The Player and The Machine

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.
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Abstract

Modern multiline video slots are popular games with high fidelity sounds and salient graphics, which allow players to wager on multiple lines at once. Interestingly, on multiline slots, many small wins actually amount to *less* than one's spin wager (e.g., bet a dollar and win back a quarter). These outcomes, however, are accompanied by flashing lines and winning sounds, *disguising* the negative gains that they truly are. Dixon, Harrigan, Sandhu, Collins, and Fugelsang (2010) termed these outcomes losses disguised as wins, or LDWs. Research has shown that players physiologically (Dixon et al., 2010), behaviourally (e.g., Dixon, Graydon, Harrigan, Wojtowicz, Siu, and Fugelsang, 2014a), and verbally (e.g., Jensen et al., 2013) miscategorize LDWs as wins rather than correctly categorizing LDWs as losses. We have also shown that LDWs lead players to overestimate how often they won during a playing session (e.g., Jensen et al., 2013), leading to what we referred to as a LDW-triggered win overestimation effect. In Chapter 2, we showed that a short educational animation could lead players to correctly categorize LDWs as losses, thus eliminating the LDW-triggered win-overestimation effect. In Chapter 3, using resistance to extinction paradigms, we showed that LDWs could behaviourally *reinforce* players, leading them to continue to gamble despite financial loss. In Chapter 4, we showed that LDWs could affect players' game preferences and game selection, leading them to choose games with LDWs over games without LDWs. We discuss that these results are disconcerting, because players choose games with reinforcing negative gains, which could lead to distorted memory of how much they won or lost, potentially leading to increased gambling despite financial loss - a hallmark of problem gambling. Finally we discuss future research on LDWs.

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Dedication

To any player who has ever experienced a problem because of slot machines

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Chapter 1

INTRODUCTION

1.1 Slot Machines

Slot machines, a type of electronic gambling machine (EGM), have long been associated with problem gambling. Slot machines are characterized by large possible attainable prizes; high allowable per game expenditures; and most importantly, fast playing speeds (Dowling, Smith, & Thomas, 2005; Zangeneh, Blaszczynski, & Turner, 2002). Players can simply place their bets, and within seconds, know whether they won big, won little, or won nothing at all. It is this continuous nature and immediacy of outcome delivery in these games that has long been associated with slot machine gambling problems (Zangeneh et al., 2002).

Many gamblers, in many nations throughout the world, experience problems due to excessive slot machine play. As such, Dowling and colleagues (2005) report that future research is required to uncover potential interactions between players and what gambling researchers call the structural characteristics of these games. This is precisely our goal, as there remains a consensus amongst many researchers, counsellors, and clinicians that slot machines do pose a problem for some individuals. For instance, The Ontario Problem Gambling Helpline receives more calls from gamblers concerned about slot machines than any other mode of gambling (Counter & Davey, 2006).

1.2 Conditioning and Erroneous Cognitions

The DSM-5 has reclassified gambling disorders under "Substance-Related and Addictive Disorders". Problem gambling is a complex condition characterized by a conglomerate of harm-related symptoms such as betting increased sums of money to arrive at similar levels of excitement (Problem Gambling Severity Index; Ferris & Wynne, 2001). Problem gambling severity is measured by scales such as the Problem Gambling Severity Index (PGSI; Part 3 of the Canadian Problem Gambling Index; Ferris & Wynne, 2001); wherein, players endorse items such as “Has gambling caused you any health problems, including stress or anxiety?” (PGSI; Ferris & Wynne, 2001) on a scale from “never” to “almost always”. As a Non-Substance-Related disorder, one has to consider what type of exogenous stimuli (rather than exogenous substances) lead to gambling problems. Brown (1986) argued that it is arousal that is the primary reinforcer regulating gambling behaviour. For slot machines, both classical and operant conditioning principles apply (e.g., see Czerny, Koeing, & Turner, 2008). Classically speaking, wins (unconditioned stimuli) lead to automatic elevations in rewarding arousal (unconditioned responses). After playing time has accrued, secondary reinforcement is possible; wherein, simply the sights and sounds associated with winning (conditioned stimuli) can lead to automatic elevations in arousal (conditioned response) as well.

From the operant conditioning perspective, getting a reward (i.e., a win) leads to an increase in behaviour (e.g., pressing a spin button). Slots follow a random ratio reinforcement schedule, where each outcome is independent from next (e.g., Haw, 2008). Random ratio schedules, like variable ratio schedules, can produce behaviours that are highly resistant to extinction (e.g., see Czerny et al. 2008, for an overview on variable ratio schedules). In extinction paradigms, individuals experience a certain schedule of rewards and then the rewards are "cut off" (referred to as the extinction phase). The number of continued responses made during this extinction phase is taken as a measure of learning. A concern for problematic gambling is that variable ratio schedules of rewards or "wins" then can lead to continued gambling despite financial loss (i.e., continued gambling during losing streaks).

Although in random ratio schedules, one response is completely independent of the other (e.g., Haw, 2008), players often *believe* that slots follow a variable ratio schedule. That is, they believe that a series of successive losses makes you "due" for a win. Some gamblers use flawed heuristics to cognitively evaluate the probability of winning on slot machines (Czerny et al., 2008). Problem gamblers, for example, have been known to use a representativeness heuristic (Tversky & Kahneman, 1990) where one believes that a local sequence represents a greater global distribution. This can lead to the belief that random distributions need to be "balanced out" or "self-corrected" (Czerny et al., 2008). These aforementioned beliefs lead to what's known as the "Gamblers Fallacy" - where a series of losses makes one "due" for a win (Czerny at al., 2008). As such, random ratio schedules can act like variable ratio schedules from an operant conditioning perspective. It could make players highly resistant to extinction, leading them to continue responding despite losing because they don't know when they are going to win but that they must continue playing for the machine to pay out. The gambler’s fallacy also elucidates the importance of cognition in gambling - the allure of slot machines is highly dependent on how people interpret and perceive the characteristics and features of these games.

The effects of erroneous cognitions and classical and operant conditioning can be argued to be "central" to problem gambling. The Pathways Model of Problem Gambling (See Blaszczynski & Nower, 2002, for a review) identifies three "pathways" that culminate in the development of problem gambling. Common to all three pathways are the effects of conditioning and erroneous cognitions (such as distorted cognitions about game probabilities, or poor judgment and decision making in general). In Pathway I, "Behaviourally Conditioned Problem Gamblers", gamblers can alternate between regular and excessive problem gambling due to the effects of conditioning and erroneous cognitions alone. Thus, it is important to study interactions between the player and the slot machine, as conditioning and erroneous cognitions can not only lead to problems in players with existing comorbidities, but also in players who are otherwise "healthy".

1.3 Multiline Slots & Losses Disguised as Wins

Slot machines are available worldwide, with modern multiline video slots (aka “pokies”) being popular in many countries, including Australia, Canada, New Zealand, and the United States. These games typically have five reels, and allow players to wager on multiple lines per spin. Here the “lines” can be horizontal or zig-zag combinations across the display. Because of this complexity, unlike traditional slots, it is difficult to tell whether you won or lost by just looking at the symbol arrangements when the reels stop spinning. Simple counters, however, indicate whether any credits were gained. Sophisticated graphics and high fidelity sounds also accompany spin outcomes in different ways. When players spin and lose, the machine goes into a state of quiet in both the auditory and visual domains. When players spin and win, the machine highlights the “winning lines”, animates the “winning symbols”, and plays celebratory sounds and jingles. Interestingly, on these multiline games, many small “wins” actually amount to *less* than one’s spin wager (e.g., players bet a dollar, win back only 25 cents, resulting in a net loss of 75 cents). Despite such losses to the gambler, these outcomes are still accompanied by celebratory sights and sounds just like actual wins. Dixon, Harrigan, Sandhu, Collins, and Fugelsang (2010) termed these outcomes losses disguised as wins, or LDWs. Figure 1.1 shows examples of a regular loss, losses disguised as wins, and an actual win.

A concern for problem gambling is that if players misconstrue LDWs as actual wins, then the presence of LDWs in multiline games could significantly distort perceived reinforcement rates. Harrigan, Dixon, MacLaren, Collins, and Fugelsang (2011) performed simulations on a commercially available game where players could play from 1 to 20 lines. The percentage of actual wins differed only slightly between 1-line (15%) and 20-line (18%) games. Crucially though for 1-line games there are no LDWs. As the number of lines played increased, so does the percentage of LDWs. For 20-line play 30% of spins resulted in LDWS. Consequently the inclusion of all these LDWs causes dramatic changes in how often players are exposed to celebratory feedback (15% of spins for 1-line games, but 48% of spins for 20-line games). If players rely on this celebratory feedback to tell if they won or lost money, they will feel like they have won far more often than they have in actuality on multiline games.

