in response to gambling for PGs (n = 5) on electronic machines, however, the amount of this increase tended to reduce following each in-vivo desensitisation session conducted. Although treatment effects were not investigated, client reports indicated biofeedback was helpful, particularly, in its ability to make them aware of their physiological reactions to gambling and for enhancing their sense of control over their thoughts and physiological reactions to the machines (Townshend, 2005).

The above experimental and clinical findings suggest that the cognitions and changes in arousal experienced in response to gambling are related. This relationship in response to gambling and winning on electronic machines warrants further evaluation.

### 3.5.2 – Impulsivity

Krueger, Schedlowski and Meyer (2005) examined the relationship among gambling behavior, impulsivity, the cardiovascular system and the hypothalamic-pituitary-adrenal axis activity in blackjack gamblers. Employing a similar methodology to Meyer et al.
(2004; see Chapter 2), 29 males were continuously monitored before, during and after a 90-min blackjack session in a casino wagering their own money. Participants were also monitored during a control condition where participants played cards for the accumulation of points. Both HR and cortisol levels significantly increased with the onset of gambling and remained elevated throughout the test session compared to the control condition. Analyses revealed that high impulsivity gamblers had significantly higher HR compared to the low impulsivity subgroup during play. No differences were observed between the groups in cortisol levels. A positive relationship was found between impulsivity scores and severity of PG. These results provide some preliminary support for arguments that impulsivity may be an important factor mediating gambling behavior and associated autonomic responses (Krueger et al, 2005). The influence of impulsivity on arousal responses to winning has not been investigated by research before. Studies are therefore required to further examine the relationship between personality traits and physiological reactivity of gamblers during gambling tasks. This may further enhance our understanding of the development and maintenance of PG.

3.5.3 – Alcohol

Arousal during gambling may also be mediated by alcohol consumption. Stewart, Collins, Blackburn, Ellery, and Klein (2005) examined HR during gambling on electronic machines and alcohol consumption, alone and in combination. Forty-four regular gamblers were randomly assigned to a moderately intoxicating dose of alcohol or a control (non-alcoholic) beverage condition. HR was taken at three times: at a pre-drinking baseline, at a post-drinking baseline, and during gambling. The results showed that alcohol consumption alone increased HR, that gambling on electronic machines
alone increased HR among participants in the control condition, and that increases in HR were greatest when participants both gambled and had consumed alcohol.

The above findings are mostly replicated in a comparison of 30 PGs and 30 non-PGs (Stewart, Peterson, Collins, Eisnor, & Ellery, 2006). Stewart et al. (2006), however, found there was no significant increase in HR following alcohol consumption alone, only following gambling. HR was again greatest for those participants who gambled and had consumed alcohol. No significant between groups differences were found in HR following alcohol consumption, during gambling or in combination.

The findings of both studies investigating alcohol consumption, arousal and gambling suggest that the reinforcing power of arousal changes during gambling on electronic machines is enhanced when combined with alcohol consumption. This may help explain why the behaviours (gambling and drinking alcohol) are often pursued together in both clinical and non-clinical populations (Stewart et al., 2006). The findings emphasise that it is important for researchers to control alcohol consumption during gambling tasks in which you are monitoring autonomic arousal responses.

### 3.6 – General Discussion

Results from the studies reviewed support conclusions that gambling increases autonomic arousal. Moreover, there is evidence that physiological responses to gambling are greater when winning. Increases in autonomic arousal are much larger when gambling is monitored in natural environments. It is also evident that tasks involving the possibility of monetary gain (as compared to points or credits of no material significance) generate the greatest arousal responses. Nonetheless, laboratory studies have revealed increases in autonomic arousal to gambling and to winning, supporting their utilisation. Findings have suggested that the amount won (Dickerson et
al, 1992; Moodie & Finnigan, 2005) mediates physiological activity. Additionally, it has been found that physiological reactivity is greater in response to greater risk (Goudriaan et al., 2006) or when more money is wagered (Anderson and Brown, 1984) during gambling. Blackjack and horse racing have been associated with greater changes in autonomic arousal to gambling and winning than when gambling on electronic machines. These activities commonly involve greater stakes than EGMs. These differences in staking levels alone highlight the need to investigate the relationship between autonomic arousal and forms of gambling individually.

In terms of group differences, there is evidence for abnormal autonomic arousal responses in PGs compared to control groups, to both gambling and winning. However, the direction of differences is not always consistent. Several studies have reported significant differences in autonomic arousal between regular and non-regular gamblers; however, an equal number has found no differences. Moreover, results are inconclusive as to whether prior gambling histories are responsible for between-group arousal differences observed during gambling or in response to winning.

There is a diversity of sampling methods used by studies. Large differences are evident for the criteria used to define high (regular) and low frequency (non-regular) gamblers, and PGs (Goudriaan et al, 2004). Several data sets are classified using somewhat subjective criteria, such as gambling more or less than once a week (e.g. Griffiths, 1993b; Coventry & Constable, 1999). The findings of Moodie and Finnigan (2005), who used relatively stringent standards for classification, reveal a higher HR increase in the frequent (PG) group compared to the infrequent and non-gambler groups. The lack of differences between groups in autonomic arousal to gambling and
winning in some studies (e.g. Coulombe et al., 1992; Coventry & Constable, 1999) could be due to the application of less stringent criteria (Goudriaan et al., 2004).

In combining different research methods and improving methodology of studies, a better insight into the aetiology of PG can be developed, and this will ultimately enable the development of new interventions that meet the needs of the heterogeneous group of PGs (Blaszczynski & Nower, 2002). A review of the previous methodologies allows for several recommendations for psychophysiological studies into gambling (Goudriaan et al, 2004). The study by Sharpe et al. (1995) included both PGs and non-PG controls. Its findings emphasise the importance of investigating PG groups: the arousal pattern of the PG group was different from both high and low frequency gamblers, whereas both high and low frequency players did not differ in arousal. This was replicated in the Moodie and Finnigan (2005) study. These findings argue against the idea that arousal levels increase along a continuum of gambling activity (i.e. non-regular, regular, problem and pathological gamblers). Both studies reported that the frequency of gambling does not necessarily correlate with a PG diagnosis, whereby classification as a PG is possible even when gambling only once a month. Therefore, using stringent criteria to define non-adaptive (PGs) and adaptive gamblers (non-PGs) is likely to provide less confusion when interpreting results, than having participants divided into groups based upon play frequency or amount wagered.

Measures of autonomic arousal differ and the majority of studies only report on a single physiological or subjective arousal measure (Goudriaan et al., 2004). Physiological changes in response to gambling have commonly been investigated by monitoring HR alone. Although studies have consistently found increases in HR to gambling, the findings are less consistent when examining the effects of winning. HR
has commonly been measured as averages derived following long periods of gambling (tonic measures). A limitation of such measurement is that the experience of the “high” that has been recorded in response to gambling and winning is likely to have been affected by confounding factors, such as the context or sequence of wins and losses experienced (Coventry & Hudson, 2001); or those related to physical movements (Dickerson et al., 1992) and/or use of chemical substances (e.g. alcohol) prior to or during the gambling session (Stewart et al., 2005; 2006). Consequently, physiological data averaged over gambling sessions does not yield a clear picture of how individuals respond to the different events including wins and losses within a gambling session. The sensitivity of previous findings to changes in autonomic arousal is therefore likely to have been reduced and needs to be complemented by investigating event-related (phasic) changes.

In terms of non-cardiac measures of autonomic arousal, skin conductance has been used in a third of studies and appears to be sensitive to both gambling and winning. 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; Rushby & Barry, 2006). The research within the gambling domain supports the relevance of using electrodermal measures. Changes in the laboratory for SCL have been comparable to changes elicited in field settings (Diskin et al., 2003). The same is not true of HR. Importantly, Goudriaan et al. (2006) demonstrated that like HR (Moodie & Finnigan, 2005), measurements of electrodermal activity can capture phasic changes in physiological activity. This study was conducted in a laboratory environment. Although there is useful and relevant research on the effects of gambling on cardiac activity, especially HR, there is a need for a systematic
and more comprehensive examination of other physiological responses associated with arousal.

It is also evident that group differences are not identical across physiological measures. A confirmation of autonomic arousal differences between PGs and non-PGs in response to gambling and winning is likely to require an examination of the extent of overlap and interaction among the various physiological measures. Moreover, it is unwise to assume that the same physiological mechanisms will be activated during different forms of gambling (Griffiths & Delfabbro, 2001).

Coventry and Hudson (2001) argue that a detailed analysis of the interaction between physiological and psychological factors in response characteristics within gambling tasks are crucial for an understanding of factors influencing continued gambling behaviour. Despite methodological problems, converging evidence from several domains indicates that biological factors, especially arousal mechanisms are likely to have an important role to play in the development and maintenance of PG (Blaszczynski & Nower, 2002; Meyer et al., 2000, Sharpe, 2002). It is acknowledged, however, that there is also data that suggest personality traits and irrational cognitions may mediate autonomic arousal in response to winning. These relationships need to be further analysed.

3.7 – Research Aims

As reviewed in Chapter 1, in Australia more money is spent gambling on electronic machines than all other forms of gambling combined. Moreover, EGMs are most commonly associated with PG. The reinforcing qualities of these devices are not fully understood. Given this lack of knowledge and the findings of the current review, this thesis aims to:
1. Investigate whether changes in SCL and HR when gambling on electronic machines as they occur in real time, can be reliably measured by current physiological equipment and computer technology.

2. Capture phasic changes in SCL and HR in response to winning and losing events experienced within sessions of gambling on electronic machines.

3. Determine the importance of the amount won and wagered on autonomic arousal during gambling.

4. Examine associations between arousal in response to gambling and psychological factors, such as gambling related cognitions and impulsivity.

5. Compare physiological activity displayed by PGs and non-PGs when gambling on electronic machines.

The following chapters present a three-stage program of empirical research that utilises state-of-the-art psychophysiological equipment that can measure phasic changes in both HR and SCL in response to wins and losses. This data will help determine whether changes in physiology may be generated by the possibility or the actuality of winning.
Chapter 4 – Study A: Win and loss events during gambling on an electronic machine: A pilot psychophysiological investigation

4.1 – Overview

This chapter focuses on a pilot laboratory study that used state-of-the-art psychophysiological equipment to monitor changes on a second-by-second basis of electrodermal activity (SCL) and heart rate (HR) of twelve university students to win and loss events while gambling on an EGM. Significantly, this study showed that current technology can reliably measure changes in HR and SCL to win and loss events during gambling. Each win and loss event was recorded and physiological changes associated with these events were sorted and averaged based on event type (win/loss) and time (pre- and post- events). Non-PGs demonstrated significantly increased electrodermal activity to wins, compared to losses, with SCL increasing immediately after wins, reaching a peak 4-8 seconds after the event and returning to baseline by 15 seconds post-win. HR activity showed a similar pattern although changes were marginal and did not reach significance. The study has important theoretical and clinical implications and these applications are discussed.

The data from Study A were presented at the 17th Annual Conference for the National Association of Gambling Studies, 14-16th November, 2007, Cairns, Australia (Wilkes, Gonsalvez & Blaszczynski, 2007a). A report on the study has also been published in the peer-reviewed journal Gambling Research (Wilkes, Gonsalvez & Blaszczynski, 2009). The title of the manuscript is “Psychophysiological responses to win and loss events during electronic gaming machine (EGM) play: A pilot investigation”.
4.2 – Aims and hypotheses

This present study can be viewed as a laboratory adaptation of the previous research into the effects of gambling and winning on the autonomic arousal of players during gambling. Similar to prior research, it investigates the association between autonomic arousal and gambling activity, but it extends this research by looking specifically at differences in arousal in response to wins and losses on an EGM. This pilot study was designed to address the criticisms of previous research outlined by Goudriaan et al. (2004) and to take advantage of sophisticated contemporary 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 pilot study used use a real (not computer simulated) EGM for this purpose.

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 SCL. It was also hypothesised that cognitions and subjective urges about gambling would be associated with psychophysiological responses to wins and losses during EGM play.

4.3 – Method

4.3.1 – Participants

Participants were drawn from introductory psychology classes in a university setting. Twelve people (10 females; 2 males) responded to an intranet-based advertisement to complete the study for research participation credits (see Appendix D). 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.

4.3.2 – Design
The study followed a 2 (win or lost events) x 4 (time intervals) repeated measures design. The two dependent variables were SCL and HR.

4.3.3 – Materials
The EGM.
Participants used a real (not computer simulated) EGM named “Alchemy” supplied by Aristocrat Technologies Australia Ltd © 2003. In the laboratory, the machine was positioned on top of a blue base station, which was also supplied by Aristocrat Technologies Australia Ltd. The combined height of the EGM and base is 1875 mm, with a maximum width of 750 mm. A photograph of the EGM as positioned in the laboratory is depicted in Appendix Q.

The “Alchemy” device is a one-cent EGM featuring a 5 (column) x 3 (row) matrix, which allows players to bet between one and 20 cents (credits) across 1, 5, 10, 20 or 25 lines. The machine allows for a minimum wager of one cent and maximum wager of five dollars. Picture 1 in Appendix R shows that the Alchemy EGM has five buttons that manipulate how many credits are bet on each play and five that control how many lines are played on each individual spin (picture 2, Appendix R). Similar combinations of these two parameters on EGMs are currently in use in many clubs in Australia.

The EGM utilises a variety of icons on its “reels” during play. These are depicted with their winning credit values in pictures 3 and 4 of Appendix R. Like most EGMS used in
Australia, the EGM has a gamble function, which allows players to reinvest their wins in an attempt to double or quadruple outcomes. The parameters of these play characteristics on the EGM are represented in pictures 5, 6, 7, and 8 of Appendix R.

It was forbidden by New South Wales Government legislation and the EGM creators for any of the internal mechanisms or controls to be altered for the purposes of research. Like most EGMs, the Alchemy EGM has a variety of pre-programmed sound and visual effects associated with gambling outcomes. The EGM manufacturers did not give the researchers permission to modify the program and hence, the EGM was used under standard club settings with one exception: the volume was set to its lowest level. As with all EGMs, the duration and intensity of auditory and visual effects delivered by the Alchemy is closely related to event outcomes. Few if any changes in visual and auditory stimuli occur following losses. Conversely, wins are associated with varied visual and sound effects (see Dowling et al., 2005; Griffiths, 1993a for a review of structural characteristics of EGMs).

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; see Appendix B) 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; see Appendix C) 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 SCL and HR 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 32 mm³), 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 mid-sternum. 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.
4.3.4 – Procedure

Ethical approval for the research project was granted by the Human Research Ethics Committee of the University of Wollongong. Participants were asked to read the information sheet attached to the intranet advertisement prior to responding for more information and booking a recording time (see Appendix D). Before any data was collected, the rationale and methods of the research were verbally explained to participants and they were presented with the Participant Information Sheet (see Appendix E). Participants were then asked to complete the Participant Consent Form (see Appendix F). The researcher then completed the AMS Participant Data Sheet (see Appendix G) recording answers given by participants. Participants reporting smoking, alcohol or medication use in the two hours prior to physiological testing were excluded.

Experimental sessions were conducted individually in a university-based laboratory setting. Participants 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 participants played the low and high stakes conditions in counterbalanced order, with the free-stakes condition always completed as the final session of testing. Participants had 2-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 5000 credits ($50) at the beginning of the session and was informed that they would win an entertainment voucher (cinema ticket valued at $11.70, which could not be used for gambling purposes) if they had
more than 7000 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. 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 video camera captured the EGM’s screen to allow the researcher to monitor trial-by-trial choices made by the participant. Each session of gambling was recorded, which allowed for the marking of event outcomes to be checked post recording. Seated in an adjoining section of the laboratory, the researcher marked events with button presses on a computer keyboard. An event was marked as a “win” (by pressing the J key) if the outcome of the bet resulted in an increase of credits (prominently displayed on the screen) and as a “loss” (by pressing the L key) if no return was paid to the player.

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.

4.4 – Data analysis and results
A 20-second epoch for each win and loss, commencing 5 seconds before to 15 seconds following events were captured and averaged. The averaging procedure that time-locks physiological changes to events, is used routinely in event-related brain potential recording to neutralize effects of random physiological fluctuations. A similar procedure was employed here for similar reasons. The results are depicted in Figure 1.
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. Error bars are the standard errors of the means.

Study A was a trial of the psychophysiological equipment. The sample mainly comprised of inexperienced EGM gamblers. For the purposes of the pilot laboratory study, only the data from the free stakes condition were analysed.
For purposes of statistical analyses, the data were collapsed to four time intervals. Participants HR and SCRs were averaged across 5 to 2 seconds prior to the event (baseline; B) and 3 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 one second). Researcher response time and accuracy is assessed in response to a computer simulated recording task in Study B (see Chapter 5 for full explanation).

Psychophysiological Responses to EGM play.

A 2 Event type (win/loss) X 4 Time (B, PE1, PE2, PE3) repeated measures ANOVA was conducted separately for the electrodermal and cardiac data. In order 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 or were examined. As the planned contrasts met the degrees of freedom for effect criteria, no Bonferroni-type adjustments for probability levels (α 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).

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 3 contrasts for Time (B vs. PE1; B vs. PE2 and B vs. PE3) were not significant. However, Event x Time interactions were significant: for B vs. PE1, $F(1,11) = 6.63, p < .05, \eta^2_p = .38$; and for B vs. PE2, $F(1,11) = 5.14, p < .05, \eta^2_p = .32$. 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.

**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, $r(12) = .33, p = .30$, and when wins and losses were considered separately: for wins, $r(12) = .33, p = .30$; for losses, $r(12) = .33, p = .29$. In order to investigate relationships between HR and SCL changes, differentials between baseline measures and at PE1 were computed and correlated. Time segments PE2 and PE3 were not considered because they may have been compromised by arousal changes prompted by subsequent win or loss events. The correlations between the SCL and HR changes (B to PE1) were 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, $r(12) = .46, p = .14$. 
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 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. In order 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 B-to-PE1 changes. 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.

4.5 – Discussion

The data generated by this pilot laboratory study (Study A) 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 an increase in electrodermal activity, while losses were found to be followed by marginally decreased arousal levels (Figure 1). Despite not wagering their own money, physiological measures were shown to be robust and sensitive to changes associated to event types on an EGM in a laboratory setting.
The results indicate that for healthy normals both cardiac and electrodermal responses last for about 10-15 seconds before returning to baseline (Figure 1). EGM events occur in close succession, in most cases occurring within a matter of a few seconds of each other (Dowling et al., 2005). The finding that the increases in electrodermal activity (SCL) evoked by wins last for a substantial period (about 8-12 seconds in this study) suggests that participants were reinforced physiologically despite the presence of new stimuli (events). In real life situations when the participant’s money is wagered these responses are likely to be amplified and the associated physiological changes may last even longer.

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 previous studies (Diskin et al., 2003) that have found greater HR arousal in field versus laboratory settings. It is possible that the small sample compromised statistical power and that by completing the free stakes condition last, the low and high stakes conditions may have served to habituate excitement in participants, thereby reducing the magnitude of their cardiac reactivity to wins. The powerful effect of winning post gambling sessions on HR observed in field settings (e.g. Moodie & Finnigan, 2005) was not replicated by this laboratory study which focused on event and not session outcomes. It is also feasible that electrodermal activity is a more reliable and robust index of physiological changes during gambling.

An additional finding of this present study was that higher gambling urges were associated with greater increases in arousal following wins. Sharpe (2002) identified that gambling urges are a mind-body interaction, and are seen as physical, psychological, or emotional motivational state that involves desire to gamble. This need
to gamble has often been associated with PG and is viewed as an important predictive factor of relapses (Sharpe, 2002). Some studies use the presence of gambling urges to evaluate the success of a treatment paradigm (McConaghy, Armstrong, Blaszczynski, & Allcock, 1983). It should be noted that although the relationship found is consistent with theories of prolonged gambling activity (e.g. Sharpe, 2002), Study A was only a pilot study and larger studies will be needed to determine whether these conclusions can be generalised and extended to a clinical sample.