Certain evidence indicates that players do find LDWs reinforcing. First, if players find LDWs reinforcing, then they should prefer playing multiline games with LDWs over single-line games with no LDWs. Jensen (2011) showed that undergraduate novices preferred playing a 6-line simulated slots game with 13% LDWs over a 3-line game with 2% LDWs, despite experiencing identical numbers of actual wins (approximately 10%) and identical payback percentages (98.2%). Templeton, Dixon, Harrigan, and Fugelsang (2015) showed that a sample of community gamblers (given the choice to play between 1 and 15 lines on commercially available slot machines in a laboratory) chose to play 15 lines on the vast majority of spins, and normally only played one-line when running out of credits. Dixon et al. (2014a) showed similar preferences from community gamblers recruited at a Canadian casino. Experienced gamblers played 250 spins on a single-line simulated slot machine with zero LDWs (again, LDWs are not possible on single-line games) and 250 spins on a 20-line

Figure 1.1 Possible outcomes on a multiline slot. (a) regular loss, (b) and (c) losses disguised as wins, (d) actual win. Red boxes highlight the amount wagered and acquired.

game with 30% LDWs. Remarkably, 94% of players reported that they preferred playing the many LDW 20-line game over the zero LDW single-line game, despite both games having similar numbers of actual wins and similar payback percentages (approximately 92%). Similar findings were obtained among Australian gamblers. Livingstone, Woolley, Zazryn, Bakacs, and Shami (2008) found that the vast majority of gamblers preferred playing the maximum number of allowable paylines.

The second line of evidence suggesting that LDWs may be reinforcing comes from players' *categorization* of LDWs. Dixon et al. (2010) showed that undergraduate novices may *somatically* miscategorize LDWs as wins. While playing a commercially available slot machine, they recorded participants' skin conductance responses (SCRs) to actual wins, regular losses and LDWs. Not surprisingly the SCRs to the wins was significantly higher than the regular losses. Crucially, the SCRs to the wins and LDWs were statistically indistinguishable. That is, participants showed similar SCRs to both wins and LDWs, both being significantly higher than SCRs to regular losses. Thus, players appear to physiologically miscategorize LDWs as actual wins, rather than correctly categorizing LDWs as losses.

Dixon, Graydon, Harrigan, Wojtowicz, Siu, and Fugelsang (2014a) showed that participants may also *behaviourally* miscategorize LDWs. Post-reinforcement pauses (PRPs) have long been used as a measure of reward processing and reinforcement learning. In slots play the PRP is typically measured as the time delay between outcome delivery (a win or a loss) and the initiation of the next spin. If an outcome is deemed as rewarding then the player will briefly pause prior to re-instigating the behaviour (pressing the spin button to initiate the next spin). In slots play, this translates to longer PRPs following wins (rewards) than losses. As a result, one could conjecture that if players regard LDWs as wins (rewards), then players should show similar PRPs following wins and LDWs. Dixon et al. (2014a) measured gamblers' PRPs following a return of 2 credits. In a 1-line game a 2 credit return was a net gain (an actual win). In a 20-line game where players bet 1 credit per line (20 credits per spin) a 2 credit return amounted to an 18 credit *net loss*. Crucially the PRPs were statistically similar in both conditions allowing these researchers to conclude that the net-losses were as rewarding as the net-wins.

A study by Dixon, Stange, Larche, Graydon, Fugelsang, and Harrigan (2017) provided a conceptual replication for how participants behaviourally treat LDWs and small wins equivalently. In this study players played a slot machine equipped with a force transducer underneath the spin button. Previous research had shown that following regular losses players initiate the next spin with small levels of force (Dixon et al., 2015). Following wins however, players appear to become excited and generate much greater levels of force to initiate the next spin, with larger wins generating more force than smaller wins (Dixon et al., 2015). Dixon et al. (2017) replicated this finding - losses were associated with minimal force, large wins (over 100 credits) with maximal force. The important contrast was between the smaller wins and the LDWs. In this study, participants used equivalent amounts of force to trigger the next spin following either the small wins or the LDWs. Both types of outcomes led to significantly greater amounts of force than regular losses, but there were no significant differences between them.

Jensen, Dixon, Harrigan, Sheepy, Fugelsang, and Jarick (2013) showed that novices *psychologically* miscategorize LDWs as wins as well. Players played 50 spins on a commercially available game. They were asked whether each outcome was a win or loss, and to report what they were thinking while making this judgement. Upon encountering LDWs, 82.5% of participants categorized these outcomes as wins. Removing those whose descriptions indicated any type of uncertainty (i.e., "I think it is a win") still left a majority (61%) of participants who failed to report any indication that they were losing money on these spins.

If players categorize LDWs as relevant "wins", then LDWs may make slot machine play more enjoyable in two ways. First, LDWs may induce elevations in potentially reinforcing physiological arousal. Second, they may make players *feel* as if they are winning more often than they actually are. Perhaps not surprisingly, LDWs appear to impact players' memories of how often they thought they won during a slots session. In multiline games, the more lines played, the more LDWs one encounters. Jensen et al. (2013) sought to show the more LDWs encountered, the greater the propensity to misremember their actual wins. Novice gamblers (undergraduate student participants) played 200 spins - wagering on either 3-lines (3.8% LDWs) or 6-lines (10.7% LDWs) on a commercially available slot machine. Participants then estimated how many times they won. Despite experiencing similar numbers of actual wins in each game, win estimates were significantly greater in the game with many LDWs. This LDW-triggered win-overestimation effect has been replicated with novice (undergraduate) gamblers (Jensen, 2011); experienced (community) gamblers (Dixon et al., 2014a; Templeton et al., 2015); and two studies that highlight how celebratory sounds play a key role in this LDW-triggered win-overestimation effect (Dixon, Collins, Harrigan, Graydon, & Fugelsang, 2015; Dixon, Harrigan, Santesso, Graydon, & Fugelsang, 2014b).

Although the LDW-triggered win overestimation effect has been replicated with both novices and experienced gamblers, there may be some subtleties involving the frequency of LDWs. Theoretically it would make sense that if the frequency of LDWs is too high players would be struck by the disconnection between hearing celebratory sounds almost every spin, and noting that their running totals keep going down. It may be that a moderate number of LDWs is most effective in triggering the win overestimation effect. Support for this comes from Templeton et al. (2015) which had players play on two commercially available machines. One machine presented LDWs on 18% of spins, the other 30% of spins. While players overestimated wins on both machines, the win overestimation effect was significantly larger for the machine with a moderate number of LDWs. Thus there may be a "sweet spot" involving a moderate number of LDWs where the disguise is most effective. In sum, research suggests that people miscategorize LDWs as wins, and that LDWs can lead players to overestimate the number of times they won during a slots session. We contend that this robust LDW-triggered win overestimation effect may reflect the reinforcing nature of LDWs in slot machine games.

1.4 LDW-triggered Win-Overestimation Effect & Miscategorization

The fact that players treat LDWs as wins is disconcerting because players lose money on these spins. If the LDW-triggered win-overestimation effect (e.g., Jensen et al., 2003) is truly a result of LDW miscategorization (rather than a memory error per se), then educating participants about LDWs may lead to correct categorization and an elimination of this effect.

The question then arises – how best to ameliorate this misconstrual? Brief educational slots animations have previously been shown to dispel myths about how slot machines work. Wohl, Christie, Matheson, and Anisman (2010) for example, showed a sample of community gamblers a 9-minute animation (see also Wohl, Gainsbury, Stewart, & Sztainert, 2013a; Wohl, Santesso, & Harrigan, 2013b) that dispelled a common myth that slot machine outcomes are interdependent (i.e., occur without replacement). This misperception can lead players to believe that they are "due" for a win during a losing streak and that losses are investments towards an eventual large reward (e.g., win, jackpot). They found that gamblers exposed to the animation showed a significant reduction in erroneous cognitions both immediately following the animation and 30 days later. Wohl et al. (2013a) replicated these results (immediately following the animation) with university non-problem gamblers. Wohl et al. (2013b) also showed a significant reduction in erroneous cognitions in a community sample of at risk gamblers; however, they report that this effect waned over time (24 hours and 30 days post animation). Wohl, et al. (2013b) concluded that educational animations can be effective *prevention* tools for low risk gamblers. At risk gamblers may require booster sessions or additional content to change already well-established belief systems regarding these games.

In Chapter 1, the purpose of the study was two-fold. First, we sought to replicate the LDW-triggered win-overestimation effect. Following the methods of Jensen (2011) we asked a sample of novice non-problem gamblers to estimate how many times they won more than they wagered after playing a 3-line game with few LDWs and a 9-line game with many LDWs game. Secondly, we sought to assess whether a LDW animation (developed by our lab) could be used as a useful preventative tool to help new players (i.e., novices) to correctly categorize LDWs as monetary losses, and eliminate (or at least reduce the size of) the LDW-triggered win overestimation effect. We also evaluated whether players would find games with more LDWs more subjectively arousing, exciting, and enjoyable, and whether viewing the LDW animation would affect these subjective experiences.

1.5 LDWs and Gambling Persistence

While continuing to gamble despite accruing debts is one hallmark of a gambling problem, it is surprising that so few studies have looked at slot machine gambling persistence in the face of financial loss. Dickerson (1993) conducted one of the first studies looking at gambling persistence using a combination of unobtrusive observational methods in a gaming venue and interviews. Interviews revealed that gamblers of all stratifications (infrequent/moderate, high frequency, and pathological gamblers) persisted in gambling because they thought the machine were about to "payout". By way of observation, low frequency gamblers were more likely to persist if they experienced elevated arousal or excitement prior to the playing session. They were also less likely to persist if they experienced a dysphoric mood during the session or spent more than they planned. By way of observation, high frequency gamblers were more likely to persist if they assigned a larger dollar value to what they considered a "big win". Retrospective reports during interviews, revealed that problem gamblers persisted for longer if they were already in debt or experienced dysphoric mood during the session (observational data was not ethically possible as problem gamblers were in treatment). Thus, motivation to persist during a gambling session appeared to differ based on gambling frequency/problem gambling symptomatology.

Concerning the structural characteristics of the games, Young, Wohl, Matheson, Baumann, and Anisman (2008) showed using an extinction paradigm that players persisted for longer if players experienced a series of small wins during the second half of a playing session than if they experienced a single large win. All players experienced the same outcomes on the first 25 spins (a priming session), then experienced either a large win or a series of small wins (between subjects design). They were then given the option to leave with their winnings (all participants had gained credits during the session), or continue to gamble for as long as they wished and quit at any time. Unbeknownst to players, all subsequent outcomes were losses (i.e., the extinction phase of the experiment in which persistence was measured). They found that high-risk gamblers continued to gamble for longer than low-risk gamblers in this phase, but *all* players persisted for longer if they had experienced a series of small wins than if they experienced a single large win. This is consistent with learning theory, where the "auxiliary" nature of the reward is purported not to matter, but it is rather the reinforcement rate that drives behaviour. Young et al. argued that the reinforcement rate may explain the phenomenon of chasing within sessions.

Young et al. (2008) also measured participants desire to gamble prior to the playing session, following 25 spins, following the playing session (50 spins), and following the extinction phase. They found that desire was significantly elevated following the first 25 spins, but that desire stabilized after 50 spins. They also found a 3-way interaction between desire at each time point, condition (single big win, series of small wins) and gambling status. For high-risk gamblers only, desire differed post-persistence for each win condition. Desire was greater if they experienced a large win compared to a series of small wins. They argued that larger wins might drive the desire to chase losses in between sessions (based on beliefs in personal luck).

To our knowledge, no study has evaluated the effects of LDWs on gambling persistence. If LDWs are treated as wins, then one could speculate that they may act like wins and make gamblers persist for longer despite financial loss. In Chapter 3, we evaluated whether LDWs could make players continue gambling despite financial loss using extinction paradigms. In the first study, as a conservative measure, we had novice players play 100 spins on a game with few LDWs or many LDWs (between subjects design). Following these spins, participants were given the option to continue playing for as long as they wished or quit at any time. Unbeknownst to players, all subsequent outcomes were losses (extinction phase). We measured the number of spins participants continued playing during this losing streak, and hypothesized that if LDWs are reinforcing, then players would persist to gamble for longer after playing a game with many LDWs over a game with few LDWs. We also measured players subjective arousal, excitement, and desire to gamble prior to the playing session, following 100 spins, and following the extinction phase to see if these experiences differed at each time-point, and whether these experiences would differ based on whether they experienced many or few LDWs. We hypothesized that games with LDWs may be more arousing and exciting than games with fewer LDWs.

In the second study, a sample of community participants played 100 spins on a game with few, moderate, or many LDWs, and were again given the choice to continue to play for as long as they wished or quit at any time (again, all subsequent outcomes were losses). As previously discussed, we believe that a moderate number of LDWs may be optimum at triggering the LDW-triggered win-overestimation effect. As such, we hypothesized that a moderate number of LDWs may also make gamblers persist for longer than a game with few or many LDWs. We also measured players subjective arousal, emotional valence, desire to gamble, and gambling urge at all three time-points to see if a short playing session on a slot machine was sufficient to change these subjective experiences over time, and perhaps, whether LDWs would differentially affect these experiences.

Given that pure losing streaks are uncommon on multiline slots (it is more common to experience a series of losses with LDWs interspersed), in the third study we evaluated whether interspersing LDWs during the losing streak would affect players persistence to gamble. Community participants experienced either few or a moderate number of LDWs during the losing streak. We predicted that, if LDWs are reinforcing, then players would persist to gamble for longer if they experienced a moderate number of LDWs during the losing streak than if they experienced few LDWs. We also measured players' subjective arousal, emotional valence, desire to gamble, and gambling urge at all three time-points to see if a short gambling session would affect these subjective experiences, and whether these experiences would differ if they experienced a moderate over few numbers of LDWs.

1.6 LDWs and Game Preferences

To our knowledge, no study has investigated whether LDWs influence players' game choices. Templeton, Dixon, Harrigan, and Fugelsang (2015) showed that players opt to play the maximum number of playable lines (which contain more LDWs) while playing a commercially available slot machine. Dixon et al. (2014a) showed that players preferred playing a 20-line game (with more LDWs) over a 1-line game (with fewer LDWs) in a sample of participants recruited from a Canadian casino. In Chapter 4, we exposed players to a slot machine game that had four quadrants. In each quadrant, there was a different game. Players were given the option to play any one of four games on each spin during game-play, and they could change games at any time. Unlike the aforementioned studies, all games were 20-line games (to remove any potential confound that just simply playing more lines is what leads to game preferences). Dixon, Fugelsang, MacLaren, and Harrigan (2013) showed that gamblers could differentiate between tight (low payback percentage or expected value games) and loose (higher payback percentage or expected value games). In the four games presented in the four quadrants of the screen, two had high payback percentage games (one with no and one with a moderate number of LDWs) and two had low payback percentage games (one with no and one with a moderate number of LDWs). Participants could elect to play whichever game they wished for 100 spins, then chose to continue playing one of the four games. We predicted that participants would choose to continue playing the higher payback percentage games over the lower payback percentage games. We also predicted that if LDWs are rewarding, then players would opt to continue playing the higher payback percentage game with a moderate number of LDWs over the higher payback percentage game with no LDWs. We also measured participants' game preferences, and hypothesized that they would be in line with the aforementioned hypotheses.

In sum the experiments below present a systematic program of research that seeks to show how losses disguised as wins impact players. The experiments highlight their deceptive nature, as well as show that they can impact how long certain players will gamble, and govern which games people will choose to play.

Chapter 2

MISCATEGORIZING LOSSES AS WINS[1]

2.1 Experiment

2.1.1 Research Questions & Hypotheses

In this experiment we sought to illustrate the deceptive nature of losses disguised as wins, and to show that there are ways of helping players to see through this deception. As previously discussed, LDWs have more features in common (e.g., flashing lines, winning sounds) with actual wins than with regular losses. We believe that these similarities lead participants to miscategorize LDWs as wins rather than correctly categorize them as losses. Furthermore, we believe that it is this *miscategorization* that drives the LDW-triggered win-overestimation effect. If this is true, then educating participants about LDWs may make them more conscientious and attentive to the features on the slot's display (e.g., bet and paid counters) that could help them truly discern whether they won or lost. Unlike the eye-catching animations on the reels, these comparatively boring counters are what will allow players to correctly perceive whether one has received a net gain or a net loss. Thus, using an educational animation to teach people the importance of attending to these counters should: (1) lead participants to correctly categorize LDWs as losses, and (2) reduce the size of, or eliminate the LDW-triggered win overestimation effect. We also hypothesized that participants who miscategorize LDWs as wins (those who are not educated about LDWs) should show higher levels of arousal, enjoyment, and excitement, than participants who

[1] Major parts of this chapter are taken directly from Graydon, C., Dixon., M.J., Harrigan, K.A., Fugelsang., J.A., Jarick, M. (2017).

correctly categorize LDWs as losses (those who are educated about LDWs via the simple animation).

2.1.2 Method

Participants

Recruitment/Selection

Seventy-three undergraduate students were recruited from the Department of Psychology's Research Experience Group. Data from 14 participants was discarded (prior to analyses) due to equipment malfunctions and/or missing data, leaving a final sample of 59 participants. At the beginning of the term, students completed a general battery of on-line pre-screen questions, which determined eligibility to view ads and sign-up for studies. To participate in this study, students had to: (1) be 19 years of age or older (2) not be in treatment for problem gambling; and (3) have played a slot machine once or less in the past 12 months (our definition of "novice" players). Participants were tested individually in a single session with the researcher present and were given $15 for their time and additional cash to play the slots games (see procedure). All study methods and procedures were reviewed and approved by the university's Office of Research Ethics.

Canadian Problem Gambling Index

After providing consent, the researcher administered the Canadian Problem Gambling Index (CPGI; Ferris & Wynne, 2001) verbally. The CPGI is employed worldwide in gambling studies and can be used to measure age, gender, and gambling habits (e.g., frequency and type of gambling). Section 3 of the CPGI, the Problem Gambling Severity Index (PGSI), is a reliable measure of gambling behaviour (Cronbach $\alpha = .84$). Using this measure, one participant's data was discarded because they were deemed at risk for problem gambling. The remaining 58 participants were non-problem gamblers: fifty-four had PGSI scores equal to 0; three had PGSI equal to 1; and one had a PGSI score equal to 2. Ages ranged between 20 and 27 ($M = 21.16$, $SD = 1.37$) and included 38 (65.5%) females.

Apparatus

Slot Machine Simulator

Figure 2.1 shows a screenshot of the simulator used in this experiment (copyright Game Planit Interactive Corp). This multiline game allows wagers on up to 9 lines per spin, and up to 5 credits per line, for a maximum wager of 45 credits. Gamblers interact with the simulator (i.e., choosing the number of lines played, spinning the reels, etc.) by clicking on various options with a mouse. The simulator was run on a PC (HP workstation xw8000) and displayed on a 19-inch monitor (Samsung SyncMaster 912N) located between two (Labtec Spin-75) speakers.

The simulator played a "spinning reels" sound upon spin initiation. On spins where credits were gained, the simulator's celebratory sounds were patterned after actual slot machines (with larger wins accompanied by longer celebratory sounds). Both LDWs and wins were accompanied by rolling sounds that "counted up" the "wins". Sound lengths for various wins sizes are shown in Table 2.1.