For the first time, this experiment investigated associations between changes in electrodermal and cardiac activity in response to events in a gambling activity and cognitions related to gambling activity. An inspection of the data related to win events reveal mean differences in the expected direction, but because of low power this association may not have achieved statistical significance. Another key factor may be the amount of gambling related cognitive distortions endorsed by the healthy controls was quite low and well below that expected of PGs (Jefferson & Nicki, 2003). The relationship between gambling cognitions and psychophysiological responses to gambling activity should therefore be examined further, preferably comparing PG and non-PG groups. It may also be of benefit to measure the degree of such associations across different forms of gambling.

The findings of Study A should be viewed in context of several constraints and limitations. The experiment was conducted in a laboratory setting and despite the use of a real EGM with all its bells and whistles, ethical constraints prevented participants from gambling with their own money. Hence physiological activity reported here and differences observed are likely to be smaller than in natural settings. It should be noted that despite these constraints, reliable and statistically significant differences were observed, highlighting the possibility that physiological measures may indeed be
sensitive and clinically useful measures. Although the findings indicate increases in 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 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 are warranted.

The researcher 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. Study B (Chapter 5) includes an analysis of researcher response time and accuracy when marking events. No significant differences were found in researcher response time across event types. On average, across event types, the response time between event outcomes and event-marking was close to one second (Wilkes, Gonsalvez & Blaszczynski, submitted). As response time variations are in the order of milliseconds, this inaccuracy is not believed to affect the direction and pattern of the results obtained.

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 winning or because of the presence of the ‘bells and whistles’ produced by EGMs following wins. Moreover, it should be observed that the participants in this study were university students who were in the main inexperienced players of EGMs. Differences between autonomic 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.

Study A demonstrated that physiological activity to win and loss events on an EGM can be reliably measured, and that rapid changes occurring in real time can be captured by current technology. The findings that responses to wins persist for a prolonged period post-event also suggest that the physiological reinforcers during EGM gambling are maintained in the absence of monetary reinforcers. The study supported the use of similar procedures in the laboratory and in-vivo gambling contexts. The following chapters explore multiple win and loss event types, with varied wagering conditions in a laboratory setting (Chapter 5) and examine differences in psychophysiological reactivity to wins and losses between PGs and Non-PGs in a natural setting (Chapter 6).
Chapter 5 – Study B: The variety of win and loss event types during gambling on an electronic machine in a laboratory setting

5.1 – Overview

Following the promising results of the pilot study, it was decided that it was important to replicate and extend the findings. Chapter 5 initially considers the importance of the two characteristics within sessions of EGM gambling related to monetary gain: the amount wagered and the amount returned to the player. Following this review of the research literature, a second laboratory study is presented. No significant changes in HR were evident in the pilot study (Study A) therefore a larger sample of 24 non-PGs was recruited to establish whether this result was an effect of the power of the sample. Study B monitored the HR and SCL of non-PGs as they were exposed to four event types, namely, losses, fake wins, wins, and big wins. This was an improvement on the pilot study, which only monitored responses to two events: wins and losses. Further, the monitoring of responses to multiple win and loss event types would enable an analysis of the physiological effects of the amounts won and the importance of monetary gain. Win events were again shown to produce significant increases in arousal up to 15 seconds post-event, whereas loss-events produced no changes. Characteristics of within session events during gambling on electronic machines appear to moderate physiological responses, with winning, amount won and amount wagered observed to be important factors. The clinical implications, including prolonged arousal to events with no monetary reward (fake wins) in the course of overall net financial losses are outlined.

The data from Study B were presented at the 17th Annual Conference of the Australasian Society for Psychophysiology, 7-9th December, 2007, Brisbane, Australia
(Wilkes, Gonsalvez & Blaszczynski, 2007b). The study has also been submitted for publication in the peer-reviewed *International Journal of Psychophysiology* (Wilkes, Gonsalvez & Blaszczynski, submitted). The title of the manuscript is “The variety of win and loss event types during electronic gambling: A psychophysiological investigation”.

### 5.2 – Does the amount wagered affect physiology during EGM play?

As highlighted in Chapter 3, the Iowa Gambling Task utilised by the Goudriaan et al. (2006) study was designed to simulate real-life decision making (Bechara et al., 1994). Importantly, this present study (Study B) measured phasic changes in electrodermal and cardiac activity to events with varied risk, but it is uncertain whether this reflects risk variations during gambling on electronic machines. Perhaps the sole risk factor that can be mediated by the player during EGM gambling, besides choosing to continue to gamble or not, is the amount staked for each bet. Unlike the Iowa Gambling Task, which allows for performance to be improved based upon participant choices (Goudriaan et al., 2006); EGMs deliver an intermittent ratio of winning and losing events, which are pseudo-randomly configured so that the “house” wins in the long term (Walker, 2004). This means that an increased bet size during EGM gambling multiplies exposure to disadvantageous stimuli and is likely to increase participants’ physiological activity in anticipation of the outcomes (Goudriaan et al., 2006).

While self-report data have indicated that PGs do not increase their bets to increase their arousal (Walker, 2004), they have objectively been found to wager more credits per line compared to recreational gamblers when playing EGMs (Blaszczynski, Sharpe, & Walker, 2001; Sharpe, Walker, Coughlan, Enersen & Blaszczynski, 2005). As reported in Chapter 3, increases in HR have been greater during activities that
commonly involve larger individual wagers, such as blackjack and horse racing. Moreover, Anderson and Brown (1984) reported greater changes in HR when more money was wagered during blackjack. It is uncertain whether the effects of wager size can be generalized to gambling on electronic machines. The direct measurement of HR and SCL in response to wagering conditions during EGM gambling has yet to be monitored and will be a feature of Study B.

5.3 – Does the amount won affect physiology during EGM play?

Chapter 3 reviewed two studies in which researchers had monitored HR and the amount won following an event during gambling on electronic machines (Dickerson et al., 1992; Moodie & Finnigan, 2005). The findings of both studies suggest that arousal changes increase in proportion to the amount won following events. Notably, Dickerson et al. (1992) compared cardiac activity between minutes of play in which no wins, small wins and big wins were recorded and reported a trend for increased heart rate with exposure to small wins and more so for big wins. Due to poor temporal resolution (tonic physiological changes obtained over minutes rather than seconds) and differential physical activity following the event types, the observed changes in HR could not be attributable to the amount won, somewhat limiting the value of the study (Dickerson et al., 1992).

In an improvement to Dickerson et al.’s (1992) examination of tonic changes in HR and the amount won during gambling on electronic machines, Moodie and Finnigan (2005) investigated phasic changes measured in between events. This methodological development reduced the possible influence of confounds, such as motor activity, on HR recorded in response to wins. Significantly greater HR increases followed larger wins (Moodie & Finnigan, 2005). The focus on phasic HR changes in response to the
amount won following individual events notably revealed significant differences, whereas the Dickerson et al. (1992) study, which compared minute segments was only able to establish a trend. These findings indicate that the physiological effects of the amount won following events may only be captured when monitored individually. Study B will utilise contemporary technologies applied in Study A to monitor HR and SCL in response to multiple event types during gambling on electronic machines. Importantly, physiological activity will be monitored on a second-by-second basis, allowing for a systematic inspection of the importance of the amount won on both HR and SCL during gambling on electronic machines.

5.4 – Aims and hypotheses

Study B encompasses a focus on within session responses to events during EGM play and should be viewed as an extension of the findings from Study A. Study B utilised comparable technology to the studies conducted by Goudriaan et al. (2006) and Study A, which allow for instantaneous changes in both electrodermal and cardiac activity to be monitored and for trends in responses to specific session characteristics of EGM play to be traced across time. The main aim of Study B was to examine autonomic responses measured within multiple biological systems (HR and SCL) to winning and losing events of varied intensity and experienced to differing staking conditions.

It was hypothesised that there would be increased responses to small wins versus no return losses (Study A). Secondly it was hypothesised, based upon monetary significance (Wulfert et al., 2005) and reinforcement (Griffiths, 1993a), that there would be increased responses to events where the amount won was less than wagered (“fake wins”) versus pure or no return “losses”. Thirdly, the responses to big wins were hypothesised to show greatest physiological changes and significantly greater responses
than that to small wins (Dickerson et al., 1992). Finally, based upon the anticipated increased exposure to risk (Goudriaan et al., 2006) it was hypothesised that normal controls would experience greater arousal during high versus low stakes conditions (Anderson & Brown, 1984).

5.5 – Method

5.5.1 – Participants
Twenty-four university students (17 females; 7 males) from introductory psychology classes responded to an intranet-based advertisement to complete the study for research participation credits. The mean age of participants was 21.04 years (SD = 5.2), which was slightly higher than Study A. Participants were excluded from the study if they reported a heart condition. All participants in Study B reported that they were born in Australia and that English was their first language. No participants in Study B participated in the pilot study (Study A).

5.5.2 – Design
The study followed a 4 (events) x 5 (time intervals) repeated measures design with skin conductance level (SCL) and heart rate (HR) as dependent variables.

5.5.3 – Materials
Study B utilised the identical materials as described in Chapter 4 for Study A, with the addition of two psychometric tests which were added to the questionnaire battery. The measures were included to assess general psychological distress and impulsivity.

The Depression Anxiety Stress Scales 21 (DASS-21) is a 21-item short form of
Lovibond and Lovibond’s (1995) 42-item self-report measure of depression, anxiety, and stress (DASS). The DASS-21 has been shown to have adequate construct validity and good reliability (Henry and Crawford, 2005). The DASS-21 was administered as an index of general psychological distress as a common factor, and the sub-scales (see Appendix H).

Impulsivity. The Impulsiveness, Venturesomeness and Empathy Questionnaire (Eysenck, Pearson, Easting, & Allsopp, 1985; I-7) is a 54-item questionnaire designed to capture pure measures of impulsivity. Only the Impulsiveness scale (see Appendix I) was administered, as impulsiveness was the primary personality trait of interest (see Krueger et al., 2005).

5.5.4 – Procedure

Study B followed a similar procedure to the pilot study with experimental sessions conducted individually in a university-based laboratory setting. Participants played on the EGM in three betting conditions: low, high and free stakes. All conditions allowed participants to wager on up to 25 lines, simulating real-life conditions. However, participants were required to multiply the bet by a factor of two in the low-stakes condition and by a factor of four in the high-stakes condition. In effect bets could range between 2 and 50 credits per trial during the low-stakes condition and between 4 and 100 credits in the high-stakes condition. In the final “free stakes” condition, the participant was free to vary bets from trial to trial with bets ranging from 2 to 100 credits. The participants played the low and high stakes conditions in counterbalanced order, with the free-stakes condition always completed as the final session of testing. Participants had two-minute rest breaks between conditions.
Due to ethical concerns, participants were prevented from gambling with their own money. Each participant was provided with 5000 credits ($50) at the beginning of the schedule and was informed that they would win a cinema ticket (valued at $11.70) if they had more than 7000 credits ($70) at the end of a 15-minute block. Fifty percent of participants had more than 7000 credits at the completion of at least one session of play and won an entertainment voucher. As in live gambling, 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 video camera was focused on the EGM’s screen to allow the researcher to monitor trial-by-trial choices made by the participant (Figure 3). Seated in an adjoining section of the laboratory, the researcher marked events with button presses on a computer keyboard. The researcher coded each play based upon the outcome into four event types: losses, fake wins, small wins and big wins. Each event type was differentiated according to increases and decreases in credits in relation to amounts wagered: An event was marked as a “loss” if no return was paid to the player; a “fake win” if the amount returned was less than that wagered; a “small win” if the outcome of the bet resulted in an increase of credits up to five times that wagered and as a “big win” if the amount returned was more than five times that which was wagered. Figure 3 (p. 96) displays the image presented to the researcher. The researcher responded to changes produced under the three headings: CREDIT, BET and WIN. Differentiation between event types for the researcher was additionally aided by distinct auditory and visual displays preceding outcomes of plays on the EGM.
Prior to testing it was decided that participants who reported smoking, alcohol and medication use in the two hours prior to physiological testing were to be excluded. During the course of testing, no participants met this exclusion criterion. On completion of the gambling task participants were given the questionnaires (SOGS, IBS, GUS, DASS-21 and I-7) 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. All participants were debriefed and offered contact numbers for problem gambling treatment services at the completion of the study.
5.6 – Data Analysis and results

Behavioural results

Table 2 (below) displays the gambling outcomes at the completion of the 15 minute gambling sessions. It shows that more people ended sessions as winners in the low stakes (10) compared to the free (9) and high (6) stakes conditions. An equal number of participants won vouchers in the low and high stakes conditions (2). However, most vouchers were won in the free stakes condition (8), which allowed a combination of low and high stakes play.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Low Stakes</th>
<th>High Stakes</th>
<th>Free Stakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>-$22.28</td>
<td>-$50.00</td>
<td>-$50.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>$142.24</td>
<td>$21.52</td>
<td>277.52</td>
</tr>
<tr>
<td>Median</td>
<td>-$4.74</td>
<td>-$25.97</td>
<td>-$9.75</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>$3.29 ($31.73)</td>
<td>-$22.36 ($24.87)</td>
<td>$3.43 ($67.44)</td>
</tr>
<tr>
<td>Winners</td>
<td>10</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Losers</td>
<td>14</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Voucher winners</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3 (p. 88) shows the frequency of event types during sessions of play in the low, high and free stakes conditions. Figure 4 (p. 88) depicts the proportion of event types across stake conditions. Big wins were the most novel event type across sessions occurring 2% of the time, followed by small wins (13%), fake wins (20%) and losses (65%). The frequency of these event types indicated that a return was paid to the participant approximately once every three wagers, but that a win (i.e. small win or big win) was experienced at a much lesser rate.
Table 3

*Mean frequency and standard deviations of event types during EGM play*

<table>
<thead>
<tr>
<th></th>
<th>Low Stakes Mean (SD)</th>
<th>High Stakes Mean (SD)</th>
<th>Free Stakes Mean (SD)</th>
<th>Across Sessions Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Losses</td>
<td>101.25 (24.14)</td>
<td>87.17 (20.66)</td>
<td>94.13 (27.54)</td>
<td>282.54 (11.71)</td>
</tr>
<tr>
<td>Fake wins</td>
<td>28.08 (8.59)</td>
<td>27.25 (10.99)</td>
<td>30.42 (10.80)</td>
<td>84.75 (4.44)</td>
</tr>
<tr>
<td>Small wins</td>
<td>20.83 (7.77)</td>
<td>15.96 (8.02)</td>
<td>18.92 (8.15)</td>
<td>55.71 (3.64)</td>
</tr>
<tr>
<td>Big wins</td>
<td>3.04 (1.63)</td>
<td>2.54 (2.11)</td>
<td>3.04 (1.73)</td>
<td>8.63 (0.97)</td>
</tr>
</tbody>
</table>

Figure 4

*Proportion of win and loss event types during EGM play.*

*Researcher response time and accuracy*

In order to calculate researcher response time and accuracy, a computer simulation task was conducted. A computer program was written by John Hu (University of Wollongong, 2008) to imitate researchers responding to the visual cues of the EGM used. Figure 5 (p. 89) illustrates the JAVA interface that was used. The program required the researcher to respond to stimuli appearing under the three headings CREDIT, BET and WIN. These stimuli were the same size and in the same visual field.
as they appear on the Alchemy EGM (Aristocrat Technologies Australia Ltd © 2003). Following the same rules for marking as required in Study B, the researcher marked events outcomes. An event was marked as a “loss” if no return was paid to the player; a “fake win” if the amount returned was less than that wagered; a “small win” if the outcome of the bet resulted in an increase of credits up to five times that wagered and as a “big win” if the amount returned was more than five times that which was wagered. The same keyboard buttons were assigned to the event types as were used during physiological recording.

The stimuli were programmed to change every 3.5 to 4.5 seconds over a 15 minute period in order to simulate the physiological recording schedules of Study B. Once the START button was pressed the program commenced and presented a combination of the four event types over 202 trials. The frequency of event types was controlled so that losses occurred most frequently followed by fake wins, small wins and big wins. The researcher completed the response time task on 10 occasions.
Table 4 (below) presents the mean and standard deviations for response time for each event type. No errors were recorded for any event type in each of the completions of the response time task. Repeated measures ANOVA was conducted on the response time data with planned contrasts between each of the event types. No significant differences were found in response time across event types. On average, across event types, the response time between event outcomes and marking was close to one second ($M=999\text{ms}$, $SD = 37.39\text{ms}$).

Table 4  
*Mean and standard deviations for response time (milliseconds) to each event type*

<table>
<thead>
<tr>
<th>Losses</th>
<th>Fake Wins</th>
<th>Small Wins</th>
<th>Big Wins</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>(SD)</td>
<td>M</td>
<td>(SD)</td>
</tr>
<tr>
<td>992.2</td>
<td>(118.2)</td>
<td>1001.4</td>
<td>(106.6)</td>
</tr>
</tbody>
</table>

The response time data indicates that the 21-second epoch captured by the figures presented in this thesis generally reflect the five seconds prior to event outcomes and 16 seconds post (1 second to be event marked plus 15 seconds). The response time of the researcher was relatively consistent and is unlikely to influence the pattern and strength of the psychophysiological findings.

*Phasic responses to EGM play*

A 21-second epoch for each event, commencing 5 seconds before to 15 seconds following the marking of the event outcome was captured. Data were then averaged separately for each event type. Based upon the results of Study A, an extended time epoch was captured in order to identify peaks of response to stimuli (events) and capture activity associated with large wins that could extend over a longer duration. Preliminary visual inspection of the data had suggested five time intervals across the 21-second
epoch: baseline [B] (prior to the event taking place), an elevation of activity soon after the occurrence of the outcome [PE1], activity peaking [PE2] and then a gradual return to baseline activity [PE3 and PE4]. For purposes of statistical analyses, the data were therefore collapsed to five time intervals. Participants HR and SCL were averaged across 5 to 2 seconds prior to the event marking (baseline; B) and 4 post-event periods: 1 to 4 seconds post-event (PE1), 5 to 8 seconds (PE2), 9 to 12 seconds (PE3) and 13 to 16 seconds (PE4). The physiological activity associated from 1 second (-1s) prior to the event marking 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 one second).

HR and SCL data were separately subjected to repeated measures ANOVA. Because we were concerned about signal:noise ratios and because there were sometimes only few events in some cells (e.g., big wins in low/high stakes), we initially collapsed the data across the three stake conditions (LOW/HIGH/FREE) and performed an ANOVA where the two factors were Event Type (LOSSES/FAKE WINS/SMALL WINS/BIG WINS) x 5 Time intervals (B, PE1, PE2, PE3 and PE4). In order to determine differences relative to baseline, planned contrasts between the baseline (B) and post event segments (PE1, PE2 PE3 and PE4) were also conducted to test each of the three hypotheses (small wins vs. losses, losses vs. fake wins, and small wins vs. big wins). Similar to Study A, all contrasts computed were a-priori contrasts based on a single degree of freedom. These analyses handled sets of contrasts in such a way that each contrast in the set remained linked with just its specific error term (O'Brien, & Kaiser, 1985). Problems with homogeneity of variance (sphericity) that typically apply for repeated measures designs therefore did not apply (Tabachnick & Fidell, 1989).
Figure 6A
Skin conductance levels (SCL) pre and post events across staking conditions during EGM play. Error bars are the standard errors of the means.

Figure 6B
Skin conductance levels (SCL) at baseline (B) and post event times (PE1, PE2 PE3 and PE4) across staking conditions during EGM play. Error bars are the standard errors of the means.
Small wins vs. losses. As shown in Figures 6A and 6B, small wins across time periods were associated with larger SCLs than losses, $F(1,23) = 20.23, p < 0.001, \eta^2_p = 0.47$. Event x Time interactions were significant: for B vs. PE1, $F(1,23) = 36.63, p < .001, \eta^2_p = .61$; for B vs. PE2, $F(1,23) = 25.67, p < .001, \eta^2_p = .53$; for B vs. PE3, $F(1,23) = 18.01, p < .001, \eta^2_p = .44$; and for B vs. PE4, $F(1,23) = 7.35, p < .05, \eta^2_p = .24$ (Figure 6B). Overall, the results indicate that significant elevations of SCL were produced immediately following win events (PE1), compared to losses, and that the increased electrodermal activity was maintained above baseline up to 16 seconds post event (PE4). In contrast, SCL showed little if any changes following a loss (Figure 6B).

There were no significant main or interaction effects for HR.