Materials

Slot Machine Animations

Prior to the gambling session, participants viewed one of two brief slot machine educational animations. Both animations were similar in length, and were illustrated and narrated by the same individual. The "LDW" animation (length = 3 minutes, 41 seconds) described how LDWs are actually monetary losses, despite looking and sounding like wins. The "Stop Button" animation (length = 3 minutes, 17 seconds) dispelled myths about how using a "stop button" affects slots play. The latter video was used as a "control video" because it discussed slots; yet, focussed on a slot feature unrelated to LDWs. These animations may be viewed online[2]

Slots Practice and Game Sessions

Overview. After viewing either the control or the LDW animation, players played a series of practice spins followed by two different games: one containing many LDWs, the other containing few LDWs. (The number of LDWs in the many LDW game was based on the average number of LDWs that occurred in two commercially available games.)

Practice Spins. Participants were given the following verbal instructions: "For the practice spins, I would like you to spin the reels on the slot machine, and after each spin, to tell me whether you gained credits or lost credits". Participants were asked to wait for any slots sounds to stop prior to initiating the next spin. Practice spins comprised 4 LDWs, 4 wins, and 12 regular losses (randomly intermixed). These spins were included for two

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[2] These animations were made publicly available after study completion. They may be viewed at https://uwaterloo.ca/gambling-research-lab/about/slot-machine-animations.

Credit Size	**Sound Length (s)**	**Credit Size**	**Sound Length (s)**
2	1.4	**24**	3.3
3, 4	1.6	**40, 43**	4.7
6	1.8	**80**	8.2
7, 8	1.9	**100**	9.6
10	2.1	**120**	10.4
12	2.2	**200**	13.5
16, 17	2.6	**300**	17.3

Table 2.1 Length of "winning" rolling sounds depending on "winning" credit size

reasons: (1) to determine/record *how* participants verbally categorized LDWs (i.e., as wins or losses) following the animations but prior to each game (2) to exclude any participants who may have *changed* the way they categorized LDWs for the many and few LDW games. Here we reasoned that if the animations were effective (or ineffective in the case of the control animation) they should influence the way players categorized LDWs equivalently across both games. In order to adequately compare win estimations in the many and few LDW games (and more importantly the effectiveness of the LDW animation) we therefore used only those participants with consistent categorizations in both practice sessions.

Many and Few LDW games

Participants played 200 spins on the many LDW game and 200 spins on the few LDW game. In the *few* (n = 4) LDW game, participants bet 3 credits per line, on a 3-line game, for a total spin wager of 9 credits per spin. In the *many* (n = 46) LDW game, participants also bet 9 credits each spin, but distributed their wagers across 9 lines (1 credit per line). We designed the few LDW game as a "control" game in which spin wagers (9 credits) were equal to the many LDW game, but LDWs were so infrequent that they would (theoretically) minimally affect one's win estimates.

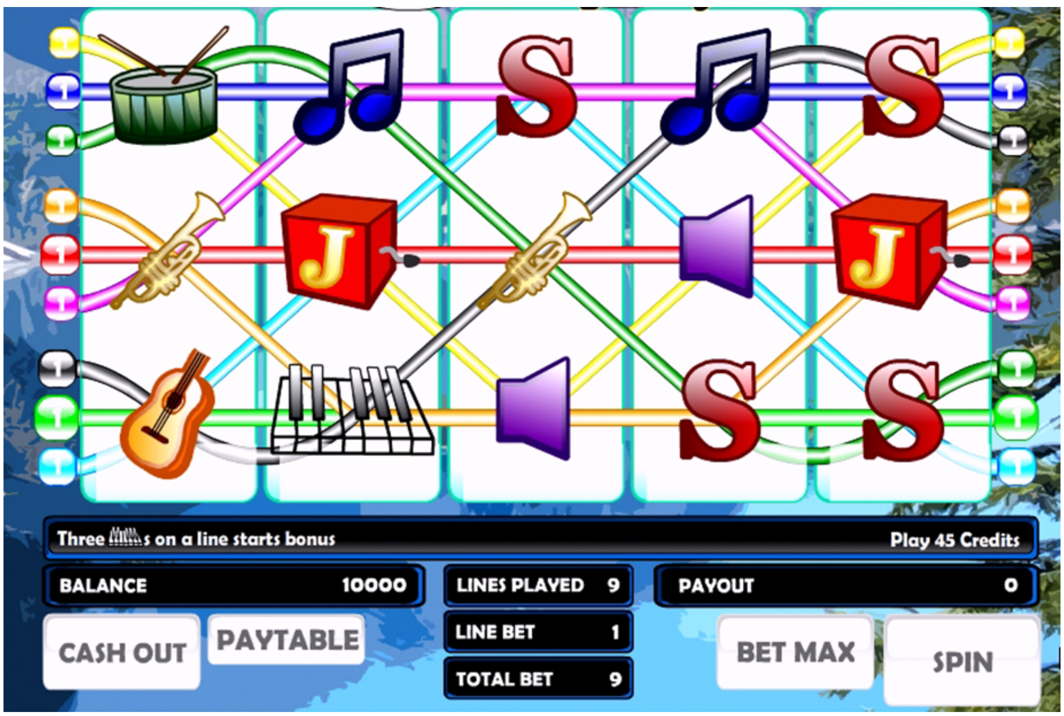

Figure 2.1 Picture of the 9-line simulator.

The starting balance on both games was pre-set to 10,000 credits, which participants were told equalled $5 CAD. The ending balance (following 200 spins) on both games was 9,820 credits (or $4.91 CAD), for a payback percentage of 90% in both games. In Ontario, the payback percentage on slots is 85% to 98%, so we used the (approximate) average of this range. In both games there were 19 actual wins. For each game, participants were randomly assigned to play one of 10 random outcome sequences. Game order (3-line, 9-line) was counterbalanced across participants.

Game Preference

After playing the few and many LDW games, we assessed players' game preferences. Participants were given the choice to play for 5 minutes on either a 3-line or 9-line game and their game choice was recorded. Prior to allowing them to play their preferred game we asked a number of subjective questions about the two games they had just played.

Win Estimation Questions

Participants were given the following written instructions [the qualifiers in brackets refers to the counterbalancing of game order]: "In the first game with 3 [9] lines you had 200 spins. Of these 200 spins, please estimate the number of times on which you won more than you wagered - that is, give a number between 1 and 200 _________________." In the second game with 9 [3] lines you had 200 spins. Of these 200 spins, please estimate the number of times on which you won more than you wagered - that is, give a number between 1 and 200 _________________."

Subjective Arousal, Excitement, and Enjoyment Questions

Participants were asked to retrospectively rate their level of subjective excitement, enjoyment, and arousal during each game using a seven-point Likert scale (1 = not exciting/enjoyable/arousing, 7 = very exciting/enjoyable/arousing).

Players then played their game of choice for 5 minutes. They were then asked to rate their overall playing experience while playing the slot machine on a 20-point Likert scale. Responses were anchored at 1 = really disliked and 20 = really liked, with 10 = neither liked/disliked.

Finally participants were asked to play 5 additional spins. They were given the following verbal instructions: " Now I am going to set a 9 line game for you. What I would like you to do is to spin the reels five times, and after each spin, to tell me whether you gained credits or lost credits". These spins were constrained to contain one LDW, one win, and three losses (presented in one of two random one orders; wherein, the LDW occurred on the second spin, and the win occurred on the fourth spin, or vice versa). The purpose of these spins was to determine/record how participants categorized LDWs following the entirety of the playing sessions.

Procedure

After reading information letters and signing consent forms, participants were seated approximately 57 cm from the simulator monitor. Participants were administered the CPGI verbally and viewed one of the two educational slot machine animations. Participants were then shown the 5 reels on the slots game, shown how to spin the reels by clicking on the "spin" icon, and then shown the various pay tables available on the simulator game.

Participants were shown the "running total" counter (pre-set to 10,000 credits). The experimenter explained that this 10,000-credit starting balance was equivalent to $5 (CAD) and that if they were to double their credits by the end of the game (or more) that they could receive up to a maximum of $10 for that game; if they were to lose all their credits during the game, then they would receive $0 for that game; and, otherwise, they would receive remuneration as a function of how many credits they won or lost during the game.

Players were told they would play two different slots games. They were shown the "lines played" counter (see Figure 2.1) and shown how to select (by clicking) three (or nine) lines in this game. They were shown how to select three (or one) credit wagers per line using the "line bet" counter and were shown that their total spin wager was nine credits (for each game). The experimenter pointed to the "total bet" counter (displaying nine credits), and told participants that every time they spun the reels on the slot machine, they were betting nine credits per spin. Finally, the experimenter explained that the "payout" counter would display the total amount of credits acquired on a spin, if any. Participants could spin as quickly or as slowly as they would like during the game, but were told to wait for any sound to go away, before re-spinning. Participants were told that unlike other slot machines, these games *did not* have a "stop button".

Participants played 20 practice spins prior to the few (or many) LDW game. They were informed that they would not win or lose any money on these spins and that these spins were just there to familiarize them with the game. Participants were asked to categorize each outcome, by verbally indicating whether they gained credits or lost on the spin. The researcher recorded their categorization following each spin. Following the practice trials, participants were then asked to play 200 spins on the few (many) LDW game.

Following a short (3 minute) break, participants played 20 more practice spins categorizing whether they gained credits or lost credits after each spin outcome. Following these practice trials, they then played 200 spins on this second game.

Next, the researcher informed players that they would be given 10,000 credits ($5 CAD) to play their game of choice (3-line or 9-line) for 5 minutes. Prior to playing, the experimenter recorded their game preference, and asked participants to complete the win estimation questions for each game, and the subjective excitement, enjoyment, and arousal questions for each game. After completing these subjective experience questions, participants then played their game of choice. (All participants had end balances below 10,000 credits and received $5 CAD for the game). Participants subsequently reported (via paper and pencil free-text response) why they chose to play either the 3-line or 9-line game, and completed the overall playing experience question. This qualitative data was collected for reasons peripheral to this study. Participants were then asked to play five final spins on the 9-line game, and to tell the researcher whether they gained or lost credits after each spin. Participants completed some additional questionnaires[3][4][5] (for pilot research not considered here), and were thanked, debriefed with an executive summary of the experiment, given responsible gambling brochures, and paid $30.

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[3] Cognitive Reflections Test (CRT); Frederick (2005)
[4] Rational-Experiential Inventory (REI); Pacini & Epstein (1999)
[5] Actively Open-Minded Thinking (AOT) Scale; Stanovich & West (1997)

2.1.3 Results

Practice Spin Categorization

Most players were consistent in their categorizations of LDWs. They either consistently categorized them as wins or as losses. No players categorized LDWs as losses on one occasion but wins on another occasion. The majority of participants (16 out of 26) who viewed the control video miscategorized LDWs as wins (monetary gains). By contrast, none of the 29 participants who viewed the LDW animation miscategorized LDWs as monetary gains. These frequency differences across animation group were statistically significant, $\chi^2(1) = 25.17$, $p < .001$.

LDW-triggered Win Overestimation Effect

Participants' win estimates following the few and many LDW games were first submitted to a video (control, LDW) by game-played (few LDW, many LDW) mixed ANOVA with game-played serving as a repeated measure.

Overall, participants win estimates were higher following the many compared to few LDW game $F(1,53) = 15.74$, $p < .001$, $MSE = 137.94$, $\eta_P^2 = .23$, and higher amongst those who viewed the control as compared to LDW animation, $F(1,53) = 5.78$, $p = .02$, $MSE = 975.21$, $\eta_P^2 = .098$. As predicted, though, these relationships were qualified by a significant game-played by animation viewed interaction[6], $F(1,53) = 11.14$, $p = .002$, $MSE = 137.94$, $\eta_P^2 = .17$. This interaction is shown in Figure 2.2.

[6] Note: There was not a significant 3-way interaction with gender, $F(1, 51) = .001$, $p = .98$, or a 3-way interaction with order of the game played, $F(1, 51) = .96$, $p = .33$.

Independent samples t-tests revealed that the control and LDW animation groups' estimates did not differ following the few LDW game, $t(53) = 1.27$, $p = .21$, $M_{difference} = 6.85$, $SE_{\text{difference}} = 5.42$. For the estimates of the many LDW game, participants who viewed the control animation, gave significantly higher win estimates ($M = 45.96$) than those who viewed the LDW animation ($M = 24.14$), $t(31.89$[7]$) = 2.91$, $p = .007$, $SE_{difference} = 7.50$[8]. Moreover, one-sample t-tests (comparing estimates to the 19 actual wins experienced in each game) revealed that the control group significantly overestimated how many times they won in the many LDW game, $t(25) = 3.84$, $p = .001$; whereas, the LDW video group (marginally) did not, $t(28) = 1.96$, $p = .06$.

The latter results suggest that viewing the brief LDW animation may significantly reduce the size of the LDW-triggered win overestimation effect. Computing Bayes factors for the aforementioned one-sample t-tests (win estimates compared to actual numbers of wins) can be used to adjudicate between the null and alternative hypotheses: (H_0) that LDWs do not trigger win-overestimates (i.e., players' estimates are accurate) and (H_1) that LDWs do trigger win-overestimates. In other words Bayes factors have the relatively intuitive interpretation as the "odds" in favour of either the null or the alternate hypothesis (Rouder, Speckman, Sun, Morey, & Iverson, 2009). Such analyses can be especially useful when interpreting both strong effects (such as the clear overestimations in the control animation group) as well as more marginal effects, (such as the win estimates observed in the LDW animation group). Bayes factors for each one-sample t-test were computed online using a Bayes factor calculator (See Rouder et al., 2009), with r = 1 (i.e., no a priori assumptions

[7] Equality of variances not assumed (Levene's test: $F = 21.73$, $p < .001$).
[8] Corrected SE for inequality of variances

made regarding effect sizes). For those viewing the control animation, the Bayes factor favoured the alternate hypothesis 42:1 (JZS BF_{10} = 41.54), suggesting that there is very strong evidence in this group that LDWs do in fact trigger win overestimates. For the LDW-informed group, however, the Bayes factor actually favoured the null 1:1.2 (JZS BF_{01} = 1.12), suggesting a significant reduction, if not a complete elimination, of the LDW-triggered win-overestimation effect.

Game Preference

Participants' game preference (whether they chose to play the 3-line or 9-line game) for the final playing session was submitted to a group (control animation, LDW animation) by game (few LDW, many LDW) chi-square test of independence. While 54% of the control group chose the many LDW game compared to 45% of the animation group, this frequency difference was not statistically different $\chi^2(1) = .45$, $p = .60$.

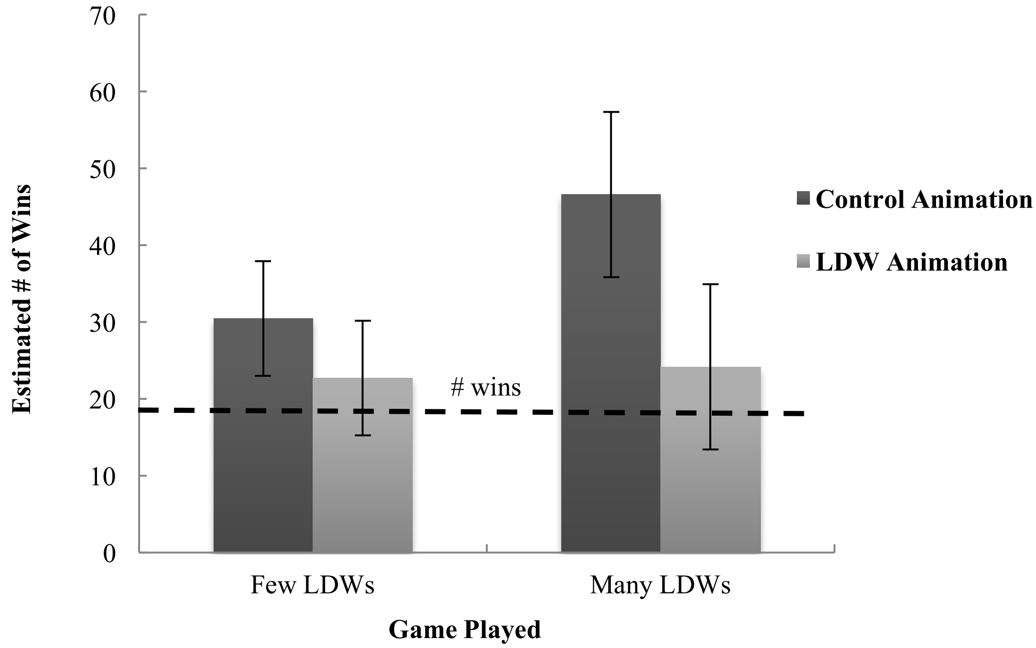

Figure 2.2 LDW-triggered win overestimation effect for the control and animation groups. Error bars represent Masson and Loftus (2003) 95% confidence intervals.

Subjective Experience

Subjective excitement, enjoyment, and arousal scores were submitted to separate video (control, LDW) by game-played (few LDW, many LDW) ANOVAs. The excitement ($M_{3\text{-}line}$ = 3.78, $M_{9\text{-}line}$ = 3.85), enjoyment ($M_{3\text{-}line}$ = 3.36, $M_{9\text{-}line}$ = 3.58), and arousal ($M_{3\text{-}line}$ = 2.84, $M_{9\text{-}line}$ = 3.00), measures did not reveal significant main effects of video, game-played, or the video by game-played interaction (all ps > .27). Furthermore, an independent samples t-test revealed that there was no difference between the control (M = 10.27) and LDW (M = 10.38) groups' overall playing experience during the study, $t(53) = -1.11$, $p = .91$. As such, no further analyses were performed on participants' subjective experiences.

Post-Game Categorization

After playing the slots games, participants categorized five additional spin outcomes (containing one LDW) on the 9-line game. Participants' categorization of the LDW (lost credits, gained credits) from each group (control animation, LDW animation) were analysed using a chi-square test of independence. The majority of participants (15 out of 26) who viewed the control video reported that they gained credits following the LDW. By contrast, none of the 29 participants who viewed the LDW animation stated that they gained credits following the LDW. This interaction was statistically significant, $\chi^2(1) = 23.01$, $p < .001$. These results are consistent with the numbers of participants who miscategorized LDWs during the pre-game practice spins. In fact, only one participant (from the control group) changed their LDW categorization (from gain to loss) between the second game and the five spins conducted at the very end of the study.

2.1.4 Discussion

This study affords two important conclusions regarding the presence of LDWs in multiline video slot machine games. First, the celebratory audio-visual feedback in multiline slots is very effective at distorting one's memory of how many times players thought they actually won money during a playing session. We contend that this is not a memory error per se, but rather a miscoding error; wherein, players are miscategorizing LDWs as monetary gains from the outset, and it is these miscoded outcomes that are erroneously encoded into memory. This miscategorization subsequently leads players to conflate these *net losses* with actual wins when recalling how many times they won more than they wagered, leading them to overestimate the number of spins on which they actually won. We refer to this phenomenon as the LDW-triggered win-overestimation effect.