Fake wins vs. losses. For the SCL data, an overall main effect for event type approached significance, $F(1,23) = 4.13, p = 0.05, \eta^2_p = 0.15$, with the results demonstrating higher SCL for fake wins. Across event types there was effect for B vs. PE1, $F(1,23) = 11.72, p < 0.01, \eta^2_p = 0.38$. No significant effects for time were evident when comparing PE2, PE3 or PE4 to B for the SCL data. As depicted in Figure 6B, there were significant Event x Time interactions for SCL: for B vs. PE2, $F(1,23) = 23.86, p < .001, \eta^2_p = .51$; and for B vs. PE3, $F(1,23) = 15.52, p < .001, \eta^2_p = .40$. No significant effects were found when comparing PE1 or PE4 to B. The results indicate significant increases in SCL for fake wins (compared to losses) occurred between 5 and 8 seconds post event (PE2) and that SCL values returned to baseline levels, 13-16 seconds post event (PE4). In effect, fake wins were associated with small but significant post-event changes, with the SCL increases being largest 5-8 seconds post event. For losses, SCL minimally decreased post event before returning to baseline levels (Figure 6B).
There was no significant main effect for event type for the HR data, but there was a significant effect for time, across event types, when comparing B to PE4, $F(1,23) = 8.10$, $p < 0.05$, $\eta^2_p = 0.26$. Comparisons between baseline and PE1, PE2 and PE3 were not significant. No significant Event x Time interactions were observed for the HR data.

**Small wins vs. big wins.** Analyses showed that for SCL there was a significant effect for event type, $F(1,23) = 11.41$, $p < 0.05$, $\eta^2_p = 0.70$, with greater electrodermal activity to big wins than to small wins (Figure 6A). There was a significant Event x Time interaction for SCL between B and PE1, $F(1,23) = 13.80$, $p < .01$, $\eta^2_p = .38$. Comparisons between B and PE2, PE3, and PE4 were not significant (Figure 6B). Both small wins and big wins were associated with increases post event outcomes. The significant differences in electrodermal activity were most evident immediately following big wins compared to small wins, with big wins associated with greater immediate increase in SCL (Figure 6B).

There were no significant main or interaction effects for the HR data.

**Stakes.** The effects of the amount wagered or staking were analysed comparing the low and high stakes conditions. The data from the free-stakes condition were excluded. Repeated measures ANOVA with three factors, Stake (LOW/HIGH) x Event Type (LOSSES/FAKE WINS/SMALL WINS/BIG WINS) x 5 Time intervals (B, PE1, PE2, PE3 and PE4) were applied to the HR and SCL data separately. Planned within subjects contrasts (B vs. PE1; B vs. PE2, B vs. PE3 and B vs. PE4) were performed for the time factor, and 3 contrasts (small wins vs. losses, small wins vs. big wins, and losses vs. fake wins) were performed for the event type factor. Figure 7B presents the SCL data at each of the time intervals.
Figure 7A
Skin conductance levels (SCL) pre and post losses and small wins (top panel): fake wins and big wins (bottom panel); for low and high stakes.
Figure 7B
Skin conductance levels (SCL) at baseline (B) and post event times (PE1, PE2 PE3 and PE4) for losses and small wins (top panel); fake wins and big wins (bottom panel); for low and high stakes.
The effects of Event Type and Time have already been presented in the previous sections, therefore only main and interaction effects of the Stakes factor are considered. For SCL, the main effect of stakes was not significant; however, there was a visual trend for mean SCL to be consistently higher in the high stakes condition (Figure 7A). Interaction effects involving the stakes factor were not significant.

For the HR data, the main and interaction effects involving stakes were not significant.

Tonic responses to EGM play

Participants were given 2-minute rest intervals before, between and after gambling sessions. Repeated measures ANOVA for the HR and SCL tonic data were computed. Planned contrasts were performed to compare baseline levels of HR and SCL to that recorded post low, high and free stakes sessions. Figure 8 shows that compared to baseline recordings, SCL was found to be greater in the two minutes following gambling activity for the low stakes, \( F(1,23) = 7.77, \ p < 0.05, \ \eta_p^2 = 0.253; \) high stakes, \( F(1,23) = 11.54, \ p < 0.01, \ \eta_p^2 = 0.334; \) and free stakes, \( F(1,23) = 7.87, \ p < 0.05, \ \eta_p^2 = 0.255; \) conditions. In general, SCL was seen to be higher following gambling sessions, compared to baseline, however, the post session changes did not significantly differ between stake types.

No significant differences were observed between baseline and post session recordings for the HR data, however, there was a trend for post-session HR to be reduced compared to the baseline levels.
Figure 8
Skin conductance levels (SCL; Top Panel) and heart rate (HR; Bottom Panel) following sessions of EGM play. Error bars are the standard errors of the means.

**Relationship between physiological measures**

Pearson correlations showed no significant associations between the tonic measures of HR and SCL data at each of the four data points. Moreover, the pre-to-post tonic changes in HR and SCL for the three staking conditions were not significantly correlated to the amount won during the staking condition. Independent samples *t*-tests were computed comparing the tonic changes in HR and SCL pre- to post- the gambling conditions with winning a voucher during the conditions as an independent variable.
There were no significant differences found in the tonic changes in HR or SCL for those that had won vouchers compared to those who had not during each staking condition.

For the phasic data, the relationship between HR and SCL was examined by computing correlations between the two physiological measures. Baseline measures (B) and baseline-to-peak differentials (averaging data points 3 to 7 seconds post-event, subtracting it from baseline levels (B) and then dividing it by B to calculate a relative change from B) served as dependent measures. Separate correlations were computed for wins and losses. Neither the phasic changes to wins, \( r(24) = .03, p = .91 \), or losses, \( r(24) = -.23, p = .28 \), were significant related between the HR and SCL data. Overall, the findings indicate that cardiac and electrodermal changes are not related, neither at the tonic or phasic level whilst participants played EGMs.

*Relationship between physiological responding to wins and losses.*

In order to examine whether physiological changes to wins matched changes to losses, correlations were computed within measures to wins and losses with B-to-Peak changes as the dependent measure. There was a significant negative relationship revealed between the responses to win and loss events for both the HR, \( r(24) = -.67, p < .001 \) and SCL, \( r(24) = -.48, p < 0.05 \). The results indicate that higher responses to small wins correlated with lower responses to losses on the same physiological measure.

*Relationship between physiological and self-report measures.*

The mean SOGS score of participants was 0.58 (\( SD = 0.83 \), range: 0-3), suggesting that all members of the group were likely to be non-PGs. As the range of scores was restricted, this variable was not analysed further. Scores on the other self-report measures revealed no significant correlations with the tonic physiological data.
Similarly, relative changes pre- to post- event types (as computed above for the phasic data) were not significantly related to any of the self-report measures for participants.

5.7 – Discussion

Study B contributes in important ways to the existing literature on the psychophysiology of gambling. The study offers a systematic and comprehensive analysis of psychophysiological changes during gambling on an electronic machine. Each of the four different event types, losses, fake wins, small wins and big wins, were examined. Cardiac and electrodermal changes were monitored and both tonic and phasic measures were obtained in high and low stake conditions. More importantly, Study B demonstrates that, with the use of the current sophistication of computer technology, physiological changes associated with gambling on an electronic machine can indeed be monitored reliably and rapid changes measured on a second-by-second basis. This was achieved by using averaging procedures routinely employed by event related potential experiments to enhance signal to noise ratios (see Picton et al., 2000). The results indicate quite convincingly that psychophysiological measures are sufficiently sensitive to detect changes in psychological states associated with win and loss outcomes during gambling on electronic machines. Although Study B examined gambling in a healthy control population it paves the way for similar ambulatory studies to occur in the field to investigate psychophysiological differences that may characterise PGs.

A key finding in Study B is that wins evoked an increase in electrodermal activity that peaked four to six seconds post event, while losses were followed by marginally decreased SCLs (Figure 6B). The general pattern of results suggests a progressive increase in SCRs with the size of the win. The increased sensitivity in healthy controls to win events corroborates with the results of the pilot study (Study A,
Chapter 4) and results on the IGT (e.g. Goudriaan et al., 2006). The lack of physiological responses to loss events during sessions of play supports the notion that winning is an important factor in producing physiological responses in healthy controls during EGM play.

Tonic measures obtained during two-minute rest breaks between gambling sessions yielded interesting results (Figure 8). When SCL was considered, the results showed that gambling activity was generally associated with an increase in arousal levels. However, this pattern was not replicated for HR. In fact, a tendency for tonic HR levels to decrease over the entire session was observed. The general increase in electrodermal activity observed post sessions of EGM play was not dependent on winning or losing. The pattern of results obtained highlights the importance of monitoring both tonic levels and phasic changes observed within session in future research.

The lack of correspondence between the electrodermal and cardiac measures is not surprising. In fact, several authors have reported similar mismatches in the past (DiCara & Miller, 1968; VaezMousavi, Barry, Rushby, & Clarke, 2007). This lack of correspondence may be due to several reasons; with the most likely being the notion of response fragmentation that suggests that different measures may be sensitive to different components and levels of the response (Barry, 2006; Croft, Gonsalvez, Gander, Lechem, & Barry, 2004). Alternative interpretations including situational response specificity (Lacey, 1967) have been suggested in the past in both healthy controls (Lacey, 1952) and in clinical populations, such as chronic pain sufferers (Carr, Minniti, & Pilowsky, 1985); and in psychiatric patients (Malmo & Shagass, 1949). Notably, Study B’s data reflected no association between cardiac and electrodermal activity in both the phasic and tonic data. The continued utilisation of devices, which
allow for simultaneous, continuous, objective measurement using multiple physiological measures, is supported by the current data.

Study B obtained data suggesting a trend for electrodermal activity to be higher in non-PGs across event types when more money was wagered (Figure 7B). It was also found that physiological activity is greatest for those events that delivered the greatest monetary reward to players, with SCL significantly higher for big wins compared to small wins (Figure 6B). It will be of value to scrutinise gambling behaviour to determine if PGs would display a differing pattern of arousal in response to event outcomes during EGM play. It is possible that the problem gambler progressively develops a tolerance to the arousal elicited by events offering low risk (low stakes) leading to a greater need to experience events that offer greatest risk (high stakes) or reward (big wins) in order to achieve similar physiological responses (Weatherly et al., 2004). Investigations between PGs and normal controls would allow for a determination of the presence of biomarkers as suggested by the findings of research using decision making tasks (Goudriaan et al., 2006).

Uniquely, the current study found that healthy controls demonstrated increases in physiological activity to specific events in the absence of monetary gain. The finding that fake wins exhibited larger electrodermal responses as compared to responses to losses highlighted this. It is possible that the occurrence of fake wins is a factor in sustaining attention and arousal in players on EGMs. The comparably significant increase in physiological activity to fake wins, even when the participant is losing, adds weight to the suggestion that EGM gambling is inherently arousing and that monetary gain acts as a secondary reinforcer (Wulfert et al., 2005).

There were no significant relationships found between both the phasic or tonic physiological changes and the self-report measures. Because the sample included
healthy controls, the limited range of scores on the IBS, I-7, DASS-21 and GUS is not surprising and is the likely reason for the insignificant findings. The analyses may have also been compromised by the small sample size. It is likely that future investigations sampling both PGs and non-PGs would allow a greater focus on the interaction between psychological and physiological factors in the development and maintenance of PG.

Some limitations should be noted when addressing the findings of Study B. Ethical concerns precluded the participants from gambling with their own money. It could be argued that gambling for an entertainment voucher in a laboratory setting has limited ecological validity given that gambling in the field involves the possibility of significant wins and losses. However, it should be noted that despite these effects, significant electrodermal effects were identified; it is likely that these differences will be amplified when participants gamble with their own money (Ladouceur et al., 2003; Roby & Lumley, 1995). It is possible that conducting the study in a naturalistic setting (for example, in a licensed club, hotel or casino) would lead to the emergence of reliable and robust differences in cardiac responses. Although this issue has not specifically been addressed in the literature for gambling on electronic machines, research in other contexts examining tonic measures support this possibility (Anderson & Brown, 1984; Diskin et al., 2003). There is no doubt that it is essential to extend this research to the field setting.

Each participant in the current study experienced a different set of event outcomes and they were permitted to play continuously. The continuous play of participants also meant that the effect of following event outcomes on arousal was not controlled for and may have contaminated the epoch of interest. However, these affect wins and losses and are likely to be averaged out. Also, the changes observed are unlikely to be explained by differential physiological activity (Dickerson et al., 1992)
given all participants were seated, pressed buttons in a similar way for wins and losses and their electrodermal activity was monitored on their non-playing hand. Hence the significant differences observed are likely to be reliable, especially because the current findings replicate the results of the pilot study (Study A).

In Study B, the programming of the EGM was not altered. Hence, the win and loss events along with the ‘bells and whistles’ associated with these events occurred “naturally” as they would be in the real world. Because wins, and particularly big wins, were very infrequent (Table 3) and are also associated with more stimulating visual and auditory stimuli from the machine, the progressively increasing physiological responses to win amounts may reflect responses to associated stimuli (e.g., music and visual displays) rather than to the amount won, in line with orienting theory (Sokolov, 1963). The continual exposure to losses during EGM play may habituate players to the event type as a stimulus to the point where they are not responded to as novel at all and therefore exhibit a limited orienting reflex across time (Barry, 1996). Although it is feasible that accompanying visual and sound cues contribute to physiological changes observed during EGM gambling, it is unlikely to be solely responsible for these changes. For instance, healthy controls have exhibited larger electrodermal responses to winning (as compared with losing) scenarios during imaginal exposure tasks when equal frequencies of winning and losing outcomes have been presented (Sharpe, 2004). Furthermore, Delfabbro, Falzon and Ingram (2005) reported the presence or absence of sound during gambling on electronic machines did not influence gambling behaviour. In the current study, the laboratory investigation was designed to match as closely as possible playing conditions in the field, hence it was important to use a commercially available EGM and measure changes as they occur in the natural environment (with the bells and whistles accompanying events). However, the influence of lights and sounds
on the physiological responses to events can easily be investigated by computer simulation of gambling tasks and by masking sound effects (e.g., via headphones) and may be a fruitful domain of investigation for future research.

Studies A and B cumulatively demonstrated that contemporary technologies can allow an investigation into the effects of within session event outcomes on physiological arousal during gambling on electronic machines. It has been established that for non-PGs, wins and losses during EGM gambling can be reliably differentiated using physiological measures, particularly electrodermal activity. SCL has been shown to be a reliable and robust index of physiological changes in normal controls during EGM play and establishes a claim to be included in paradigms as a gold standard for future studies as it has in orienting theory research (see Rushby & Barry, 2006). The findings indicate that in a healthy control population, the inherent qualities of wins and losses during EGM gambling appear to moderate physiological responses (as measured by SCL and HR), with winning, amount won and amount wagered observed to be important factors. Exploring the impact of wins and losses during EGM gambling on physiology with comparison of PGs and non-PGs is an important focus for future study. The following chapter focuses on an examination of underlying physiological differences of problem and non-problem gamblers monitored during EGM gambling in a field setting.
Chapter 6 – Study C: Psychophysiological profiles of problem versus non-problem gamblers during gambling on electronic machines: An exploratory field study.

6.1 – Overview

This chapter explores differences in the physiological responses of problem versus non-problem gamblers during EGM play in a licensed gambling venue in New South Wales, Australia. An initial summary of the recommendations within the gambling research literature will be outlined followed by a presentation of an exploratory field study (Study C). Study C examined electrodermal activity and cardiac reactivity of six PGs and six non-PGs in response to win and loss events while playing an EGM. Compared to losses, wins are shown to evoke increases in physiological activity. Importantly, it was shown that healthy controls exhibit increases in electrodermal and cardiac activity immediately following wins. PGs were found to respond minimally to both wins and losses. Moreover, healthy controls show significant increases in HR post gambling sessions, while PGs showed reductions. Autonomic responses to wins and losses were also found to be associated with scores on psychometric measures of urges to gamble and cognitions related to gambling. These results have important theoretical and clinical implications that are discussed.

6.2 – PG vs. Non-PG group differences

As reviewed in the Chapters 1, 2 and 3, the basis of most research conducted on gambling behaviour is that PGs may possess intrinsic characteristics that predispose them to their excessive participation (Griffiths & Delfabbro, 2001). Despite this underlying guiding principle of explaining PG psychophysiological investigations have largely examined other group factors, such as gender (Coventry & Constable, 1999; Coventry & Hudson, 2001); preferred gambling type (Cocco et al., 1995); and gambling
frequency (Coventry & Norman, 1997; Griffiths, 1993b). Moreover, those studies that have been designed to examine physiological differences between PGs and non-PGs have largely been investigated outside of actual gambling participation (Blanchard et al., 2000; Sharpe, 2004; Sharpe et al., 1995) or in a laboratory environment (Diskin & Hodgins, 2003).

Moodie and Finnigan (2005) conducted an in-vivo examination of cardiac activity in response to electronic gambling sessions and to within session characteristics; such as wins, bonuses, nudges and features. Although gambling frequency was used as a between groups factor, analyses did reveal that the frequent gamblers were likely PGs. This group was found to have significantly increased HR throughout and post sessions of play (tonic measures), compared to infrequent and non-gamblers. Moreover, there was a trend for frequent gamblers (PGs) to have greater cardiac responses to wins, nudges and features than non-gamblers. There was also a trend for frequent gamblers to have greater cardiac responses to each of the within session characteristics than the infrequent gambling group. It is noted that the infrequent gamblers group did include some individuals with SOGS scores five and above. Their inclusion in this group may have contributed to the lack of significant differences observed. Importantly, this study demonstrated that arousal studies conducted in a field setting can be successfully conducted and that responses to unique play characteristics offered during gambling on electronic machines can be captured. Moodie and Finnigan (2005) provide some promising evidence that physiological differences between PGs and non-PGs may exist in both how they respond to electronic gambling in general (tonic measures) and how they respond to event-related outcomes within the task (phasic measures). If elevated tonic levels of arousal are reinforcing by themselves to some individuals (PGs), desired arousal states may be generated by the possibility rather
than the actuality of winning. Conversely, differing patterns of arousal changes in response to within session outcomes may indicate that the experience of winning is a significant factor in reinforcing participation and maintaining PG.

Findings have been inconclusive in regard to phasic changes associated with wins. Although Moodie and Finnigan (2005) found that PGs respond more to wins than other groups, Goudriaan et al. (2006) have subsequently demonstrated PGs exhibit lesser responding to wins during a computed simulated gambling task compared to healthy controls. Further examinations of both tonic and phasic arousal responses of PGs and non-PGs to gambling tasks are required to clarify these conflicting findings.

As acknowledged in Chapter 3, arousal research has provided some good support for the idea that PGs may react differently to wins and losses than non-PGs. Notwithstanding these promising findings, the design of past research paradigms has limited comparisons of the arousal of PGs and non-PGs (Goudriaan et al., 2004). Firstly, studies have infrequently utilised stringent criteria to differentiate PGs from non-PGs. Secondly, single measures of autonomic activity, most commonly HR, have been taken in contrast to indications from some researchers who emphasise that SCL but not HR is a valid measure of arousal (Rushby & Barry, 2006; VaezMousavi et al., 2007) and despite several findings indicating that more insight can be provided into physiological systems when multiple measures are applied (Blanchard et al., 2000; Diskin & Hodgins, 2003; Sharpe et al., 1995). Thirdly, physiological responses have commonly been monitored during laboratory or imaginal tasks, which are less likely to reveal differences than those obtained in the natural setting (Diskin et al., 2003). Finally, paradigms have rarely asked participants to gamble with their own money,
which may have significantly reduced the arousal changes observed (Ladouceur et al., 2003; Roby & Lumley, 1995).

Fundamentally, five key recommendations have been identified within the research literature to strengthen future investigations of psychophysiological differences between PGs and non-PGs (Goudriaan et al., 2004):

1. Strict criteria to be used to identify PGs.
2. Multiple physiological measures to consistently monitor responses to gambling behaviour.
3. Recording to take place in a natural field environment (club/casino) in response to real world gambling tasks.
4. Participants to gamble with their own money.
5. Responses to within session characteristics (wins/losses) to be individually monitored within the same individual.