In this study, participants in both animation groups were explicitly shown the functions of all the counters on the machine. As such (unlike players at actual slots venues), they were explicitly provided with all of the necessary information to unambiguously discern winning outcomes from the LDWs that cost the player money. Despite explicit allusions to the counters (e.g., bet, paid), participants in the control group still significantly overestimated how many times they won during the playing session, even though they were explicitly asked to estimate how many times they won *more than they wagered*. Despite only experiencing 19 actual wins, these novices estimated (on average) that they won 47 times. We assert that these players were miscategorizing many LDWs as actual monetary gains, which is supported by the fact that the majority of participants in the control group miscategorized LDWs as monetary gains at three different time-points -- during the two practice trials sessions prior to the first and second games, and at the end of the study during the post-games categorization spins. These results are disconcerting, as this miscategorization and LDW-triggered win-overestimation effect can significantly inflate perceived reinforcement rates of multiline games.

Fortunately, we also found that showing novices a short animation about LDWs could significantly reduce this LDW-triggered win-overestimation effect. Novices who viewed the LDW animation flawlessly categorized LDWs as monetary losses at all three time-points (practice spins before the first and second games, and again at the end of the study) and estimated that they won significantly less often than control participants in the many LDW game. Furthermore, participants who viewed the LDW animation did not significantly overestimate the number of times on which they won more than they wagered. Thus, we argue that this animation may be a useful tool for unmasking the disguise that accompanies LDWs.

In the prevention of slot machine gambling problems, a potentially powerful ally for health providers are the managers of the venues in which the games are housed. If it can be shown that the tools used to reduce gamblers' cognitive distortions do not negatively impact the enjoyment of the games, then such tools are more likely to be promoted by such managers. Here, we showed that although the LDW video significantly reduced participants' propensity to overestimate their wins, watching the video did not lessen their enjoyment of the game. Participants in both groups rated their game experience as equally exciting, enjoyable, and arousing regardless of which video they watched prior to play.

Participants' game preferences also did not differ between the two conditions. Rather, we found that in both groups, some participants preferred the less complicated 3-line game with larger wins, while others preferred the 9-line game with a perceived higher reinforcement rate and a more exciting, complicated display. Given that research suggests that the majority of experienced gamblers like to play the maximum number of playable lines, it would be interesting if future research explored whether individual differences in early playing experiences affects later gambling behaviour.

At the purely behavioural level one could speculate that LDWs could encourage prolonged slot machine play despite financial loss. Young, Wohl, Matheson, Baumann, and Anisman (2008) used extinction paradigms to show that players gamble for significantly longer during a losing streak if they previously played a game with many small interspersed wins (a high reinforcement rate). If LDWs cause players to (mis) perceive the reinforcement rate as high (even if the actual wins are relatively rare), one might predict similar effects. We investigate this question in the next chapter.

Chapter 3

Gambling Despite Financial Loss

3.1 Experiment 1

3.1.1 Research Questions & Hypotheses

In Chapter 2, we showed that the majority of participants who are not informed about LDWs miscategorize LDWs as wins, leading them to overestimate their wins during a playing session. Given that LDWs are misinterpreted as wins, we predicted that they may also influence players' gambling experiences and behaviours. In Chapter 2, though, we failed to find any differences in LDW-informed versus uniformed players' subjective arousal, excitement, and enjoyment. In this experiment, we used more formal, established measures of subjective experiences - namely, self-assessment manikins for subjective arousal and emotional valence (Bradley and Lang, 2004), and a visual analogue scale for desire to gamble (Young et al., 2008). Overall, we also hypothesized that a short playing session on a slot machine would be sufficient to increase one's arousal, improve one's mood, and increase one's desire to continue gambling (see Young et al, 2008 for the latter). Importantly, we hypothesized that players who experience many LDWs may show higher arousal, more positive mood (emotional valence), and higher desire to continue gambling than players who experienced fewer LDWs.

To date, no research has directly evaluated whether LDWs are in fact reinforcing. Following a classic resistance to extinction paradigm, we sought to evaluate whether a 100-spin playing session with more LDWs (more rewards) would be more reinforcing than a session with fewer LDWs (fewer rewards) by measuring the number of spins participants played (or persisted for) during a subsequent losing streak. (In the animal literature, this is akin to the number of lever presses made after food pellets (rewards) are cut off. The number of lever presses is taken a measure of the degree of learning established by the previous reinforcement schedule). We hypothesized that if LDWs are in fact reinforcing, then players should continue to gamble voluntarily for longer (i.e., persist) if they experienced many LDWs (rewards) compared to few LDWs during the 100-spin playing session. As a first assay, here we used two very conservative measures of learning. First, we only used novice slot machine gamblers (a sample of undergraduate students who had not played a slot machine in the past 12 months). Thus, these players should have little to no previous "learning" of slot machine reinforcement schedules. Secondly, we only included regular losses during the losing streak (i.e., no reinforcement during the extinction phase).

3.1.2 Method

Participants

Recruitment/Selection

Seventy-nine undergraduate students were recruited from the Department of Psychology's Research Experience Group. Data from 10 participants was discarded prior to analyses due to equipment malfunctions and/or missing data, leaving a final sample of 69 participants. At the beginning of the term, students completed a general battery of on-line pre-screen questions, which determined eligibility to view ads and sign-up for studies. To participate in this study, students had to: (1) be 19 years of age or older (2) not be in treatment for problem gambling; and (3) *not* have played a slot machine in the past 12 months (our definition of "novice" players). Participants were tested in a single session in a group setting in the lab's "casino" (see Apparatus). Up to three participants could play in the "casino" at any given time. Multiple researchers were present during the study. Participants were given the option to receive 10 dollars, 5 dollars plus half a course credit, or one course credit for their time. They were also given 20 dollars to play the slot machine and were informed that they could keep the cash remaining on the machine (end balance) up to a maximum of 40 dollars once the playing session was over. In actuality, the most they could receive is $17. All study procedures/methods were reviewed and approved by the University's Office of Research Ethics.

Canadian Problem Gambling Index

After providing consent, the researcher administered the Canadian Problem Gambling Index including the Problem Gambling Severity Index (PGSI). Using the interpretive cut-offs proposed by Currie, Hodgins, and Casey (2013), PGSI scores indicated that 57 participants were non-problem gamblers and 12 participants were low-risk gamblers. (These groupings were only used to characterize our undergraduate sample and were not formally analyzed). Ages ranged between 20 and 46 (M = 21.43, SD = 3.22) and included 47 (68%) females.

Apparatus

Slot Machine Simulator

Figure 3.1 shows a screen shot of "Sands of Splendor" (hereafter referred to as SoS). SoS is a 5-reeled desert themed game that allows players to play up to 20 lines, at up to five credits per line, for a maximum possible wager of 100 credits per spin. The version of SoS used here is in gambling parlance a “penny machine”. Upon spin initiation, the reels on SoS spin sequentially from left to right, playing a "spin reels" sound during the process. On commercially available slots, once the final reel stops spinning, slots spins that return credits (i.e., wins and LDWs) are accompanied by a "count up" sound. Sounds in this experiment ranged from 1.5s to 5s. During the "count-up" sounds on commercially available games, "unique" sounds can also appear on some spins. As such, we included "monkey", "camel", and "belly dancer" sounds during the count-up on some outcomes where players gained credits. The frequencies of these sounds were patterned after a commercially available game. Players in this study could not stop the reels while they were spinning, but could terminate any celebratory sounds and advance to the next spin by pressing the spin button. The simulator was run on a Dell OPTIPLEX 9010 desktop computer with a BOSE Companion 5 Multimedia Speaker System.

Slot Machine Cabinet

For the purposes of this study, to make our simulators as ecologically valid as possible, we placed the game's computer, speakers, and subwoofer in to the shell of a commercially available slot machine cabinet (Figure 3.2). We relayed the video from the computer to the cabinet's display screen. We modified the wiring in the cabinet so that the mouse cursor from the game would activate the physical spin button on the cabinet. Features imbedded in the game allowed us to display the game full screen and hide the mouse cursor (i.e., in attempt to disguise the fact that it was a computer generated game). We