6.3 – Aims and hypotheses

The current study (Study C) was designed as an in-vivo adaptation of the methods utilised in the laboratory for Studies A and B. It similarly investigates the association between arousal and gambling activity, but looks specifically at differences in electrodermal and cardiac responses to wins and losses on an EGM between two groups: problem and non-problem gamblers. As outlined in the preceding section, past differentiations between PGs and non-PGs have been criticised due to research design. The current exploratory field study was designed to address the five recommendations outlined above. It would allow for a trial of the monitoring equipment in relation to use in a field setting and provide recommendations for future field studies.

Four main hypotheses were tested:
6.4 – Method

6.4.1 – Participants

Twelve participants (7 females; 5 males) responded to poster advertisements placed at entrances to a licensed gambling venue. Following the experimental sessions, each of the participants was classified as probable PGs or non-PGs. All participants reported that they were born in Australia and that English was their first language.

6.4.2 – Design

The study followed a 2 group (PG/Non-PG) x 2 event type (wins/loses) x 5 time intervals repeated measures design with electrodermal (SCL) and cardiac activity (HR) as dependent variables.
6.4.3 – Materials

Study C utilised similar materials as described in Chapters 4 and 5. The questionnaire battery was slightly altered with the participants completing the SOGS, I-7, GUS, and IBS. Please refer to sections 4.3.3 and 5.4.3 for descriptions of these measures. Additionally, a second assessment of gambling behaviour was taken to allow for a stringent classification of PGs.

Assessment of Gambling Behaviour.

In addition to the SOGS, which was utilised by studies A and B, the Canadian Problem Gambling Index (Ferris & Wynne, 2001; CPGI; see Appendix P) was used to obtain information on previous gambling behaviour. The CPGI has nine scoring items and was validated with a general population sample, unlike other instruments (e.g. SOGS and DSM-IV-TR) that were developed using clinical samples of PGs. The CPGI has an advantage over other instruments as it successfully describes sub-types of PGs and non-PGs; systematically obtaining the correlates of PG (McCready & Adlaf, 2006).

Psychophysiological measures of arousal.

Physiological recordings were obtained using identical equipment (AMS-3) as Studies A and B. Please refer to Chapter 4 for a full description.

6.4.4 – Allocation to specific gambling groups

A strict classification criterion was imposed to classify participants into groups. Participants were assigned to the PG group if their responses were above clinical reference group cut-offs on both psychometric measures of PG behaviour:
1. SOGS score of five or above (Lesieur & Blume, 1987).
2. CPGI score of eight or above (Ferris & Wynne, 2001).

Following classification, the groups comprised of six PGs (4 females, 2 males) and six non-PGs (3 females, 3 males). The characteristics of the two experimental groups are presented in Table 5 (below). Independent sample t-tests were conducted to see whether there was an effect for group on age, SOGS, CPGI, I-7, GUS, and IBS scores. There was no significant difference between the groups in terms of age. Reflecting the stringent criterion for PG that was applied; there were significant differences between the groups on both the SOGS and CPGI; the PG group scoring significantly higher on both measures. Additionally, the PG group recorded significantly more gambling related urges (GUS) and gambling related cognitive distortions (IBS) than the control group. The two groups did not significantly differ in terms of trait impulsivity (I-7).

Table 5
*Characteristics of experimental groups*

<table>
<thead>
<tr>
<th></th>
<th>Problem gamblers (n = 6)</th>
<th>Non-problem gamblers (n = 6)</th>
<th>Sig.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>t</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>36.50 (6.32)</td>
<td>43.17 (16.31)</td>
<td>.933</td>
<td>.373</td>
</tr>
<tr>
<td>SOGS</td>
<td>7.67 (2.73)</td>
<td>0.5 (0.55)</td>
<td>5.401</td>
<td>.000b</td>
</tr>
<tr>
<td>CPGI</td>
<td>13.83 (3.19)</td>
<td>0.5 (1.33)</td>
<td>6.687</td>
<td>.000b</td>
</tr>
<tr>
<td>I-7</td>
<td>10.50 (5.32)</td>
<td>10.83 (4.45)</td>
<td>.118</td>
<td>.909</td>
</tr>
<tr>
<td>GUS</td>
<td>22.50 (7.12)</td>
<td>10.17 (3.60)</td>
<td>3.786</td>
<td>.004a</td>
</tr>
<tr>
<td>IBS</td>
<td>84.00 (21.46)</td>
<td>30.83 (8.59)</td>
<td>5.635</td>
<td>.000a</td>
</tr>
</tbody>
</table>

*a* significant at *α* = 0.01

*b* significant at *α* = 0.001
6.4.5 – Procedure

The Human Research Ethics Committee of the University of Wollongong granted ethical approval for the research project. Before the study commenced, licensed gambling venues were contacted via email and/or in person. Once contacted, the venues were provided with an outline of the purpose of the study (see Appendix J). The venues then completed a venue consent form (see Appendix K), which outlined the conditions of their support. Over the course of two years over fifty licensed gambling venues in New South Wales, which had EGMs, were approached for venue support, however, a positive response was only obtained from one venue. All testing and recruitment was conducted in the gaming room located within its premises.

The researcher attended the venue for testing at a variety of times of day on multiple occasions during an 18-month period. When the researcher was within the facility, posters (see Appendix L) were placed at entrances to the gaming room. All interested parties were directed to contact the service desk, which would then direct the patrons to the researcher. No patrons were directly approached by the researcher or the venue to participate in the study.

Upon referral to the researcher, the rationale and methods of the research were verbally explained to participants and they were presented with the Participant Information Sheet (see Appendix M). Participants were then asked to complete the pre-testing assessment forms. This battery of forms consisted of the Participant Consent Form (see Appendix N) and a verbally taken AMS Participant Data Sheet (see Appendix O). No participants reported smoking; alcohol or medication use in the two hours prior to physiological testing and consumption was not permitted throughout the testing procedure. Physiological testing commenced in an administrative area within the club, with two-minutes of baseline physiological recording taken.
Following this initial interview and testing period experimental sessions moved into the gaming room. Participants self selected an EGM of choice within the gaming area. All experimental sessions were collected on one-cent EGMs featuring a 5 x 3 matrix. The participant was free to vary bets from trial to trial, with bets ranging from 1 to 500 credits (i.e. 1c to $5). All machines used allowed participants to gamble or “double-up” their wins by predicting the colour or suit of the next card, however, no players engaged with this feature during play. Participants gambled using their own money. All winnings were paid out to the participants via a cashier at the completion of their involvement with the study. Participants were permitted to end the session of gambling at any time. The shortest gambling session recorded was 5 minutes, while the longest was 30 minutes in length (\(M = 13\) minutes, \(SD = 6.3\) minutes).

During their play, the researcher sat in a chair behind the player holding the AMS-3 device in their dominant hand. The researcher monitored trial-by-trial choices made by the participant. Two types of events (wins and losses) were event-marked by the researcher via button presses on the AMS-3 device.

On completion of physiological recording during gambling, the participant and researcher moved back into the administrative area of the venue. Once seated, two minutes of further physiological recording was taken as a post gambling measure. Following the removal of the physiological equipment, participants were given the questionnaires (SOGS, I-7, GUS, IBS, and CPGI) to complete. To preserve the anonymity of participants, all questionnaires were de-identified and matched to the physiological data at a later date. At the completion of the experimental session, participants were debriefed, presented with two movie vouchers valued at $23.40 and offered contact numbers for problem gambling counselling services.
6.5 – Data analysis and results

Behavioural results

Table 6 (below) displays the session characteristics of the gambling outcomes comparing the two experimental groups. It shows that the frequency of wins was much less than for wins for both groups. Two participants had won at the completion of the recording and they were both in the PG group. Independent samples t-tests were computed comparing the session characteristics of frequency of wins and losses; percentage of wins; and the overall outcome at the completion of the experimental sessions. There were no significant differences revealed between the groups in terms of frequency of wins and losses; and overall outcomes. Analyses did reveal that PGs experienced wins significantly more often than non-PGs; experiencing a win once in every five spins, while non-PGs won once in every seven to eight trials. One PG and one non-PG had won overall at the completion of the gambling session.

Table 6

Gambling session characteristics for experimental groups

<table>
<thead>
<tr>
<th></th>
<th>Problem gamblers (n = 6)</th>
<th>Non-problem gamblers (n = 6)</th>
<th>t</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wins (frequency)</td>
<td>15.67 (6.68)</td>
<td>11.67 (6.77)</td>
<td>1.030</td>
<td>.327</td>
</tr>
<tr>
<td>Losses (frequency)</td>
<td>60.50 (23.09)</td>
<td>80.83 (43.95)</td>
<td>1.003</td>
<td>.347</td>
</tr>
<tr>
<td>Wins (percentage)</td>
<td>20.50 (2.55)</td>
<td>13.21 (3.53)</td>
<td>4.106</td>
<td>.002*</td>
</tr>
<tr>
<td>Overall Outcome</td>
<td>$2.95 ($28.36)</td>
<td>-$14.13 ($5.01)</td>
<td>1.452</td>
<td>.203</td>
</tr>
</tbody>
</table>

*significant at $\alpha = 0.01$

Phasic responses to EGM play

A 21-second epoch for each event, commencing five seconds before to 15 seconds following the marking of the event outcome was captured. Data were then averaged
separately for each event type. Following an analysis of researcher response time (see Chapter 5), it was estimated that the event outcomes occurred approximately one second prior to the event marking. The 21-second epoch therefore captures five seconds pre- to 15 seconds post- the event outcomes. For purposes of statistical analyses, the data were collapsed into five time periods using the same method as Study B. Participants HR and SCL were averaged across 5 to 2 seconds prior to the event marking (baseline; B) and 4 post-event periods: 1 to 4 seconds post-event (PE1), 5 to 8 seconds (PE2), 9 to 12 seconds (PE3) and 13 to 16 seconds (PE4). Multiple post event time intervals were analysed in order to identify peaks of response to stimuli (events) and the duration of response. The physiological activity associated from 1 second (-1s) prior to the event marking 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 one second).

HR and SCL data were separately subjected to ANOVA. involving: 2 Group (PGs/non-PGs) x 2 Event Type (LOSSES/WINS) x 5 Time intervals (B, PE1, PE2, PE3 and PE4) with repeated measures for the last two factors. Planned, within subjects contrasts (B vs. PE1; B vs. PE2, B vs. PE3 and B vs. PE4) were performed for the time factor. All contrasts computed were a-priori contrasts based on a single degree of freedom. Problems with homogeneity of variance that typically apply for repeated measures designs therefore did not apply. Table 7 presents a summary of the ANOVA results.
Table 7

*Analyses of phasic data (2 Groups x 2 Event Types x 5 Time intervals)*

<table>
<thead>
<tr>
<th></th>
<th>$F (1,10)$</th>
<th>Sig.</th>
<th>$\eta^2_p$</th>
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<tr>
<td><strong>HR</strong></td>
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<tr>
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<td>.70</td>
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</tr>
<tr>
<td>Group</td>
<td>1.68</td>
<td>.22</td>
<td>.14</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B vs PE1:</td>
<td>.39</td>
<td>.55</td>
<td>.04</td>
</tr>
<tr>
<td>B vs PE2:</td>
<td>11.91</td>
<td>.01</td>
<td>.54 *</td>
</tr>
<tr>
<td>B vs PE3:</td>
<td>1.43</td>
<td>.26</td>
<td>.13</td>
</tr>
<tr>
<td>B vs PE4:</td>
<td>.03</td>
<td>.87</td>
<td>.00</td>
</tr>
<tr>
<td>Event Type * Time</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>B vs PE1:</td>
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<td>.23</td>
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<tr>
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<td>.01</td>
<td>.55 *</td>
</tr>
<tr>
<td>B vs PE3:</td>
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<tr>
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</tr>
<tr>
<td>Event Type * Group</td>
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<tr>
<td>Time * Group</td>
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<td></td>
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<tr>
<td>B vs PE1:</td>
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<td>.00</td>
</tr>
<tr>
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<td>.01</td>
<td>.50 *</td>
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<tr>
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<td>.39</td>
<td>.08</td>
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<td>.57</td>
<td>.03</td>
</tr>
<tr>
<td>Group * Event Type * Time</td>
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<td></td>
<td></td>
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<tr>
<td>B vs PE1:</td>
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<tr>
<td>B vs PE2:</td>
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<tr>
<td>B vs PE3:</td>
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<td>.55 *</td>
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<tr>
<td>B vs PE4:</td>
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</tr>
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<td><strong>SCL</strong></td>
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<td>Event Type</td>
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<tr>
<td>Group</td>
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<tr>
<td>Time</td>
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<td></td>
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</tr>
<tr>
<td>B vs PE1:</td>
<td>14.51</td>
<td>.00</td>
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<tr>
<td>B vs PE2:</td>
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<td>B vs PE3:</td>
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<td>.24</td>
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<td>Event Type * Time</td>
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<tr>
<td>B vs PE2:</td>
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<td>.50 *</td>
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<tr>
<td>B vs PE3:</td>
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<td>.94</td>
<td>.00</td>
</tr>
<tr>
<td>B vs PE4:</td>
<td>2.42</td>
<td>.15</td>
<td>.20</td>
</tr>
<tr>
<td>Event Type * Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time * Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B vs PE1:</td>
<td>13.31</td>
<td>.00</td>
<td>.57 *</td>
</tr>
<tr>
<td>B vs PE2:</td>
<td>4.64</td>
<td>.06</td>
<td>.32</td>
</tr>
<tr>
<td>B vs PE3:</td>
<td>1.83</td>
<td>.21</td>
<td>.16</td>
</tr>
<tr>
<td>B vs PE4:</td>
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<td>.87</td>
<td>.00</td>
</tr>
<tr>
<td>Group * Event Type * Time</td>
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<td></td>
<td></td>
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<tr>
<td>B vs PE1:</td>
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<tr>
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<td>.00</td>
</tr>
<tr>
<td>B vs PE4:</td>
<td>.31</td>
<td>.59</td>
<td>.03</td>
</tr>
</tbody>
</table>

*a** significant at $\alpha = 0.05$

*b** significant at $\alpha = 0.01$
Similar to Studies A and B (Chapters 4 and 5), visual representations of the data are first presented that capture the entire 21 second epoch (Figures 9A, 10A, and 11A), followed by the data used for analyses across the time segments: B, PE1, PE2, PE3 and PE4 (Figures 9B, 10B and 11B).

Figure 9A
Skin conductance levels (SCL, top panel) and heart rate (HR, bottom panel) across groups in response to wins and losses during EGM play. Error bars are the standard errors of the means.
Figure 9B
Skin conductance levels (SCL, top panel) and heart rate (HR, bottom panel) across groups in response to wins and losses at baseline (B) and post event times (PE1, PE2 PE3 and PE4). Error bars are the standard errors of the means.
Figure 10A
Skin conductance levels (SCL, top panel) and heart rate (HR, bottom panel) of problem versus non-problem gamblers across event types during EGM play.
Figure 10B
Skin conductance levels (SCL, top panel) and heart rate (HR, bottom panel) of problem versus non-problem gamblers across event types at baseline (B) and post event times (PE1, PE2, PE3 and PE4). Error bars are the standard errors of the means.
Figure 11A
Skin conductance levels (SCL, top panel) and heart rate (HR, bottom panel) of problem versus non-problem gamblers in response to wins and losses during EGM play. Error bars are the standard errors of the means.
Figure 11B
Skin conductance levels (SCL, top panel) and heart rate (HR, bottom panel) of problem versus non-problem gamblers in response to wins and losses at baseline (B) and post event times (PE1, PE2 PE3 and PE4). Error bars are the standard errors of the means.
Heart Rate. The main effect for Event Type was not significant. Across event types, PGs had a higher HR ($M = 83.42, SD = 4.20$) compared to non-PGs ($M = 75.83, SD = 1.43$), but this effect for Group fell short of statistical significance. There was a significant Group x Event Type interaction, $F(1,10) = 5.94, p < 0.05, \eta_p^2 = 0.37$), indicating that group differences were smaller for win-events than they were for losses. For PGs, HR was slightly higher for losses ($M = 83.78, SD = 0.28$) versus wins ($M = 83.10, SD = 0.35$). The opposite was true for the non-PGs, with mean HR to losses ($M = 75.28, SD = 1.20$) being lower compared to wins ($M = 76.16, SD = 3.55$). This interaction was further qualified by a significant 3-way interaction between Group, Event, and Time (Figure 11B), that will be discussed below.

The HR data revealed a significant effect for Time for B vs. PE2, $F(1,11) = 11.91, p < .05, \eta_p^2 = .54$. This suggests that across groups and event types, HR was higher five to eight seconds post event compared to baseline levels. This B vs. PE2 effect was qualified by a significant Event Type x Time interaction, $F(1,11) = 12.31, p < .05, \eta_p^2 = .55$; Figure 9B, a Time x Group interaction, $F(1,10) = 10.04, p < .05, \eta_p^2 = .50$; Figure 10B, and a Group x Event Type x Time interaction, $F(1,10) = 11.80, p < 0.05, \eta_p^2 = 0.54$, Figure 11B. Together, these results indicate that the HR increases at PE2 were specific to wins, but not losses, and occurred only for non-PGs. The three-way interaction was also significant for B vs. PE3 [$F(1,10) = 12.15, p < 0.05, \eta_p^2 = 0.55$], indicating that this between-group difference persisted over the 5-12 second period, post event. In fact, the HR pattern of problem gamblers, whilst being marginally higher than that of non-problem gamblers, showed little variation from baseline. Neither wins nor losses produced a noticeable change (Figure 11B).
**Skin Conductance Level.** The SCL data revealed a pattern of results similar to that of HR. There were no significant main effects for Group or Event Type on SCL. The SCL data revealed a significant effect for Time: for B vs. PE1, $F(1,11) = 14.51, p < .01, \eta^2_p = .59$. This suggests that across groups and event types, HR was higher one to four seconds post event compared to baseline levels. This “B” vs. “PE1” effect was qualified by a significant Event Type x Time interaction [$F(1,11) = 25.61, p < .01, \eta^2_p = .72$; Figure 9B], a Time x Group interaction [$F(1,10) = 13.31, p < .01, \eta^2_p = .57$, Figure 10B], and a Group x Event Type x Time interaction, $F(1,10) = 19.44, p < 0.01, \eta^2_p = 0.66$; Figure 11B]. Collectively, these results indicate that the SCL increase at PE1 was specific to wins, but not losses, and occurred only for non-PGs. The three-way interaction was also significant for B vs. PE2 [$F(1,10) = 8.29, p < 0.05, \eta^2_p = 0.45$; Figure 11B], indicating that this between-group difference persisted over the 1-8 s period, post event.

In terms of phasic changes, the PG group showed neither a similar cardiac nor electrodermal responsivity to win events as non-PGs despite wagering with their own money. Additionally, no limits were put on participants relating to wager size other than the parameters in place on the machines, which they had chosen to play on.

*Tonic responses to EGM play*

Participants were given 2-minute rest intervals before and after gambling sessions. Repeated measures ANOVA for the HR and SCL tonic data were computed to compare pre-to-post gambling sessions on tonic levels of HR and SCL. Analyses revealed a significant group x sessions interaction for the HR data, $F(1,10) = 21.559, p < 0.01, \eta^2_p = 0.683$. Figure 12 (below) shows that the problem gamblers exhibited higher HR prior to EGM play (non-gambling, resting baseline) and following a session of play HR
decreased. The reverse was true for the non-problem gambling group, who experienced an increase in HR following a session of EGM play.

There were no significant differences between the groups in electrodermal activity pre- to post- sessions of EGM play.

![Figure 12](image)

**Figure 12**

Skin conductance levels (SCL; Top Panel) and heart rate (HR; Bottom Panel) for problem and non-problem gamblers following sessions of EGM play. Error bars are the standard errors of the means.

*Relationship between physiological responses and self-report measures.*

In order to investigate associations between responses to event related outcomes and the self-report questionnaires (GUS; IBS; I-7) two measures were computed for loss and win event types: measure of baseline levels prior to the event outcome (the average physiological activity from the four seconds prior to the event outcome) and physiological reactivity or baseline-to-post-event-peak measures for each individual. As
highlighted previously, the peaks in SCL occurred earlier than in HR, therefore the peak responses were taken from three to seven seconds post event outcomes for SCL and from five to nine seconds post event outcomes for HR. Correlations were then computed between the physiological and self report questionnaire data.