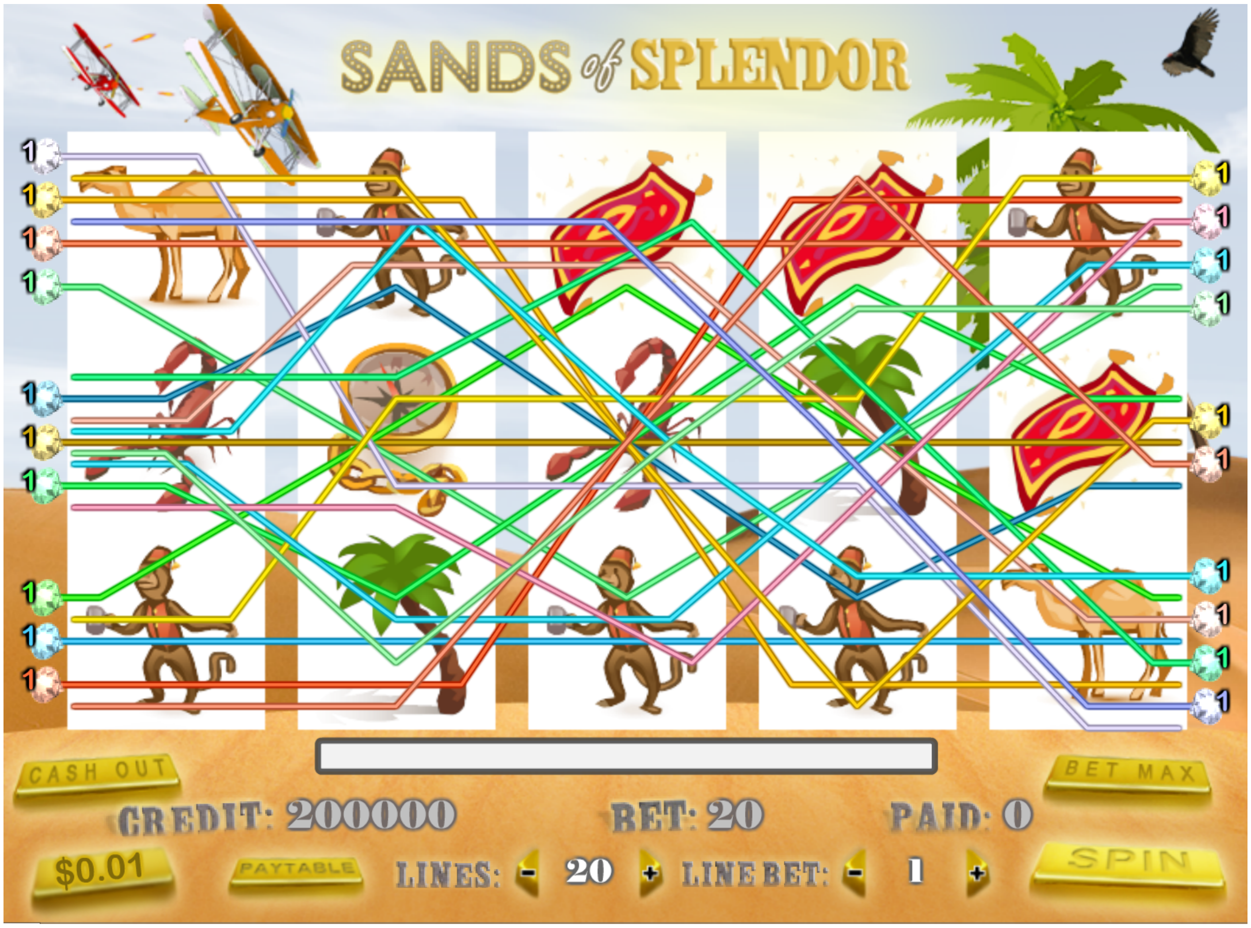

Figure 3.1 Sands of Splendor slot machine simulator showing the 20 playable lines.

placed custom built glass (patterned after SoS) in the top and base of the slot's shell (Figure 3.2).

Slots Game Designs

In part one of the playing session, participants played 100 spins on 20 lines, betting one credit per line, for a total wager of 20 cents per spin. Participants were given a 2000 credit ($20) starting balance, which would be enough for participants to play 100 spins if they were to (theoretically) lose on all 100 spins. All participants experienced 19 actual wins (credit returns greater than 20 cents). There were two LDW conditions: few (n = 6) LDWs and many (n = 30) LDWs. Microsoft Excel's random number generator was used to determine the order of outcomes (wins, LDWs, losses) within the 100 spins, with the constraint that the wins and LDWs were approximately evenly distributed across the 100 spin session. We did this by dividing the 100 spins into four blocks of 25-spins, and allocating approximately equivalent numbers of wins and LDWs into these blocks. These spins were then hard-coded into the simulator with all participants getting the spins in the same order. The end balance after 100 spins on both versions was 1700 credits ($17 CAD), amounting to a payback percentage of 85%. This is the lowest payback percentage available on commercially available games in Ontario. In part two of the playing session (where participants could choose how long they wished to play), there was a loss on the first spin, a LDW (10 credits) on the second spin, and subsequent losses on all other spins. Persistence was calculated as the number of spins played following spin 2 (LDW) in the second part of the playing session.

Figure 3.2 Sands of Splendor slot machine cabinet and simulator

Materials

Slot Machine Tutorial

Prior to the playing sessions, a researcher went through a tutorial (approximately 8 minutes long) with participants that explained how Sands of Splendor worked. Screen shots from the game were imported into PowerPoint (2011 for Mac), and animated shapes/lines were used to draw attention to various parts of the display (e.g., reels). The researcher explained that it was a 5-reel game in which players could wager on 20 different lines and that they would be betting one credit (one cent) per line for a bet of 20 credits (20 cents) on each spin. They were shown the pay tables, which included the various symbol combinations and associated returns, as well as the rules of the game. Next, the researcher highlighted the various counters on the bottom of the screen (see Figure 3.1). The credit box showed their starting balance (2000 credits), and their running total throughout the game. The bet box showed that they were wagering 20 credits per spin. Importantly, the paid counter showed the credits acquired on a spin, if any. Finally, they were shown the cash out, one cent, paytable, lines, line bet, bet max, and spin button, but were informed not to use these buttons during the game. Note: participants were asked to use the spin button on the cabinet during the playing session (see procedure).

Measures

Subjective arousal and mood. Self-assessment manikins (Bradley and Lang, 2004) were used to measure subjective arousal and emotional valence (separately) at three different time points during the session (see procedure). The manikins were presented on paper and administered on a clipboard. These measures show five manikins in a row. Participants rate their arousal and mood using a nine-point scale by placing a check mark on one of nine circles presented below the manikins so as to be aligned on (or in between) Manikins. For the arousal manikins, the pictures went from low arousal (left) to high arousal (right). For the valence manikins, the pictures went from happy mood (left) to sad mood (right).

Desire to Gamble. We used a paper visual analogue scale to measure participants desire to gamble on a 100-point scale (Young et al., 2008). Participants placed a hash mark on a 100 mm line and desire to gamble was measured using a ruler.

Procedure

Participants came to a participant waiting area that was in a separate room adjacent to the study casino. A researcher gave the participants an informed consent form outlining the study and highlighted key points including eligibility (which was confirmed), remuneration, and risks. After reading and signing consent forms, participants were given a hard copy of the CPGI to complete in the waiting area and informed that they could approach the researcher if they had any questions. Next, participants were asked to sign a receipt for their time and cash was placed in an envelope in front of the participant. They were informed that they were being given $20 to bring in to the casino along with a blank receipt so that they could be given their winnings (if any) at the end of the playing session. All documentation accumulated at this point was placed on a clipboard with the $20 clearly visible. Prior to the playing session, coins (of various denominations) were placed in the hopper on the bottom of the slot machine cabinet. Participants were later told that they could grab their earnings from the hopper. These steps were taken to reinforce to participants the fact that they were playing with real money.

Once the participant was ready, another researcher brought the participant (and their clipboard) in to the lab's "casino". The three simulator machines were interleaved among several commercially available games. There was a "Cashier" area and three laptop stations. Given that the order of the outcomes were hard coded, in this, and all subsequently described experiments, we staggered participants by 15 minutes in order to prevent accidental alignment of outcomes from different machines during game play.

Once in the casino, participants were seated at a laptop station. Here, they completed some questionnaires collected for reasons peripheral to this study[9]. They were then brought to the "cashier" area where they were shown the slot machine tutorial. Emphasis was placed on the games' counters, especially the amount wagered and paid to ensure participants were aware of the information that would inform them whether they won or lost money. After the tutorial, participants were brought to a slot machine. They were reminded of the key features described in the tutorial. Participants were told that they would be wagering 20 cents per spin for 100 spins and then would be asked some additional questions. They were informed that they did not need to count the spins, instead the researcher would come over when there were 2 spins remaining. They were instructed that they could not change their wager or the number of lines played during the game. (These features were disabled on the simulator for the purpose of this study). They were informed that the game was preset to a balance of 2000

[9] Depression, Anxiety, and Stress Scale (DASS 21; Lovibond and Lovibond, 1995)**;** Positive and Negative Affect Schedule (PANAS; Watson, Clark, and Tellegan,1988); Gambling Related Cognitions Scale (GRCS; Raylu and Oei, 2004)

credits or $20 and that they could keep the remaining balance on the machine (if any) up to a maximum of $40.

Prior to playing, participants were administered the arousal and emotional valence manikins, and the desire to gamble item. Participants played 98 spins, after which they were reminded they had two spins left. At 100 spins, the researcher re-administered the arousal, valence, and desire to gamble items. At this critical point, the researcher handed participants an instruction "ticket" that stated "At this point during the playing session, you can continue to play for as long as you wish or can choose to stop playing at any time." "Once you have decided to stop playing, please take your earnings from the hopper, and bring this ticket back to the casino desk area." The researcher then left the playing area. Participants read the instruction ticket and continued to play (or stopped immediately if they wished). After finishing play, they retrieved their earnings from the hopper and returned to the cashier area. The researcher then brought the participant back to the machine and re-administered the arousal, valence, and desire to gamble items one final time. They were then asked to estimate how many times they won more than they wagered in the first 100 spins[10]; and to then to write why they chose to stop playing when they did on a clipboard[11]. After this playing session, participants were brought back to the laptop stations to complete some additional questionnaires[12] for reasons peripheral to this study. Participants signed a receipt for any cash

[10] Participants experienced different numbers of spins because of the persistence trials, which could affect participants' retrospective win estimates. Therefore, we did not include this item in the results section.