For the electrodermal data, SCL reactivity (baseline-to-peak) to losses was negatively correlated with the GUS, \( r(12) = -.69, p < .05 \) and the IBS, \( r(12) = -.61, p < .05 \). These associations reveal that those who exhibited greatest SCL increases following loss events held less gambling urges and endorsed fewer gambling related cognitive distortions. There were no relationships between peak changes in HR to losses and any of the self-report questionnaires.

Peak electrodermal changes following win events were negatively correlated with the IBS, \( r(12) = .67, p < .05 \). This indicates that those who exhibited the greatest increases in SCL following wins endorsed fewer beliefs indicating informational biases related to EGM play. There were also significant negative relationships with the GUS, \( r(12) = -.58, p < .05 \), and the IBS, \( r(12) = -.65, p < .05 \), with the peak cardiac responses following win events. These associations indicate that those participants who experienced greatest increases in HR following win events had less urges to gamble and endorsed fewer gambling related cognitive distortions following EGM play. Moreover, the findings indicate that the gambling cognitions held by participants explained 42% and 44% of their variation in electrodermal and cardiac activity, respectively, in response wins during EGM play. There were no significant relationships found between impulsivity and any of the peak physiological changes in HR or SCL following events during EGM play.
6.6 – Discussion

Study C addressed criticisms directed at past research by employing strict criteria to identify PGs, monitoring multiple physiological objective measures (HR and SCL), while participants gambled with their own money, in response to within session characteristics (wins/losses) during gambling on electronic machines in a natural field environment. The study showed that, with the aid of sophisticated ambulatory computer technology, physiological changes associated with gambling on electronic machines can be captured reliably in a field setting.

The results of Study C indicated that healthy controls (non-PGs) showed significantly greater increased autonomic arousal (both HR and SCL) immediately following wins compared to PGs. The findings that PGs exhibited less increases in arousal compared to non-PGs following wins during gambling on electronic machines in a field setting are consistent with previous data collected in laboratory environments following winning decisions in the Iowa Gambling Task (Goudriaan et al., 2006) and subsequent to imagined winning events (Sharpe, 2004). Moreover, the results showed that although there was a trend for PGs to have higher HR (baselines) during play (Figure 10B; Figure 11B); the phasic responses (HR and SCL) to wins were much larger in the non-PG group.

Hence, PGs may need to be exposed to comparatively larger wins than non-PGs in order to experience the equivalent changes in psychophysiological arousal. The amount won following an event has previously been indicated to mediate physiological responses in healthy controls (Study B) and in high frequency players (Dickerson et al., 1992; Moodie & Finnigan, 2005) following events during gambling on electronic machines. The lesser physiological responses after wins in PGs support the notion of lower reward sensitivity in PGs (Goudriaan et al., 2006).
As highlighted in Chapter 2, Reuter et al. (2005) found PGs exhibited decreased activation in two brain areas related to reward response compared to controls, suggesting that they experience diminished reward from gambling. Study C’s data corroborate the proposal of diminished physiological responding in response to wins; this might mean that PGs need to experience multiple wins or wins of higher magnitude (e.g. features or jackpots) in order to attain similar event-related boosts in arousal that healthy controls attain with lesser rewards. The allure of repeating the experience of features or jackpots on EGMs have been reported by PGs to be significant triggers for them to bet more than they intended to before play (McDonnell-Phillips Pty Ltd, 2006). It was observed in the current study (Study C) that PGs did play maximum lines on the EGMs more often than non-PGs, which increased the percentage of trials that had winning outcomes (Table 6). The current findings suggest that the experience of more wins does not increase physiological responses for PGs. “Winning Big” or features/jackpots may therefore be required for PGs to experience a rush during gambling. An analysis of the amount won was not possible with current equipment available at the time of Study C. Future studies may benefit from the recording of multiple event types (small wins, big wins, jackpots, losses, etc.) in the field setting.

It should be acknowledged that our findings are correlational and do not indicate cause-effect relationships. In other words, it is unclear whether the diminished responsiveness to wins observed in PGs was a consequence of frequent gambling or whether it contributes to problem gambling. In order to resolve this distinction, there are several options for researchers. It may be pertinent to first examine sensitivity to rewards in individuals at early adulthood, prior to exposure to gambling and then at long term follow-up. Current psychometric measures of gambling behaviour (e.g. CPGI) also allow for sub-types of PGs and non-PGs to be investigated across a continuum. The
collection of cross-sectional physiological data may consider whether diminished sensitivity to rewards is not only displayed in those suffering most harm (PGs), but also in individuals experiencing some problems as a consequence of their gambling behaviour.

Although Study C found PGs responded less to wins than non-PGs; neither PGs nor non-PGs exhibited significant physiological responses to losses during gambling on electronic machines (Figure 11B). Insensitivity to losses has previously been proposed as contributing factor for the persistence of PGs in the face of large net financial losses (Campbell et al., 2004; Custer, 1984). PGs previously have been described as having blunted responses to losses in an imaginal gambling task (Sharpe, 2004). However, the current findings reveal that both PGs and non-PGs are similarly insensitive (at least in a physiological sense) to individual losses on EGMs. The sizes of individual losses are comparatively of much lower monetary value on EGMs than those which have been portrayed in previous imaginal tasks. Additionally, the rapid and continual exposure to losses on EGMs may habituate responding to individual loss events in both PGs and non-PGs. These factors may explain the lack of physiological differences obtained to individual losses. In fact, responses to losing may only be evident at the conclusion of participation. Several participants in the sample continued to gamble after their participation; therefore an analysis of this factor was restricted.

With regard to tonic HR, Study C revealed significant differences in physiological activity pre to post sessions of gambling. For non-PGs, tonic HR increased from baseline to post session; whereas for PGs tonic HR decreased (Figure 12). Notably, only one participant in each group had won overall at the completion of physiological recording, therefore the between group changes observed are unlikely to be accounted for by different outcomes from the gambling sessions. This between-group
pattern of results is also consistent with the possibility that PGs respond to end-session losing by a decrease of HR (relative to their baselines) whereas non-PGs respond in the opposite direction. However, this explanation is tentative because losses are accompanied by similar drops in HR when phasic data are considered. Increased arousal in response to losing sessions for non-PGs may aid their self-regulation. Future investigations may attempt to further scrutinise responsiveness of PGs and non-PGs to losing on EGMs by monitoring arousal over multiple sessions. This would allow for physiological responses to winning and losing at the completion of sessions to be compared within the same individual.

The non-PG group produced autonomic responses similar to that obtained in previous laboratory investigations of normal controls where they have not wagered their own money (Goudriaan et al., 2006; Study A; Study B). In this field study, participants played an EGM using their own money and physiological measures were shown to be robust and sensitive to changes associated with winning outcomes for non-PGs. However, unlike in the previous laboratory studies (Goudriaan et al., 2006; Study A; Study B) non-PGs in Study C were found to respond differentially on both physiological measures obtained (HR and SCL) in response to winning outcomes. This finding may reflect the possibility that electrodermal measures are more sensitive to minor changes whereas changes in HR are observed only when more substantial changes to the arousal state occur. In any case, the current results help make sense of inconsistent results observed previously by clarifying that stronger cardiac responses to gambling are likely to occur in fields settings (Anderson & Brown, 1984; Diskin et al., 2003) and/or when participants gamble with their own money (Ladouceur et al., 2003), but not in laboratory settings that provoke minor arousal changes.
Although similar patterns of reactivity to wins and losses were evident for the two physiological measures used (HR and SCL), for non-PGs, there were some discrete between-group differences. For non-PGs, electrodermal peaks to wins occurred earlier than HR peaks to wins (Figure 11B). Moreover, across the 21 second epoch, non-PGs were seen to have elevated SCL, compared to PGs (Figure 11A). While electrodermal activity was generally lower for PGs, their HR was generally higher during the entire 21-second epoch examined (Figure 10A). It was only in response to wins, that non-PGs experienced similar levels of cardiac activity and this was only for a few seconds.

The temporal and intensity differences between the SCL and HR data further support suggestions that physiological measures vary in their sensitivity to different components or levels of the response (Barry, 2006; Croft et al., 2004). Studies should therefore continue to employ multiple measures. The use of SCL is particularly indicated given its consistent ability to portray response differences to wins and losses during gambling on electronic machines in both laboratory (Study A; Study B) and field (Study C) environments. The dissociation between changes in HR and SCL during gambling on EGMs is more closely examined in the following discussion chapter.

The physiological reinforcement (arousal) experienced during gambling on electronic machines has been identified as an important factor for the initiation and maintenance of PG; however, it is an insufficient explanation in itself (Moodie & Finnigan, 2005). Study C assessed urges to gamble, gambling related informational biases and impulsivity, and their association with physiological responses to within session characteristics during EGM play. No association between measures of impulsivity and responses to gambling outcomes were observed. The findings may have been compromised by the small sample size. Suggesting an importance of arousal achieved during the task, those participants who displayed diminished responses to wins
(PGs) reported the highest urges to gamble following the task. Moreover, the presence of gambling related cognitive distortions was related to lowered responses to both wins and losses. These unique findings support proposals that identify that both physiological and cognitive components mediate PG (e.g. Griffiths 1993b; Sharpe, 2002) and illustrate a need to investigate the interactions further.

Some limitations should be acknowledged with regard to the generalisation and interpretations of the findings of Study C. It utilised an in-vivo gambling task where participants played an EGM in a club setting. Similar to Studies A and B, which were conducted in a laboratory, participants engaged with commercially available EGMs and were monitored experiencing a variety of event outcomes. Participants experienced different sets of event outcomes. The researcher marked event outcomes and this carries small discrepancies in regards to response time (see Chapter 5 for a full analysis of experimenter response time and accuracy). The EGMs in the club setting were not altered by the researcher; losses occurred more frequently than wins (Table 6). The continuous play of participants also meant that the effect of following event outcomes on arousal was not controlled. These limitations of the experiment are not expected to have significantly altered the pattern or strength of results obtained.

Some environmental variables remained beyond the control of the researchers. The club’s layout required participants to move between administration and gaming areas. The effects of these movements on the tonic measures of HR and SCL are uncertain. Throughout recording sessions, participants were seated and there were limited movements whilst playing. The sound and visual stimuli elicited by surrounding machines or by other patrons within the gaming room were not controlled; however, the participants did not communicate with others during the task. These variables are not expected to have affected the strength or pattern of results for the phasic data. Also,
although all participants chose to gamble within non-smoking areas of the gaming lounge, it should be noted that second-hand smoke entering from surrounding smoking areas was not controlled and this may have differentially affected participants’ recordings. Nonetheless, reliable and robust significant differences between PGs and non-PGs were observed.

Study C uniquely investigated between groups psychophysiological differences in response to win and loss events during gambling on electronic machines. Notably, participants gambled with their own money on real not computer simulated EGMs in a natural setting. Measures of both electrodermal and cardiac activity captured responses of PGs and non-PGs to gambling. Wins but not losses were shown to evoke increases in physiological activity. Importantly, the results show that PGs exhibit reduced electrodermal and cardiac responses after wins, compared to healthy controls, which suggests a diminished sensitivity to rewards during gambling on electronic machines. Additionally, healthy controls exhibited significant increases in HR post gambling sessions, while PGs showed reductions.

Overall, although physiological responses have been identified as potential factors in the onset and development of PG, they provide an inadequate account for the persistence in the face of large net financial losses. Longitudinal studies investigating associations between physiological and psychological measures applying methods similar to Study C would seem particularly valuable.

The data collected in the current program of research (Studies A, B and C) have elucidated evidence for a number of theoretical positions held in the gambling research community. The implications of these collective findings are discussed in the following chapter.
7.1 – Overview

This chapter integrates findings from the 3 studies and critically evaluates their contributions. The chapter is organized as follows: A précis of the key empirical findings from Studies A, B and C is provided. Their contributions to theory and research are then discussed. Potential clinical applications stemming from the current findings are considered. Finally, strengths and limitations of this thesis are outlined, with recommendations for future research provided.

This thesis has presented the findings of a three-stage program of empirical research. Three studies were conducted to increase knowledge of how gambling behaviour develops and is maintained. An emphasis was placed on EGMs as they account for the majority of gambling expenditure (Office of Economic and Statistical Research, 2006; Productivity Commission, 1999) and are the preferred form of gambling for most PGs (Faunce, 2006; Productivity Commission, 1999) in Australia. Following an extensive literature review, several gaps appeared in the research literature:

1. Although increases in arousal had commonly been found post sessions of gambling, there were limited systematic investigations of physiological responses exhibited to events (i.e. wins and losses) within sessions of gambling.
2. The physiological effects of winning and losing had rarely been monitored within the same individual.
3. Physiological changes in response to gambling were commonly investigated by only monitoring single physiological measures, most commonly HR.
4. Few studies had compared the physiological responses of PGs and non-PGs during participation in real world gambling tasks.

Consequently, it was not clear whether gambling on electronic machines is intrinsically reinforcing or if winning is an important factor in sustaining arousal and maintaining gambling behaviours on EGMs. Specifically, it was critical to determine the effects of win and loss events on the psychophysiology of the gambler.

Studies A and B allowed for a trial of the physiological monitoring equipment with an electronic gambling machine in a controlled environment. The laboratory environment enabled the researcher to reduce the impact of confounds related to the effects of alcohol (Stewart et al., 2005, 2006); physical movement (Dickerson et al., 1992); or external visual and auditory stimuli, such as that elicited by other machines or gamblers. Studies A and B were also conducted to establish a psychophysiological profile for non-PGs. Recruitment of participants can be hampered in field settings. Ethical and legal requirements state that participants cannot be encouraged to gamble with their own money for the purposes of research. Furthermore, there can be a lack of cooperation from licensed gambling venues for research to be undertaken.

Table 8 highlights the key empirical findings of Studies A, B and C. Each of the studies conducted made significant contributions to theory and research. Study A (Chapter 4) showed that physiological activity (both HR and SCL) could be reliably captured on a second-by-second basis during gambling on electronic machines. Study A employed averaging procedures designed to enhance signal-to-noise ratios (Picton et al., 2000). This procedure enabled a sophisticated comparison of event-related phasic electrodermal and cardiac activity during gambling on electronic machines. Study A found that physiological responses to wins could be differentiated from losses. Non-PGs
SCL significantly increased immediately following win events and remained elevated for up to eight seconds.

Table 8

Research summary: Key empirical findings

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>N</th>
<th>Study Type</th>
<th>Self-report measures</th>
<th>Key empirical findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Undergraduates (non-PGs)</td>
<td>12</td>
<td>Laboratory</td>
<td>IBS SOGS GUS</td>
<td>1. Modern technologies can be utilised to capture physiological responses to win and loss events in EGM gambling.</td>
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<td>2. Non-PGs exhibited greater physiological activity in response to wins compared to losses.</td>
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<td>3. Increases in electrodermal activity to wins lasted for a prolonged period (up to eight seconds).</td>
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<td></td>
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<td></td>
<td>4. Gambling urges were associated with the level of electrodermal reactivity to wins.</td>
</tr>
<tr>
<td>B</td>
<td>Undergraduates (non-PGs)</td>
<td>24</td>
<td>Laboratory</td>
<td>IBS SOGS GUS DASS-21 I-7</td>
<td>5. Win events (both small and big) were shown to produce significant increases in arousal, whereas loss-events produced minimal changes.</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td>6. Both the amount won and amount staked influenced physiological activity during EGM gambling.</td>
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<td></td>
<td>7. Non-PGs responded to events offering no monetary gain (fake wins).</td>
</tr>
<tr>
<td>C</td>
<td>PGs and non-PGs</td>
<td>12</td>
<td>Field</td>
<td>IBS SOGS GUS CPGI I-7</td>
<td>8. Physiological responses to within session outcomes during EGM gambling were captured in a field setting.</td>
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<td></td>
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<td></td>
<td>9. Compared to losses, non-PGs demonstrated significantly increased electrodermal and cardiac activity to wins, while PGs did not evince this difference.</td>
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<tr>
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<td></td>
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<td></td>
<td>10. Higher levels of endorsement of gambling related irrational cognitions were associated with differential physiological responses to wins and losses.</td>
</tr>
</tbody>
</table>
In Study A, HR was slightly elevated following win events; however, the changes were not significant. Study A’s findings therefore indicated that SCL may be a more sensitive measure of phasic changes in physiological activity than HR. Importantly, Study A showed that physiological activity to win and loss events on an EGM can be reliably measured. Moreover, these rapid changes were captured in real time.

It was important to replicate and extend the findings of the pilot study. Therefore, Study B (Chapter 5) recruited a larger sample and monitored phasic changes in HR and SCL following win and loss events and examined tonic changes pre to post gambling sessions. Study B replicated the pilot study in that win events were once again found to produce significant increases in SCL, whereas loss-events produced no changes. In addition, Study B showed that increases in SCL following events were greater as the amount won increased. These findings suggest that monetary gain does affect autonomic arousal in non-PGs. Nonetheless, non-PGs who mostly had lost overall had significantly increased SCL, compared to baseline, supporting proposals that gambling is inherently arousing.

Study B monitored HR and SCL in response to a larger variety of event outcomes (losses, fake wins, wins, and big wins). Analysis of multiple win and loss event types also showed that increases in SCL during gambling are associated with events offering additional auditory and visual stimuli, but no monetary gain (fake wins). This finding supports arguments that monetary gain acts as a secondary factor mediating physiological activity during gambling (Wulfert et al., 2005). This finding is also supported by behavioural evidence that suggests both non-PGs and PGs prefer a strategy of playing maximum lines over betting more credits per line on EGMs (Blaszczynski et al, 2001). Frequent returns are favoured over returns that are larger and more financially rewarding, but less frequent (Dowling et al., 2005).
The findings of Study B indicate that arousal achieved during gambling on electronic machines is likely to be moderated not only by winning, but also by factors controlled by the player, such as the amount staked on each outcome. A progressive increase in SCL was found in relation to the amount wagered. No significant tonic or phasic changes in HR were found in Study B. This further supported arguments that SCL may be a more sensitive measure of autonomic arousal when gambling on electronic machines.

It was important to transfer the physiological recording methods tested in the laboratory to a natural field environment, and this occurred in Study C. Study C (Chapter 6) was an investigation of the effects of wins and losses on HR and SCL during gambling on electronic machines in a club setting. Both HR and SCL were significantly increased following wins, compared to losses. However, a comparison of phasic physiological responses of non-PGs and PGs to wins and losses showed that PGs exhibited reduced physiological activity (both HR and SCL) following wins compared to non-PGs. The psychophysiological profile of non-PGs was therefore consistent across all three studies, with greater electrodermal responses exhibited to winning versus losing events when gambling on electronic machines. Notably, significant changes in HR to wins were only found in non-PGs when wagering their own money in a field setting (Study C). Moreover, PGs were found to respond similarly to wins and losses. These findings indicate that PGs experience different physiological activity when gambling compared to non-PGs. Significantly, Study C showed that rapid changes in physiological activity to win and loss events during EGM gambling can be reliably monitored in a natural setting.
7.2 – Discussion of thesis findings

Collectively, the studies provide empirical support for a number of factors relating to the development and maintenance of PG amongst EGM gamblers. The following sections evaluate the findings and position them against the theoretical landscape of gambling research. The factors addressed are reinforcement, reward and punish sensitivity, avoidance of negative affect, cognitions and impulsivity.

7.2.1 – Physiological arousal as reinforcement

The current program of research evaluated both state (tonic) changes in autonomic arousal to sessions of gambling on electronic machines and event-related (phasic) changes to wins and losses experienced within sessions of gambling. The tonic measures (measured in 2-minute periods in between gambling sessions) were utilised to measure how gambling on electronic machines affects arousal in general, while the phasic changes were to be indicative of the reinforcing qualities of wins and losses.

The tonic measures attained in this thesis indicate that following sessions of gambling activity non-PGs experience increases in autonomic arousal, whereas PGs showed no evidence of reinforcement. Non-PGs exhibited significant increases in SCL in the laboratory (Study B), while significant increases in HR were found in the club setting (Study C). PGs, meanwhile, demonstrated slight reductions in HR and relatively stable electrodemal activity pre to post sessions of gambling on electronic machines in the club setting (Study C). These findings suggest that gambling is not intrinsically arousing for all participants as suggested by Wulfert et al. (2005). The findings are contrary to Moodie and Finnigan (2005) who found that frequent gamblers (PGs) exhibited greater increases in HR during and post sessions of gambling on electronic machines, compared to infrequent and non-gamblers. It should be noted that in the
Moodie and Finnigan (2005) study, 53 of the 63 participants observed walked away having “won” more than £1 following their 20 shots on an EGM. This extremely high proportion of participants experiencing monetary gain as a result of the gambling episode may have shown that winning created greater HR increases in PGs across sessions of gambling, rather than simply gambling on EGMs having produced the changes. Notably, only one of the six PGs in Study C experienced monetary gain at the end of the gambling episode. The difference in the proportion of “winners” versus “losers” across sessions of gambling, between the two studies (Moodie & Finnigan, 2005; Study C) may explain the inconsistent tonic findings.

Another potential explanation of the inconsistency in the between group tonic HR findings is that Moodie and Finnigan (2005) controlled wager size and provided funds for betting in their field study. It is possible that in Study C PGs wagered smaller amounts of their own money than they would normally due to being observed by the researcher. This may have reduced the arousal changes in PGs in response to gambling in Study C. The general inconsistency in results when focusing on tonic changes in physiological activity indicates that other methods, such as a focus on event-related phasic changes in response to winning should be employed.

The original contribution of this thesis to the body of knowledge was achieved by tracing phasic changes in autonomic measures during gambling on electronic machines. All three studies indicated that wins produced greater increases in arousal than losing events (losses or fake wins). Non-PGs showed physiological reactivity to wins in all three studies. Significantly, PGs did not respond to wins. This is contrary to the findings of Moodie and Finnigan (2005), who found frequent gamblers (PGs) exhibited greater increases in HR following wins on electronic machines, compared to infrequent and non-gamblers. Unlike the present field study (Study C), Moodie and
Finnigan (2005) interrupted the participants between trials for recordings to take place. This may have increased frustration levels within the PGs, which may have contributed to greater increases in their HR. Reductions in the speed of EGM play have previously been reported to increase frustration and displeasure in PGs compared to non-PGs (Blaszczynski et al., 2001). However, given the inconsistency in results between the studies it seems particularly pertinent to attempt to replicate the current findings with a comparison of larger samples of PGs and non-PGs.

The importance of reinforcement via wins during gambling on electronic machines must not be underestimated. In the case of EGMs, reinforcement is delivered via a variable-ratio schedule, with rewards delivered following varying numbers of spins. The frequency of event outcomes during gambling on electronic machines is directly proportionate to the amount rewarded to the player. Similar to previous data (e.g. Delfabbro & Winefield, 1999; 2000), Study B identified that returns (fake wins, small wins and big wins) are delivered approximately once in every three spins. Study B’s data also confirmed past findings (Dickerson et al., 1992; Moodie & Finnigan, 2005) that the magnitude of physiological responses (reinforcement) experienced are proportionate to the amount won. Collectively, the findings suggest event frequency and the amount returned to the player are significant predictors of changes in physiological activity when gambling.

The phasic findings across the three studies conducted comprehensively support proposals that wins are important in triggering arousal changes (reinforcement) during sessions of gambling on electronic machines. The occurrence of fake-wins and the accompanying bells and whistles that accompany these and other wins might further contribute to reinforcing arousal changes.
The current program of research has shown that phasic changes in autonomic arousal are greater in response to wins than losses on electronic machines for non-PGs (Studies A, B and C). The following section discusses how the behaviour of PGs may be explained by how they respond physiologically to rewards.

7.2.2 – Reward sensitivity

A primary aim of the psychophysiological investigations conducted in this program of research was to explore whether PGs possess unique physiological differences that would predispose them to continue to gamble despite adverse psychosocial consequences. Significantly, it was found there was a difference in response to rewards between non-PGs and PGs. The psychophysiological profile of non-PGs in response gambling on electronic machines was consistent in all three studies conducted with non-PGs exhibiting differential responses to winning versus losing events. Heightened sensitivity to rewards (wins) was therefore evident in non-PGs. However, PGs were found to respond minimally to both win and loss events (Study C).

The finding of reduced physiological responses after wins in PGs, compared to non-PGs, is consistent with previous empirical research (Goudriaan et al., 2006) and support the notion that they have diminished reward sensitivity. Lowered physiological activity in regions of the brain commonly associated with reward response, have similarly suggested that PGs may experience diminished reward from gambling (Reuter et al, 2005). These results are both interesting and valuable.

As highlighted in Chapter 3, Damasio (1996) proposed three physiological explanations for PG based upon responses to rewards and punishment within gambling tasks. Study C’s findings are inconsistent with the first hypothesis that PGs may be hypersensitive to rewards. Moreover, neither PGs nor non-PGs exhibited sensitivity to
punishment (losses) within gambling tasks (see Section 7.2.3, below). The evidence obtained does support, however, Damasio's (1996) third hypothesis that PGs may be generally insensitive to both positive (wins) and negative (losses) outcomes within gambling tasks. Without a physiological cueing of exposure to rewards or punishment when gambling on EGMs, PGs attention may be set on the prospects of, rather than the actuality of, winning (Damasio, 1996). This may also contribute to the abnormal development and maintenance of irrational cognitions related to the prospects of winning for PGs (see Section 7.2.5).

Our finding of lowered sensitivity to rewards is also consistent with homeostatic conceptions of arousal that postulate that higher and lower deviations from an optimal or normal range (e.g., temperature) are intrinsically aversive, triggering strategies to revert to a homeostatic balance. In other words, PGs may need to experience more frequent and/or larger wins than non PGs to attain similar levels of arousal. PGs may therefore resort to gambling more often or with more money. Unfortunately, these strategies carry significant financial risks, which likely increase their exposure to significant adverse psychosocial consequences.

The impact of stake-size and win-size manipulations on psychophysiology within gambling tasks and in live gambling are yet to be systematically examined. Such investigations should aid in the identification of which factors affect arousal in PGs whilst gambling. Current evidence does suggest that PGs do gamble with greater persistence and with more money (Blaszczynski et al, 2001; Sharpe et al., 2005). It remains uncertain whether this is for purposes of achieving optimal levels of arousal (Anderson & Brown, 1984).

The current findings in all studies presented in this thesis provide preliminary, but promising evidence that PGs respond differently to rewards than non-PGs.
However, the results of the studies do not ascertain whether the diminished reward sensitivity of PGs during gambling on electronic machines existed before or is a consequence of their exposure to EGMs. An examination of reward sensitivity, prior to and post exposure to EGMs in a longitudinal design with high-risk individuals is required. Such a study has the potential to identify whether sensitivity to rewards can predict those developing PG from those who do not.

7.2.3 – Punishment sensitivity

The importance of punishment sensitivity during gambling on electronic machines was not evident in the findings of this thesis. Sharpe (2004) has argued that responses to losing may be most important for the development and maintenance of PG. Conversely, Goudriaan et al (2006) reported that scores on psychometric measures of sensitivity to punishment indicated that PGs have a somewhat higher sensitivity to immediate negative consequences than non-PGs. Contrary to this, Studies A and B both showed that non-PGs experience minimal changes in HR and SCL following loss events. Similarly, no differences were found between PGs or non-PGs in how they responded to loss events when participants gambled with their own money (Study C). Both groups displayed no significant changes in HR or SCL post losses. Because losses on EGMs are experienced so frequently and are of such small scale individually compared to other forms of gambling (e.g. blackjack) the observed lack of a physiological response may be specific to small losses. The impact of major losses on physiological activity needs further investigation in both PGs and non-PGs.

The conditioning effect of punishment is mediated by the time between event stimulus and actual punishment (Staddon & Cerutti, 2003). While win events on EGMs are delivered with additional positive stimuli immediately, losses are less perceptible,
with fewer associated “bells and whistles”. Negative consequences (punishment) may only be perceived with accumulated losses or when gambling can no longer continue. Evidence does suggest that a cumulative loss of $20 or more is more likely to trigger continued gambling beyond preset limits on EGMs in PGs more so than for non-PGs (McDonnell-Phillips, 2006). Physiological differences in how PGs and non-PGs respond to negative outcomes (punishment) may only be evident at the completion of sessions of gambling on electronic machines.

Because several participants in Study C continued to gamble on EGMs after their participation, our results were not analysed in a between-group, winners vs. losers design. Study C did indicate that in groups of PGs and non-PGs that mostly had lost overall, non-PGs exhibited greater pre-to-post increases in physiological activity (HR). This provides some preliminary support to suggestions that PGs are less sensitive to losing (punishment) than non-PGs (Campbell et al., 2004; Custer, 1984; Sharpe, 2004). Direct comparisons of physiological responses of larger groups of PGs and non-PGs at the completion of losing sessions of gambling on electronic machines are required to further examine the role of sensitivity to punishment.

This thesis has indicated that physiological activity is increased when experiencing larger rewards (Study B); the same may be true for punishment. In terms of phasic responses to punishment on EGMs it may therefore be pertinent to examine HR and SCL in response to big losses on EGMs. This may be achieved comparing physiological responses to larger losses following attempts to gamble or double-up returns on EGMs.
7.2.4 – Avoidance of negative affect

Research has found that ability to exhibit self-control is predicted by both sensitivity to punishment and the experience of negative affect (Slessareva & Muraven, 2004). PG is characterised by a lack of self-control and has commonly been associated with mood disorders (Crockford & el-Guebaly, 1998; Potenza et al., 2002). PG has therefore been explained in terms of a removal of adverse feelings. Avoidance of negative affect or unpleasant circumstances as a determinant for engaging in gambling behaviour has been identified by several authors (Blaszczynski, et al., 1990; Jacobs, 1988). PGs are considered to have recurring and intensified needs that remain unsatisfied outside of gambling activity (McCormick, 1988).

Psychometric measures of distress were unrelated to physiological responses during gambling on electronic machines in the laboratory sample of non-PGs (Study B). This was a non-clinical group, however, which exhibited few indicators of depression, anxiety or stress. No measures of distress were administered in Study C, because of a desire to minimize task requirements for field participants. Therefore generalisations that can be made about interactions between adverse arousal and subsequent gambling behaviour are limited.

In an attempt to self-regulate negative affective experiences, PGs may engage with EGMs for stress reduction (relaxation) and escape (Delfabbro & LeCouteur, 2005). In Study C, non-PGs exhibited significant increases in cardiac arousal following EGM gambling, while PGs experienced reductions. This may reflect levels of relief experienced by PGs. PGs would then pursue gambling tasks for longer in order to continue to regulate their arousal. Reductions in attention for the negative arousal may also be moderated by the experience of reinforcement. Excitement following large wins (Study B) may aid distraction from day to day boredom or distress. Also, “chasing” or
continued gambling following large losses could be explained by a return to gambling to avoid or put off negative feelings (Lesieur, 1984).

Future psychophysiological investigations may include measures of motivations to gamble, life satisfaction or general levels of distress in PGs and non-PGs in order to fully uncover the relationships and the relevance of escape to persistent gambling on electronic machines despite adverse consequences. This research could have significant clinical implications for therapeutic treatments. The implication is that treatments of individuals with PG may not have to focus on the experience of gambling, but rather on challenging individual’s general perceptions of the world and organisation of their life in terms of need to escape (Slessareva & Muraven, 2004).

7.2.5 – Irrational cognitions

The general experience and perceptions of the world may differ for PGs and non-PGs (as discussed above), however, research has identified cognitions regarding gambling and its outcomes differ significantly between the groups (e.g. Jefferson & Nicki, 2003; MacKillop, Anderson, Castelda, Mattson & Donovick, 2006). Study C is the first field research to have examined interactions between irrational cognitions and physiological activity in PGs and non-PGs to wins and losses during gambling on electronic machines. Study C was exploratory and had a small sample, which may limit the generalisability of the findings. Nonetheless, physiological responses to wins were significantly greater for those participants who held less irrational cognitions related to gambling on electronic machines. Because PGs held more irrational cognitions, this finding may be a consequence of gambling status or may be independent or additional to gambling status. It will be important for research to investigate whether this association holds in larger samples and for PG and non-PG groups separately.
Significantly, the close association between irrational cognitions and arousal elicited in response to win and loss events (Study C) supports suggestions that it may be possible to affect the proposed physiological response differences to gambling in PGs by addressing their endorsement of cognitive distortions related to gambling (Freidenberg et al., 2002; Walker et al., 2007). Examinations of process mechanisms of therapeutic change in future evaluations of treatments could enable a clearer understanding of the relationships between cognitive distortions related to gambling, arousal and PG. Particularly, if randomized control trials are employed. These are required for the identification of central mediators of treatment outcomes for PGs (Pallesen et al., 2005).

7.2.6 – Impulsivity

The current findings support conclusions that impulsivity only has a small impact on the expression of gambling behaviour for a limited proportion of PGs (Steel & Blaszczynski, 1998), particularly in relation to EGM use. Impulsivity was investigated in Studies B and C as an underlying factor that may mediate physiology during gambling on electronic machines. Study B found no relationships between impulsivity and physiological reactivity to wins or losses during gambling on electronic machines in non-PGs. Similar to Study B, across PG and non-PG groups, no association was found between impulsivity and physiological responses to event outcomes (Study C). It should be noted that neither of the studies recruited high and low impulsivity participants. This may have somewhat limited the power of relationships between impulsivity and arousal in response to wins and losses.

Notably, the impulsivity scores of the PGs and non-PGs obtained in Study C did not significantly differ as in previous studies which have monitored other forms of
gambling, which involve greater skill components. Krueger et al. (2005) found that most of the high impulsivity blackjack gamblers sampled were PGs. Blackjack is considered as a gambling type in which skill can affect the outcome of events (Delfabbro & LeCouteur, 2005). It is possible that sub-types of impulsive PGs (Blaszczynski & Nower, 2002) are attracted to such gambling activities which reward skill and greater opportunities for decision making than offered on EGMs. As Study C was an exploratory study, the small sample prevented a meaningful within group comparison of impulsivity and physiological reactivity to wins and losses amongst PGs. Larger studies may be required to elicit physiological response differences to gambling on electronic machines mediated by this personality trait. Nonetheless, neither Study B nor Study C’s findings support proposals that impulsivity is associated with physiological reactivity to EGMs.

7.3 – Psychophysiology of gambling on EGMs: relationships between HR and SCL

HR and SCL have long been the two primary indices of arousal in empirical research (Hassett, 1978). However, these measures have often been examined in isolation, and in gambling research disproportionate attention had been placed on measuring tonic rather than phasic activity. This thesis has reported both tonic and phasic data for HR and SCL, which was captured simultaneously in response to gambling on EGMs. This current section will first discuss the responses captured by HR and SCL in the current program of research before their theoretical implications including the response fractionation hypothesis and dual process theory are discussed.

Across the three studies in the current program of research it was found that neither tonic nor phasic changes in cardiac and electrodermal activity were correlated within individuals. Moreover, in Study C it was found that PGs had higher baseline HR
compared to non-PGs, prior to gambling on EGMs, but a lower SCL. In fact, non-PGs exhibited significant increases in tonic activity for one measure (HR) and showed a trend to decrease for the other (SCL), following gambling on EGMs. Mismatches in response between the electrodermal and cardiac systems is not uncommon in psychophysiological research (e.g. DiCara & Miller, 1968; Vaezmousavi et al., 2007), but the evidence presented in the current thesis is particularly compelling because both tonic and phasic measures were examined to multiple events during the gambling task.

Previous results had indicated a tonic fractionation of autonomic activity in response to gambling in general when multiple physiological measures had been used (see Table 1, Part A). The methodology applied in the current program of research also allowed for a phasic capture of cardiac and electrodermal activity on a second-by-second basis. This procedure facilitated a close inspection of the relationship between phasic cardiac and electrodermal changes in response to gambling on EGMs. The current findings highlight a probable phasic fractionation of autonomic activity (Barry, 2006), and argue against unitary theories of autonomic response (e.g. Sokolov, 1963): SCL was found to be sensitive (in non-PGs) to wins in all three studies completed and it exhibited an earlier response compared to HR in Study C. Further focus at phasic changes in autonomic activity across multiple measures (e.g. HR, BP, SCL, EMG, etc.) is indicated, given the disparities in response between HR and SCL in the current research.

The above findings also support arguments that changes in electrodermal activity are a robust and reliable measure of phasic autonomic arousal and are consistent with findings demonstrating increased electrodermal activity when exposure to new or rewarding stimuli occurs (Rushby & Barry, 2006). Cardiac activity, meanwhile, was again shown to be a more reliable indicator of state-based tonic differences between
groups in response to gambling activity in general (Study C). Both the tonic and phasic findings support notions that cardiac and electrodermal activity are not in synchrony (Croft et al., 2004). Cardiac and electrodermal responses were found to be exhibited in response to different factors (e.g. laboratory vs. field setting) and at different times (e.g. immediately following events vs. slightly delayed) when individuals engaged with gambling on EGMs. If response fractionation is the mechanism that underpins HR-SCL differences, it may be evident at both phasic and tonic levels.

The current program of research is among the first to demonstrate that changes in cardiac and electrodermal activity vary in magnitude and may follow different temporal courses when individuals are exposed to wins and losses on EGMs. The fact that such a response differentiation is measurable in a reliable manner may have several theoretical and applied implications. Notably, the electrodermal changes exhibited by non-PGs to win events (fake wins, small wins, and big wins) were subtle in terms of magnitude, yet significant and reliable. The presence of electrodermal changes in healthy controls has previously been associated with improved behavioural responses on gambling tasks, even prior to the overt knowledge of these physiological changes, or the task rules to which the participants are responding to (Bechara, Damasio, Tranel & Damasio, 1997). It is possible that the observed electrodermal changes to wins in our study also represent, at least in part, the effects or correlates of unconscious marker mechanisms that are subtle and imperceptible on the majority of occasions (Damasio, 1994). Given that the responses were larger for wins than for losses, it is likely that the electrodermal activity represents a composite of several effects including reactivity to event-outcomes, or a somatic marker deficit that is specific or more pronounced to win events. The current study therefore extends findings about persons with PG. In addition to potentially reduced somatic marker-activation that would likely affect wins and
losses (probably unconscious, and better examined by the IGT), the study points to reduced responsivity to win outcomes among PGs. As mentioned previously, it is unclear whether this deficit represents a trait-deficit among PGs that contributes to the development of gambling or whether it represents a habituation-type effect that is the consequence of experiencing similar events from gambling for extended periods of time.

If Damasio’s theory is accurate, the presence of covert somatic markers (Damasio, 1994), may moderate the gambling behaviour of non-PGs via an unconscious to conscious cognitive pathway. The covert changes in electrodermal activity experienced by non-PGs may cue their attention to helpful information related to gambling tasks, such as how often and how much they are winning and/or losing. Importantly for PGs, their experience of fewer or no electrodermal somatic signals of winning events during gambling on EGMs may conversely contribute to an abnormal level of inattention (both conscious and unconscious) to discrete details during gambling episodes; or an ability to only respond to highly meaningful or rewarding stimuli (i.e. features or big wins), which may create less-subtle (conscious) physiological changes. With a narrowed attention for phasic stimuli, irrational gambling related cognitions based upon non-factual biases may develop to explain/rationalise prolonged gambling behaviour despite significant net overall losses (i.e. System 2 cognitions; Evans & Coventry, 2006).

Further research that investigates the attention of PGs and non-PGs to stimuli during gambling on EGMs may benefit our understandings of the conscious and unconscious processes during the gambling episode. Methods may include the replication of the current experimental paradigm, with the additional measurement of eye-movements and requesting verbal feedback related to what individuals are directing
their attention towards and physiologically experiencing following wins and losses on EGMs. Given the observed mismatch between physiological measures, a mismatch between self-report changes and actual changes in phasic physiological activity may be anticipated. Researchers have previously reported incongruence between self-reported experience and changes in tonic physiological activity (Diskin et al., 2003).

The lack of concordance between HR and SCL measures is also noteworthy. Importantly, the current psychophysiological findings suggest that changes in electrodermal and cardiac activity are triggered by different factors during gambling on electronic machines. The fact that wins events generated SCL changes during simulated gambling tasks (Studies A and B) when non PGs played for small incentives (movie vouchers) and SCL and HR changes in real-life conditions (Study C) would suggest that SCL may be sensitive to subtle changes in autonomic activity, whereas HR may be sensitive to larger changes. The absence of a win-loss HR difference for PGs could be the result of long-term habituation. In effect, PGs would be expected to demonstrate such a difference only for very large wins. An investigation that monitored responses to large wins in both PG and non-PG samples, or a longitudinal study that examined win-loss differences during the developmental course of PG might be able to verify these hypotheses. Additionally, it is also possible that the two measures (HR and SCL) are differentially sensitive to conscious and unconscious processes.

The following section highlights possible clinical applications of the data obtained in the current research, which has highlighted the influence of mind and body on gambling behaviour.
7.4– Clinical implications

The findings that non-PGs manifest consistent and reliable physiological changes to win (but not loss) events during gambling on electronic machines are the results that have the greatest potential for clinical application. It is important to determine whether these changes also occur among PGs. The pilot field study we conducted yielded promising results. The psychophysiology of PGs demonstrated no change whatsoever to win events. If our results are replicated, physiological abnormalities exhibited by PGs in response to gambling may allow for screening tools to be developed that could identify EGM players at risk (i.e. those with low reward sensitivity). The key advantage of physiological measures to be used as screening tools over subjective experience is that they are likely to be more objective and reliable (Blanchard et al., 2000). Self-reports of gambling behaviour are unreliable and open to deliberate and unintentional distortion. They may not necessarily correlate with objective physiological measures (Diskin & Hodgins, 2003). Moreover, PGs only seek help in a small minority of cases (Productivity Commission, 1999). Therefore, subtle physiological abnormalities (such as low sensitivity to rewards) if demonstrated to have good sensitivity and specificity may prove to be a useful screening measure to identify PGs and persons at risk for PG.

Following the development of objective physiological screens, prevention programs may be applied to individuals not otherwise identified. An example may be short psycho-education programs for those found to have low reward sensitivity. These may particularly focus on the chances of winning or effecting outcomes on EGMs and the consequences of persistence (Ladouceur & Walker, 1996; Walker et al., 2007).

A second potential clinical application from the current findings is the development of physiological measures as indicators of treatment progression or success. A pilot study has indicated that reductions in cardiac responses to gambling
cues coincided with lowered SOGS scores following treatment (Freidenberg et al., 2002). Physiological changes experienced during gambling on electronic machines may similarly act as an objective indicator of treatment progression, success and/or predictor of relapse.

The results of Study C indicate that gambling urges post sessions of gambling on electronic machines are associated with levels of physiological reactivity to win and loss events. As reviewed in Chapter 3, the reduction of gambling urges when exposed to gambling stimuli has been a feature of recent clinical treatments for PG (Oakes et al., 2008; Tolchard et al., 2006; Townshend, 2005). The findings from the current program of research suggest that monitoring physiological responses (particularly to wins) during exposure sessions may provide additional objective feedback to both the client and to clinicians. This may further enhance exposure sessions and possibly enhance treatment outcomes by further weakening associations between gambling triggers, arousal and gambling behaviours (Townshend, 2005). The clinical value of biofeedback during exposure-based treatments for PG warrants systematic evaluation.

7.5 – Strengths of the research

The strengths of this three-stage program of empirical research are:

- Multiple physiological measures (HR and SCL) were continuously monitored on a second-by-second basis during gambling on electronic machines.
- The averaging method employed in event-related brain potential research was used to capture reliable physiological responses to winning and losing events within the same individual.
- Responses to all four common event types associated with EGM gambling were monitored, which allowed for a greater understanding of the importance of winning and the amount won in reinforcing gambling behaviour.
• Laboratory testing of high versus low stakes allowed a comparison of arousal achieved in response to events based upon the amount wagered.

• The psychophysiological methods tested and shown to be reliable in the laboratory were demonstrated to be useful in the field.

• A stringent criterion was used to identify PGs.

• The program of studies included a range of gambling tasks including low-incentive and a real gambling study where participants gambled with their own money.

• Application of similar methods can be usefully adopted in other field studies (e.g. physiological responses to wins and losses during blackjack or horse racing).

• Both physiological and psychological indicators were measured and their relationships examined.

7.6 – Limitations of the research

A key limitation of the field study is the small sample size. This reduced the power of detecting significant differences between the PG and non-PGs groups, and limits the generalisability of the findings. Despite the small sample, between-group differences were found and these need to be examined by studies with larger samples.

Over fifty licensed gambling venues (clubs, hotels and a casino) were approached for access for physiological recording. However, there was great concern shown by managers and owners towards the privacy of their patrons. Additionally, there were levels of suspicion related to the use of physiological equipment and the possibility of bad publicity related to EGMs. Consequently, the recruitment of participants in the field study was limited to individuals intending to gamble on EGMs on the day of recording who responded to advertisements placed within one licensed gambling venue.
As emphasised previously, in the gambling literature, there was limited information on physiology in response to realistic gambling tasks. The sensitivity of past findings was therefore likely to have been reduced. In order to offset this limitation commercially available EGMs were utilised by the current program of research. This carries several limitations and these have previously been highlighted. They include:

- Participants experienced varied sequences of win and loss events.
- The sound and visual stimuli associated with event types were not controlled.
- The frequency of event types, such as, wins and losses was not controlled.
- The researcher marked the events.
- The time between events was not controlled.

The key limitation of current program of research is an inability to ascertain a direction of causality between the physiological and/or psychological factors and PG. Essentially, it is still unknown whether the abnormal physiological responses of PGs found are a result or cause of uncontrolled persistent gambling, which has adverse consequences (PG). This quandary extends to all attempts to draw associations between psychological explanations (reinforcement, escape, irrational cognitions and impulsivity) and PG. This highlights the importance of examinations of gambling across time.

Current psychometric tools (e.g. CPGI) allow for an identification of low to high-risk problem gambling groups. Research could sample individuals who have displayed some problematic behaviours related to gambling, but have not exhibited clinical levels of PG. Investigations could then trace their physiological and psychological qualities over time and possibly identify which factors differentiate those
developing PG from those whose problem behaviours decline or remain at the high risk levels.

The laboratory findings were likely to have been affected by the participants being prevented from wagering their own money. Participants in the laboratory samples were mostly inexperienced EGM players. Although demonstrated to be non-PGs, their gambling behaviour history did not reflect the experience of the population who are healthy controls. Since exposure to gambling is likely to influence characteristics in the gambler themselves, it would be wise for future studies to ensure PGs and non-PGs with a breadth of gambling experience are investigated.

An additional limitation of the studies conducted is that baseline physiological recordings were recorded in resting states on the same day and location of the gambling sessions. These recordings may be confounded by some anticipation for gambling activity or responses to gambling cues (particularly in the field task). It is not likely that these procedures affected the within session responses to events during play. Nonetheless, attaining additional measures in response to control tasks or on non-gambling days may have been beneficial.

Across the three studies, participants were mainly female and the groups in Study C were not sex-matched. Proposals of differential physiological responding by males and females to gambling tasks have previously been suggested when focusing on tonic measures (Coventry & Constable, 1999). Females have been observed to experience increases in arousal following exposure to winning and not to losing (Coventry & Constable, 1999), whereas males have shown significant increases to both winning and losing (e.g. Coventry & Norman, 1997). On the other hand, when psychophysiological responses of males and females have been investigated alongside each other, and under the same conditions, no significant gender differences have been
revealed (Coventry & Hudson, 2001). Yucha, Bernhard and Prato (2007) acknowledged that the balance of the evidence at hand suggests that males and females experience similar tonic increases in arousal whilst playing EGMs. Nonetheless, given the gender differences in rates of participation and forms of gambling pursued (Delfabbro & LeCouteur, 2005), future research should consider the possibility of gender differences exhibited at the phasic level in response to individual wins and losses during gambling tasks.

Another consideration when viewing the data collected is that it represents psychophysiological profiles in response to EGM use. It was deemed important to focus on EGMs because of their association with high expenditure and PG. Generalisation of the findings to some other forms of gambling, which involve less continuity of play or greater skill components may be limited. Adaptations of the methods used, however, are expected to be easily transferred across gambling types.

7.7 – Conclusion

The program of research reported in this thesis has provided an extension of knowledge in psychophysiological approaches to understanding the impact of win and loss events on individuals as they gamble on EGMs. The three studies conducted demonstrate that multiple physiological measures (HR and SCL) can be monitored on a second-by-second basis throughout a gambling episode on an EGM. In all three studies, this monitoring showed that non-PGs had significant increases in physiological activity (arousal) immediately following wins compared to losses. Moreover, significantly greater changes in arousal were found when non-PGs won larger amounts. Proposals that monetary gain is an important factor moderating arousal changes during gambling are supported by these findings.
Importantly, in the field study, PGs responded significantly less to individual win events when gambling on electronic machines compared to non-PGs. This original finding may help explain why PGs gamble excessively on EGMs (i.e. with more money or for longer periods than non-PGs). This may have significant implications for clinical practice. Corroboration of these results by other studies may form the basis of objective screening tools for PG and for ongoing physiological assessments during treatment. These may assist in the prevention and treatment of PG, and reduce the adverse psychosocial consequences experienced by the individual, their family, friends and the greater community.


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http://www.camh.net/egambling/issue11/index.html


Appendix A: SOGS

Please indicate which of the following types of gambling you have done in the past year. After each type of gambling, answer by placing a tick under "not at all", "less than once a week" or "once a week or more."

<table>
<thead>
<tr>
<th>Activity</th>
<th>not at all</th>
<th>less than once a week</th>
<th>once a week or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. play cards for money</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>b. bet on horses, dogs or other animals (at OTB, the track or with a bookie)</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>c. bet on sports (parlay cards, with a bookie or at Jai Alai)</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>d. play dice games (including craps, over and under or other dice games) for money</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>e. gamble in a casino (legal or otherwise)</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>f. play the numbers or bet on lotteries</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>g. play bingo for money</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>h. play the stock, options and/or commodities market</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>i. play slot machines, poker machines or other gambling machines</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>j. bowl, shoot pool, play golf or play any other game of skill for money</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>k. pull tabs or &quot;paper&quot; games other than lotteries</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>l. engage in some form of gambling not listed above (please specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. What is the largest amount of money you have ever gambled with on any one day in the past year?

<table>
<thead>
<tr>
<th>Amount</th>
<th>O</th>
<th>O</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I've never gambled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. $1 or less</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. more than $1 but less than $10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. more than $10 but less than $100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. more than $100 but less than $1,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. more than $1,000 but less than $10,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Which of the following people has (or had) a gambling problem?

<table>
<thead>
<tr>
<th>Relative</th>
<th>O</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. father</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. mother</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. brother or sister</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. spouse or partner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. child or children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. grandparent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. another relative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. no one in my family has (or had) a gambling problem</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. In the past year, when you gamble, how often do you return to win back the money you lost?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>O</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. never</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. some of the time (less than half of the times I lost)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>c. most of the times I lost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. every time I lost</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. In the past year, have you ever claimed to be winning money while gambling, even though you were actually losing money?

<table>
<thead>
<tr>
<th>Claim</th>
<th>O</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. never</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. yes, less than half of the times I lost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. yes, most of the time</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. In the past year, have you felt like you have had a problem with betting money or gambling?

<table>
<thead>
<tr>
<th>Feeling</th>
<th>O</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. no</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. yes, in the past, but not now</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. In the past year, did you ever gamble more than you intended to?  

8. Have people in the past year criticized your betting or told you that you had a gambling problem, regardless of whether or not you thought it was true?  

9. Have you in the past year felt guilty about the way you gamble or what happens when you gamble?  

10. Have you in the past year felt like you would like to stop betting money or gambling but you didn't think you could?  

11. Have you in the past year hidden betting slips, lottery tickets, gambling money, I.O.U.s or other signs of betting or gambling from your spouse, children or other important people in your life?  

12. Have you in the past year argued with people you live with over how you handle money?  

13. (If you answered yes to question 12) Have money arguments ever centered on your gambling?  

14. Have you in the past year borrowed from someone and not paid them back as a result of your gambling?  

15. In the past year, have you lost time from work (or school) due to betting or gambling?  

16. In the past year, If you borrowed money to gamble or to pay gambling debts, who/where did you borrow from? (Please indicate, by circling, “YES” or “NO”)

<table>
<thead>
<tr>
<th>From</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>From household money?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From your spouse?</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>From other relatives or in-laws?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From banks, loan companies or credit unions?</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>From credit cards?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From loan sharks?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You cashed in stocks, bonds or other securities?</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>You sold personal or family property?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You borrowed on your checking account?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You have (had) a credit line with a bookie?</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>You have (had) a credit line with a casino?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. In the past year when you gambled, what percentage of your free time a week did you devote to gambling? ________ %.

18. In the past year when you gambled, what percentage of your income after living expenses, did you commit to gambling? ________ %.

Lesieur & Blume (1987)
Appendix B: IBS

The following is a list of statements about electronic gambling machine (EGM) use. Please read each statement carefully and indicate how much you agree or disagree by placing a tick in the appropriate column. Please do not take too much time to respond to the items.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I believe that some machines keep me from winning because they are programmed to produce fewer wins than normal.</td>
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<td></td>
<td></td>
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<tr>
<td>2</td>
<td>In some establishments, the EGMs are more likely to pay out than others.</td>
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<tr>
<td>3</td>
<td>I would rather use an EGM that I am familiar with than one that I have never used before.</td>
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</tr>
<tr>
<td>4</td>
<td>The longer an EGM has gone without paying out a large sum of money, the more likely are the chances that it will pay out in the very near future.</td>
<td></td>
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<tr>
<td>5</td>
<td>I have purposely avoided playing on EGMs that have recently paid out a lot of money.</td>
<td></td>
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<tr>
<td>6</td>
<td>I know some EGM users who are just plain lucky.</td>
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<td></td>
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<tr>
<td>7</td>
<td>I have a favourite EGM that I use.</td>
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<tr>
<td>8</td>
<td>One’s chances of winning are better if he or she gambles on a machine that has not paid out in a long time.</td>
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<tr>
<td>9</td>
<td>People win large amounts of money on EGMs on a fairly frequent basis.</td>
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<tr>
<td>10</td>
<td>Hearing about other people winning on EGMs encourages me to keep on playing.</td>
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<tr>
<td>11</td>
<td>When I see others winning on EGMs, I feel that my turn is coming, too.</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>12</td>
<td>There are certain strategies (for example, betting all of your credits at once) that one can use with EGMs to help him or her win.</td>
<td></td>
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<tr>
<td>13</td>
<td>It makes me upset when I almost win on EGMs.</td>
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<tr>
<td>14</td>
<td>If I win on a certain machine, I am more likely to use that machine again at a later date.</td>
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<tr>
<td>15</td>
<td>After a long string of wins on an EGM, the chances of losing become greater.</td>
<td></td>
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</tr>
<tr>
<td>16</td>
<td>If I experience a long string of losses on an EGM, a big win must be coming just around the corner.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>17</td>
<td>If I’m experiencing a losing streak, the thought that a win has to be coming soon keeps me gambling.</td>
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<td></td>
</tr>
<tr>
<td>18</td>
<td>I know some people who gamble who are just plain unlucky with EGMs.</td>
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<td></td>
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<tr>
<td>19</td>
<td>Thinking about times that I have won on EGMs encourages me to keep playing.</td>
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<tr>
<td>20</td>
<td>I sometimes find myself trying to win back money that I have lost on EGMs.</td>
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<tr>
<td>21</td>
<td>Winning on EGMs makes me feel skillful.</td>
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<tr>
<td>22</td>
<td>Sometimes, I’ll keep on playing EGMs because I get a strong feeling that I’m about to win.</td>
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<tr>
<td>23</td>
<td>I sometimes talk to the machine in order to make it do what I want. For example, I will sometimes mutter, “Come on! Come on!” under my breath.</td>
<td></td>
<td></td>
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<tr>
<td>24</td>
<td>Winning on EGMs encourages me to keep playing.</td>
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<tr>
<td>25</td>
<td>I tend to think more often about my wins than my losses on EGMs.</td>
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<td></td>
</tr>
</tbody>
</table>

Read each of the following statements carefully. Rate to what extent you agree or disagree with each statement by placing a tick in the appropriate column. Please answer the questions in terms of how you are feeling now when completing the questionnaire.

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Moderately disagree</th>
<th>Mildly disagree</th>
<th>Neither agree or disagree</th>
<th>Mildly agree</th>
<th>Moderately agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All I want to do now is gamble.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>It would be difficult to turn down a gamble this minute.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Having a gamble now would make things seem just perfect.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I want to gamble so bad That I can almost feel it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Nothing would be better than having a gamble right now.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I crave a gamble right now.</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

$T = 0$
Appendix D: Intranet Advertisement

<table>
<thead>
<tr>
<th>Study Name</th>
<th>A study investigating the psychophysiological profiles for problem gambling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This study aims to monitor the &quot;buzz&quot; (as measured via changes in heart rate and galvanic skin response) in people as they respond to 'wins' and 'losses' while gambling on an electronic gambling machine.</td>
</tr>
<tr>
<td>Description</td>
<td>Each participant will play on an electronic gaming machine for 3 x 15 minute periods. Participants will also complete short questionnaires relating to gambling behaviour. It must be noted that: 1. The machine will not pay out money to participants. 2. Participants are not required to gamble with their own money. 3. Participants will win an entertainment voucher if their credit is above a preset amount at the completion of each of the three testing periods (maximum of 3 vouchers).</td>
</tr>
<tr>
<td>Duration</td>
<td>60 minutes</td>
</tr>
<tr>
<td>Credits</td>
<td>2 Credits</td>
</tr>
</tbody>
</table>
| Researchers         | Benjamin Wilkes  
|                     | Office: 41.G35A - Psychophysiology Lab 2  
|                     | Phone: 0431019885  
|                     | Email: blw03@uow.edu.au                                                      |
| Participant Sign-Up | 12 hours before the study is to occur                                        |
| Deadline            |                                                                 |
| Participant Cancellation Deadline | 24 hours before the study is to occur                                      |
Appendix E: Participant Information Sheet (laboratory studies)

IDENTIFYING PSYCHOPHYSIOLOGICAL MARKERS FOR PROBLEM GAMBLERS: THE DIFFERENCE BETWEEN “WINS” AND “ LOSSES”.

Researchers: Benjamin Wilkes (PH: 4221 3747); Craig Gonsalvez (Ph: 4221 3674).

The study aims to track and measure the “buzz” or “suspense” levels (called arousal mechanisms in psychology, and measured by heart rate and galvanic skin responses) that the body obtains in response to wins and losses during gambling on an electronic gambling machine. The study also examines whether such a pattern of bodily reactions to wins and losses are different for persons who gamble excessively.

Understanding the types of physiological responses exhibited by those where gambling activity is a problem will assist in identifying those at risk and potentially aid the development of future gambling treatment programs to improve outcomes for clients.

What does participation involve?

In this study that involves a researcher providing you with monitoring devices to wear whilst you play an electronic gambling machine in a laboratory setting:

- You will be asked to wear four electrodes (two placed on your fingers and two placed on your chest throughout your participation). These will monitor your heart rate and skin conductance level. You will be asked to wear this equipment for up to one hour, including 30 minutes whilst you play on an electronic gaming machine.
- It is expected that your participation will not entail a time commitment of greater than one hour of your time.
- It is asked that if you choose to participate, that you refrain from using drugs or alcohol.

Agreement to participate should in no way oblige you to continue playing on the electronic gaming machine. You are free to stop gambling at any time. You are also able to have your data withdrawn from the study up until the time of publication or thesis submission.

Throughout your participation in the research, the University of Wollongong will not affect wins/losses on the gambling machines in any way. It is to be noted that your participation will not require any investment of your own money and that no money is to be paid to you out of the machine. If your credits total at the end of observation is greater than when you started playing, you will receive an entertainment voucher.

The researcher will be sitting next to you at the next machine and a pressing a button, so that your wins and losses are recorded differently. Following your observation you will be asked to fill out a short questionnaire about your previous gambling activity, which should take you up to fifteen minutes to complete. You will not be required to enter your name on the questionnaire, preserving the anonymity and confidentiality of your responses.

If desired, following your participation, you will be given feedback to show your body responses to wins and losses.

If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, Research Services Office, University of Wollongong on 4221 4457. G-line (NSW) is a telephone counselling service for problem gamblers and their families. If you feel you need to talk to trained counsellors please call 1800 633 635. Referrals for face-to-face services can also be made with G-line’s assistance.

Thank you for your consideration. Please indicate to the researcher if you would like to participate in the study.
Appendix F: Participant Consent Form (laboratory studies)

IDENTIFYING PSYCHOPHYSIOLOGICAL MARKERS FOR PROBLEM GAMBLERS: THE DIFFERENCE BETWEEN “WINS” AND “LOSSES”.

Researchers: Benjamin Wilkes (PH: 4221 3747); Craig Gonsalvez (Ph: 4221 3674).

I have been given information about ‘Identifying psychophysiological markers for problem gamblers: The difference between “wins” and “losses”’ and discussed the research project with Benjamin Wilkes who is conducting this research as part of a Master of Psychology (Clinical) supervised by A. Prof Craig Gonsalvez in the School of Psychology within the Faculty of Health and Behavioural Sciences at the University of Wollongong.

I understand that, if I consent to participate in this project I will be asked to wear 4 small electrodes, and equipment (about the size of a large mobile phone) used to monitor physiological responses (including heart rate and skin conductance level) and be monitored using these devices whilst I play on an electronic gaming machine in a laboratory setting. I realise that the machines do not pay out money and I will not be required to invest any money to participate; however, I will receive an entertainment voucher if my credits total at the end of observation is greater than when I start playing. I will also be asked to complete a questionnaire on previous gambling activity.

I have been advised of the potential risks and burdens associated with this research, which include the inconvenience of wearing 4 stick-on electrodes (2 chest, 2 finger) and have had an opportunity to ask Benjamin Wilkes any questions I may have about the research and my participation.

I understand that my participation in this research is voluntary. I am free to refuse to participate and I am free to withdraw from the research at any time up until the time of publication or thesis submission.

If I have any enquiries about the research, I can contact Benjamin Wilkes (Ph: 4221 3747) and Craig Gonsalvez (Ph: 4221 3674) or if I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, Research Services Office, University of Wollongong on 4221 4457.

By signing below I am indicating my consent to participate in the research entitled “Identifying psychophysiological markers for problem gamblers: The difference between ‘wins’ and ‘losses’”, conducted by Benjamin Wilkes as it has been described to me in the information sheet and in discussion with him. I understand that the data collected from my participation will be used for his thesis and journal publication, and I consent for it to be used in that manner.

Signed ................................................................. Date ........................................

Name (please print) .................................................................

.................................................................
Appendix G: AMS Participant Data Sheet (laboratory studies)

| ID: ............................... | Date and Time of Recording: ................................................................. |
| AGE: .................  SEX:  M / F |

1. **AMS Checklist:**
   a) Is the computer time correct?
      YES / NO
   a) Entered ID on computer?
      YES / NO
   a) Loaded configuration?
      YES / NO

2. Use of caffeine (coffee, tea, coke) during the two hours prior to the recording. If yes, how much and when (relative to commencement of recording)

3. Smoking during the two hours prior to the recording. If yes, how much and when:

4. Use of alcohol during the two hours prior to the recording. If yes, details:

7. Current medication that might affect recording: (Beta blockers, medication for BP, antidepressants, anxiolytics, etc). If yes, details of medication.

8. Any problems or interruptions with the equipment?

<table>
<thead>
<tr>
<th>Schedule (L, H or P)</th>
<th>Start Credits</th>
<th>Target Credits</th>
<th>End Credits</th>
<th>Voucher (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
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<td>2.</td>
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<td>3.</td>
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</tbody>
</table>

**Credits on completion of feature:**

<table>
<thead>
<tr>
<th>Schedule 1:</th>
<th>Schedule 2:</th>
<th>Schedule 3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.</td>
<td>1.</td>
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<tr>
<td>2.</td>
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<td>3.</td>
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<td>4.</td>
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<td>5.</td>
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<td>6.</td>
<td>6.</td>
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<tr>
<td>7.</td>
<td>7.</td>
<td>7.</td>
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</table>

**Comments:**
Appendix H: DASS-21

DASS21

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
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</table>

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

*The rating scale is as follows:*

0  Did not apply to me at all  
1  Applied to me to some degree, or some of the time  
2  Applied to me to a considerable degree, or a good part of time  
3  Applied to me very much, or most of the time

<table>
<thead>
<tr>
<th>Statement</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I found it hard to wind down</td>
<td></td>
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<tr>
<td>2 I was aware of dryness of my mouth</td>
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<tr>
<td>3 I couldn’t seem to experience any positive feeling at all</td>
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<tr>
<td>4 I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)</td>
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<tr>
<td>5 I found it difficult to work up the initiative to do things</td>
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<tr>
<td>6 I tended to over-react to situations</td>
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<tr>
<td>7 I experienced trembling (eg, in the hands)</td>
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<tr>
<td>8 I felt that I was using a lot of nervous energy</td>
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<tr>
<td>9 I was worried about situations in which I might panic and make a fool of myself</td>
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<tr>
<td>10 I felt that I had nothing to look forward to</td>
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<tr>
<td>11 I found myself getting agitated</td>
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<tr>
<td>12 I found it difficult to relax</td>
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<tr>
<td>13 I felt down-hearted and blue</td>
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</tr>
<tr>
<td>14 I was intolerant of anything that kept me from getting on with what I was doing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 I felt I was close to panic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 I was unable to become enthusiastic about anything</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 I felt I wasn't worth much as a person</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 I felt that I was rather touchy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 I felt scared without any good reason</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 I felt that life was meaningless</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Lovibond and Lovibond (1995)*
For each statement below, please answer each question by putting a circle around 'YES' or 'NO' following the questions. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the question.

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Do you often buy things on impulse?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Do you generally do and say things without stopping to think?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Do you often get into a jam because you do things without thinking?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Are you an impulsive person?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Do you usually think carefully before doing anything?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Do you often do things on the spur of the moment?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Do you mostly speak before thinking things out?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Do you often get involved in things you later wish you could get out of?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Do you get 'so carried away' by new and exciting ideas that you never think of possible snags?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Do you need to use a lot of self-control to keep out of trouble?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Would you agree that almost everything enjoyable is illegal or immoral?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Are you often surprised at people's reactions to what you do or say?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Do you think an evening out is more successful if it unplanned or arranged at the last moment?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Do you usually work quickly, without bothering to check?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Do you often change your interests?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Before making up your mind, do you consider all the advantages and disadvantages?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Do you prefer to 'sleep on it' before making decisions?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>When people shout at you, do you shout back?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Do you usually make up your mind quickly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eysenck, Pearson, Easting and Allsopp (1985)
Appendix J: Venue Information Sheet

Gambling in Australia

For many people gambling is a legitimate part of their leisure and recreation activities. While most people who gamble do so in a responsible manner and enjoy gambling as entertainment, for some it is a cause of problems for themselves, their families and the community. The challenge for research is to find a response that balances the legitimate opportunity for individual Australians to gamble if they wish, with the ongoing responsibility of governments for overall community welfare.

Opportunity to support research!

The bulk of the previous research that has been conducted suggests that gambling influences the arousal of players; however, there is little knowledge available on the separate effects of winning and losing on the arousal of players. The University of Wollongong requires industry support for the recruitment of patrons to participate in a gaming research study, which will focus on the associated arousal of players in response to winning and losing on electronic gaming machines.

How will the research be conducted?

**Step 1:** A sign will be placed in an appropriate section of the club asking for those patrons already intending to gamble and interested in participating in gambling research to contact the researcher. No patrons will be approached to participate in study. All participants will be voluntary and self-selected.

**Step 2:** The researcher will inform the potential participant (patron) of what their participation entails. (Information sheet provided to patrons attached).

**Step 3:** The researcher will ask whether the potential participant (patron) would like to support the study. Signed consent will be obtained from each participant. Each patron will be free to refuse to participate and will be free to withdraw from the research at any time up until the time of publication or thesis submission.

**Step 4:** The researcher will monitor each participant’s arousal (heart rate and skin conductance) over a 10-30 minute period as they play with their own money.

**Step 5:** The participant will then complete an anonymous questionnaire on their previous gambling behaviour. All data collected will preserve the anonymity of the licensed gambling institutions and that of their patrons.

**Step 6:** The participant will receive compensation in the form of vouchers once their completed questionnaires are received.

What’s the next step?

If your organization wishes to give its support and allow recruitment of its patrons to take place, please complete the attached consent form and contact Benjamin Wilkes on 0431019885. Alternatively, you can fax the completed consent form to 0242686098. Please do not hesitate to contact us if you require any further information regarding the study.

Thank you for your consideration,

Benjamin Wilkes
Appendix K: Venue Consent Form

Identifying psychophysiological markers for problem gamblers: The difference between “Wins” and “Losses”.

Researchers: Benjamin Wilkes (PH: 4221 3747); Craig Gonsalvez (PH: 4221 3674).

I have been given information about “Identifying psychophysiological markers for problem gamblers: The difference between ‘wins’ and ‘losses’” and discussed the research project with Benjamin Wilkes who is conducting this research as part of a Doctor of Psychology (Clinical) supervised by A. Prof Craig Gonsalvez in the School of Psychology within the Faculty of Health and Behavioural Sciences at the University of Wollongong.

I understand that, if I give support for participants to be recruited from within this licensed gambling institution and that they will be asked to wear 4 small electrodes, and equipment (about the size of a large mobile phone) used to monitor physiological responses (including heart rate and skin conductance level) and be monitored using these devices whilst they play on an electronic gaming machine that they already were intending to use. I understand that they will also be asked to complete a questionnaire on previous gambling activity.

I have been advised of the potential risks and burdens to participants associated with this research, which includes the inconvenience of wearing 4 stick-on electrodes (2 on their chest, and 2 on their fingers). I have had an opportunity to ask Benjamin Wilkes any questions I may have about the research and the participation of our patrons.

I understand that my agreement to support this research is voluntary. I understand that we are free to refuse the research being conducted within our institution and that we are free to withdraw our support for the research at any juncture, up until the time of publication or thesis submission. The researchers and the University of Wollongong will not be responsible for any monetary losses during the course of the participation of any patrons. The data obtained during the course of research from within the licensed gaming venue will be de-identified preserving the confidentiality of the patrons and your organisation.

If I have any enquiries about the research, I can contact Benjamin Wilkes (PH: 4221 3747) and Craig Gonsalvez (PH: 4221 3674) or if I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, Research Services Office, University of Wollongong on 4221 4457.

By signing below I am indicating my consent and support for participants to be recruited and observed for the research entitled “Identifying psychophysiological markers for Problem Gamblers: The difference between ‘Wins’ and ‘Losses’”, conducted by Benjamin Wilkes, as it has been described to me, within the licensed gambling institution identified below. I understand that the data collected will be used for his thesis and journal publication, and I consent for it to be used in that manner.

Name of the licensed gambling institution where the research is agreed to take place:

..............................................................................................................................................

Signed          Date
.............................................................................................................................................. 

Name (please print)        Position:
..............................................................................................................................................
ARE YOU GOING TO PLAY AN ELECTRONIC GAMBLING MACHINE TODAY?

DO YOU WANT TO KNOW HOW YOUR BODY RESPONDS TO WINS AND LOSSES DURING PLAY?

IF SO…

Do you want to help with some research?

If you are interested in participating please contact the service desk, which will direct you to the researcher.

Participants will receive entertainment vouchers following their participation.

Thank you for your help and consideration!
Appendix M: Participant Information Sheet (field study)

IDENTIFYING PSYCHOPHYSIOLOGICAL MARKERS FOR PROBLEM GAMBLERS: THE DIFFERENCE BETWEEN “WINS” AND “LOSSES”.

Researchers: Benjamin Wilkes (PH: 4221 3747); Craig Gonsalvez (Ph: 4221 3674).

The study aims to track and measure the “buzz” or “suspense” levels (called arousal mechanisms in psychology, and measured by heart rate and galvanic skin responses) that the body obtains in response to wins and losses during play on electronic gambling machines, “the pokies”. The study also examines whether such a pattern of bodily reactions to wins and losses are different for persons who gamble excessively.

Understanding the types of physiological responses exhibited by those where gambling activity is a problem will assist in identifying those at risk and potentially aid the development of future gambling treatment programs to improve outcomes for clients.

What does participation involve?

This study will involve a researcher providing you with monitoring devices to wear whilst you play an electronic gaming machine of your choice:

- You will be asked to wear four electrodes (two placed on your fingers and two placed on your chest throughout your participation). These will monitor your heart rate and skin conductance level. You will be asked to wear this equipment for up to one hour, including up to 30 minutes whilst you gamble.
- It is expected that your participation will not entail a time commitment of greater than one hour of your time.
- It is asked that if you choose to participate, that you refrain from using drugs or alcohol.

Agreement to participate should in no way oblige you to gamble differently from what you had intended. You are free to stop gambling at any time or stop recording while you continue to gamble. You are also able to have your data withdrawn from the study up until the time of publication or thesis submission.

The University of Wollongong is independent of the club/casino management, and will not influence gambling outcomes. Throughout your participation in the research, the University of Wollongong will not affect wins/losses on the gambling machines in any way.

The researcher will be sitting next to you at the next machine and pressing a button, so that your wins and losses are recorded differently. Following your observation you will be asked to fill out a short questionnaire about your previous gambling activity, which should take you up to fifteen minutes to complete. You will not be required to enter your name on the questionnaire, your anonymity and the confidentiality of your responses.

In appreciation for your time (approximately 1 hour) and slight discomfort whilst wearing the devices, you will receive an entertainment voucher for your participation. If desired, you will be given feedback to show your body responses to wins and losses. The researchers and the University of Wollongong would not be responsible for losses you incur during the course of your gambling.

If you have any concerns or complaints regarding the way the research is or has been conducted, you can contact the Complaints Officer, Human Research Ethics Committee, Research Services Office, University of Wollongong on 4221 4457. G-line (NSW) is a telephone counselling service for problem gamblers and their families. If you feel you need to talk to trained counsellors please call 1800 633 635. Referrals for face-to-face services can also be made with G-line’s assistance.

Thank you for your consideration. Please indicate to the researcher if you would like to participate in the study.
Appendix N: Participant Consent Form (field study)

IDENTIFYING PSYCHOPHYSIOLOGICAL MARKERS FOR PROBLEM GAMBLERS: THE DIFFERENCE BETWEEN “WINS” AND “LOSSES”.

Researchers: Benjamin Wilkes (PH: 4221 3747); Craig Gonsalvez (Ph: 4221 3674).

I have been given information about ‘Identifying psychophysiological markers for problem gamblers: The difference between “wins” and “losses”’ and discussed the research project with Benjamin Wilkes who is conducting this research as part of a Doctor of Psychology (Clinical) supervised by A. Prof Craig Gonsalvez in the School of Psychology within the Faculty of Health and Behavioural Sciences at the University of Wollongong.

I understand that, if I consent to participate in this project I will be asked to wear 4 small electrodes, and equipment (about the size of a large mobile phone) used to monitor physiological responses (including heart rate and skin conductance level) and be monitored using these devices whilst I play on electronic gaming machines that I already was intending to use.

I will also be asked to complete a questionnaire on previous gambling activity.

I have been advised of the potential risks and burdens associated with this research, which include the inconvenience of wearing 4 stick-on electrodes (2 chest, 2 finger) and have had an opportunity to ask Benjamin Wilkes any questions I may have about the research and my participation.

I understand that my participation in this research is voluntary. **I am free to refuse to participate and I am free to withdraw from the research at any time up until the time of publication or thesis submission.** The researchers and the University of Wollongong will not be responsible for any monetary losses during the course of my participation.

If I have any enquiries about the research, I can contact Benjamin Wilkes (Ph: 4221 3747) and Craig Gonsalvez (Ph: 4221 3674) or if I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, Research Services Office, University of Wollongong on 4221 4457.

By signing below I am indicating my consent to participate in the research entitled “Identifying psychophysiological markers for problem gamblers: The difference between ‘wins’ and ‘losses’”, conducted by Benjamin Wilkes as it has been described to me in the information sheet and in discussion with him. I understand that the data collected from my participation will be used for his thesis and journal publication, and I consent for it to be used in that manner.

Signed ........................................................................................................ Date ........................................................................................................

Name (please print) ........................................................................................................

........................................................................................................
## Appendix O: AMS Participant Data Sheet (field study)

<table>
<thead>
<tr>
<th>ID: …………………..</th>
<th>Date and Time of Recording: ………………………………………………</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Should enable physiological data to be linked to questionnaire data).</td>
<td></td>
</tr>
<tr>
<td>AGE: ………………</td>
<td>SEX: M / F</td>
</tr>
</tbody>
</table>

### AMS Checklist:

<table>
<thead>
<tr>
<th>a) Is the computer time correct?</th>
<th>YES / NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Entered ID on computer?</td>
<td>YES / NO</td>
</tr>
<tr>
<td>a) Loaded configuration?</td>
<td>YES / NO</td>
</tr>
</tbody>
</table>

- **Use of caffeine (coffee, tea, coke) during the two hours prior to the recording. If yes, how much and when (relative to commencement of recording)**

### Smoking during the two hours prior to the recording. If yes, how much and when:

### Use of alcohol during the two hours prior to the recording. If yes, details:

### Current medication that might affect recording: (Beta blockers, medication for BP, antidepressants, anxiolytics, etc). If yes, details of medication.

### Notes:

Any problems or interruptions with the equipment?

<table>
<thead>
<tr>
<th>Amount Bet</th>
<th>End Credits (Loser/Winner)</th>
<th>Outcome Amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix P: CPGI

Some of the next questions may not apply to you, but please try to be as accurate as possible. **THINKING ABOUT THE LAST 12 MONTHS...**

1. Have you bet more than you could really afford to lose? Would you say never, sometimes, most of the time, or almost always (please indicate your responses with a tick)?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

2. Still thinking about the last 12 months, have you needed to gamble with larger amounts of money to get the same feeling of excitement?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

3. When you gambled, did you go back another day to try to win back the money you lost?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

4. Have you borrowed money or sold anything to get money to gamble?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

5. Have you felt that you might have a problem with gambling?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

6. Has gambling caused you any health problems, including stress or anxiety?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

7. Have people criticized your betting or told you that you had a gambling problem, regardless of whether or not you thought it was true?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

8. Has your gambling caused any financial problems for you or your household?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

9. Have you felt guilty about the way you gamble or what happens when you gamble?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Almost always</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

*Ferris and Wynne (1985)*
Appendix R: Play parameters of EGM used in the laboratory studies

1.

2.
3.

4.
5. **Alchemy Gamble/Game Rules**

**Gamble Feature**
To gamble any win, press Gamble then select Red/Black or a suit. Bet is doubled (X2) if Red/Black choice is correct. Bet is quadrupled (X4) if suit choice is correct. Winnings may be gambled up to 5 times. Press Gamble to alternate between full & half gamble. Maximum win per gamble is $10000.

**Game Rules**
Choose your bet per line.
Choose your number of paylines.
All wins on lines played except scatters which are added to payline wins.
Scatter wins added to payline wins.
Scatter wins added to different line paylines added.
Coinciding wins on each payline added.

Malfuction voids all pays and plays. Player is responsible to confirm credits registered before game start.

---

Door Mismatch - Main

1c $1 Buys 100 Credits

6. **Alchemy Free Game Feature**

Win up to 20 Free Games
Scattered 'Scales' pay any

12, 15 or 20 Free Games are won with any 3x, 4x or 5x scattered 'Scales' respectively.

Scatter wins multiplied by total number of credits staked. All wins shown in credits.

---

Door Closed - Note Acceptor

1c $1 Buys 100 Credits
7.

Alchemy Free Game Feature Continued

During the free games only, the reels where 'man' appear are held, and all other reels are respun once. All prizes during the free games and bonus respins are doubled. Free games can be won again during the free games and bonus respins. Credits staked and lines played are the same as the game that started the free games.

Door Closed - Note Acceptor 1c $1 Buys 100 Credits

8.

Alchemy Substitute Feature

'Man' substitutes for all symbols at the same time in all positions on the reels it appears, except for scattered 'scales'. 'Man' appears on reels 2, 3, 4 and 5 only.

Door Mismatch - Main 1c $1 Buys 100 Credits