[11] This item was included to collect qualitative data to inform future research. This item is not included in the results section.

[12] Rational-Experiential Inventory (REI; Pacini & Epstein,1999); Cognitive Reflections Test (CRT; Frederick, 2005); Actively Open-Minded Thinking (AOT; Stanovich & West, 1997); Adult ADHD self-report scale (ASRS; Kessler, Adler, Ames, et al., 2005); Attention Related Cognitive Errors Scale (ARCES; Carriere, Cheyne, & Smilek, 2008).

obtained from the end balance on the machine, and were given their cash for participating; a debriefing form, two responsible gambling brochures; a wallet card with a pencil with the problem gambling helpline's number on it, and information for a local community crisis/mental health/addiction hotline.

3.1.3 Results

General Analytical Notes

Given the sample size and relatively limited range of players with any gambling problems for this experiment, we did not include PGSI group as a factor in our analyses of variances. Recall that there were three key time-points in the playing session: before the game started, after the 100 spin playing session, and after the participant decided to quit during the extinction period (after their persistence spins). We refer to these three time-points as pre-game, post-game, and post-persistence respectively. Prior to each analysis, we performed an outlier rejection procedure using +/- 2.5 SD above or below the mean. For repeated measures factors, we performed outlier rejection procedures on each level, and excluded any participants who had had an outlier on one or more levels. If sphericity was violated in repeated measures and mixed ANOVAs, then we report Mauchly's chi-squared and p-values, and used Greenhouse-Geisser corrections for degrees of freedom. If homogeneity of variance was violated in independent samples t-tests, then we report Levene's test and report corrected values. We used Tukey post hoc comparisons to evaluate main effects in ANOVAs involving between subjects factors. We evaluated independent and paired-samples t-test against Bonferroni corrected p-values if we performed multiple comparisons. For brevity, we only report significant results for analyses. Maximum F and t values, and minimum p values are provided for the remaining set(s) of non-significant results.

Arousal

No outliers were removed prior to analyses. Participants' arousal scores were submitted to a 2-way mixed ANOVA, with time-point (pre game, post game, post-persistence) as the repeated measures factor and condition (few LDWs, many LDWs) as the between subjects factor. There was a main effect of time-point, $F(2, 126) = 27.53$, $p < .001$, $MSE = .58$, $\eta_p^2 = .30$. To explore the main effect of time-point, we ran paired-samples t-tests evaluated against a Bonferroni correction of p/3= .017. Arousal was highest after the game. Post-game arousal was significantly higher than pre-game arousal, $M_{diff} = .97$, $SE_{diff} = .12$, $t(64) = 7.82$, $p < .001$, and post-persistence arousal, $M_{diff} = .31$, $SE_{diff} = .12$, $t(64) = 2.48$, $p = .016$. Arousal was also higher post-persistence than prior to the game (pre-game), $M_{diff} = .31$, $SE_{diff} = .12$, $t(64) = 2.48$, $p = .016$, $M_{diff} = .66$, $SE = .15$, $t(64) = 4.44$, $p < .001$. There was not a main effect of the LDW game played, $F(1,63) = .70$, $p = .41$, $MSE = 5.22$, or a game played by time-point interaction, $F(2, 126) = .61$, $p = .54$, $MSE = .58$. Table 3.1 shows the means and standard deviations for players' arousal scores at each of the three time-points.

Emotional Valence

Participants' subjective emotional valence scores were reversed coded so higher scores corresponded to more positive mood. Two outliers (1 NPG, 1 ARG) were removed prior to analyses. The remaining participants emotional valence scores were submitted to a 2-way mixed ANOVA, with time-point (pre game, post game, post-persistence) as the repeated measures factor and condition (few LDWs, many LDWs) as the between subjects factor. All effects were not significant, all *Fs* < 3.26, *ps* $> .076$. Table 3.1 shows the means and standard deviations for players' mood scores at each of the three time-points.

Desire to Gamble

Desire was calculated by measuring the participants' hash marks on the 100mm "desire to gamble" line. One outlier (NPG) was removed prior to analyses. The remaining participants' desire to gamble scores were analyzed using a 2-way mixed ANOVA, with time-point (pre-game, post-game, post-persistence) as the repeated measures factor and condition (few LDWs, many LDWs) as the between subjects factors. Analyses revealed that Mauchly's test of sphericity was violated, $\chi^2(2) = 20.89$, $p < .001$, Greenhouse-Geisser $\varepsilon = .78$, and corrections were applied to degrees of freedom.

The main effect of time-point was significant, $F(1.56, 99.83) = 4.14$, $p = .027$, $MSE = 175.98$, $\eta_P^2 = .06$. We used paired-samples t-tests to explore the main effect of time point, evaluating p values against a Bonferroni correction of p/3 = .017. Desire was not significantly higher post-game than pre-game, $M_{diff} = .29$, $SE_{diff} = 1.84$, $t(65) = .16$, $p = .88$. Desire was significantly higher post-game than after the persistence phase (post-persistence), $M_{diff} = 5.15$, $SE_{diff} = 1.65$, $t(65) = 3.12$, $p = .003$. There was not a significant difference between players' self-reported desire pre-game than post-persistence, $M_{diff} = 4.86$, $SE_{diff} = 2.50$, $t(65) = 1.95$, $p = .056$.

The main effect of LDW condition was also significant $F(1, 64) = 4.98$, $p = .029$, $MSE = 1030.17$, $\eta_P^2 = .072$. Overall, participants' desire to gamble was higher in the few LDW condition ($M = 35.07$, $SE = 3.50$) than in the high LDW condition ($M = 24.77$, $SE = 3.01$). Complicating the interpretation of this result, participants' pre-game desire in the few

LDW condition (*M* = 36.00, *SD* = 22.97), was slightly higher than participants' pre-game desire in the high LDW condition (*M* = 26.74, *SD* = 19.04), *t*(64) = 1.79, *p* = .07. Table 3.1 shows the means and standard deviations for players' desire to gamble scores at each of the three time-points.

Persistence

Persistence was calculated as the number of spins following the LDW on spin 2 during the persistence phase (i.e., after the initial 100 spins). Three outliers (1 NPG, 2 LRG) were removed from further analyses. In total, 42 participants (63.4%) did not persist to gamble following the 100-spin game. Participants' persistence from the few LDW and many LDW games were compared using an independent samples t-test. Participants' persistence scores in the few LDW game (*M* = 3.33, *SD* = 5.81) did not differ from participants' persistence scores in the many LDW game (*M* = 4.76, *SD* = 7.16), *t*(62) = .85, *p* = .40, *SE* = 1.68 (η_P^2= .011, *power* = .13). Figure 3.3 shows the persistence scores from the two LDW groups.

Table 3.1 Participants' subjective experiences prior to the 100-spin playing session (pre-game), following the playing session (post-game), and following the persistence phase (post-persistence)

	Pre-Game		**Post-Game**		**Post-Persistence**	
	M	SD	M	SD	M	SD
Arousal	3.6	1.4	4.6	1.4	4.3	1.5
Emotional Valence	6.3	1.3	6.2	1.3	6.5	1.5
Desire to Gamble	31	21	31	23	26	20

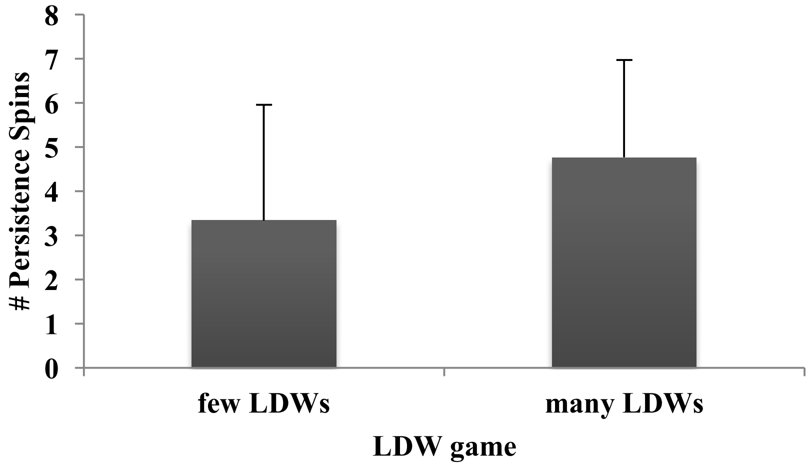

Figure 3.3 Participants' mean number of persistence spins from each of the LDW games (few LDWs, many LDWs). Error bars represent Masson and Loftus (2003) 95% confidence intervals.

3.1.4 Discussion

We predicted that, overall, a short 100-spin playing session on the slot machine would be sufficient to increase one's arousal, improve one's mood, and increase one's desire to gamble. This was true for subjective arousal - arousal was significantly elevated after the 100-spin game and remained above baseline after participants decided to stop playing after the persistence phase. Contrary to our expectations, mood (emotional valence) did not differ at any of the three time-points. Furthermore, desire to gamble was not elevated after the 100-spin playing session, but did significantly decrease following the persistence phase. Given that Brown (1986) argued that physiological arousal is the primary reinforcer regulating gambling behaviour, subjective arousal may be the best measure of participants' gambling experience in this study. As for mood, it may be possible that the session was either too short to lead to changes in mood; that participants (cognitively) were not subjectively privy to subtle mood changes; or that our laboratory casino environment and/or games were not exciting enough to induce affective changes.

Regarding LDWs, we predicted that participants' subjective arousal, mood, and desire to gamble might be greater for those who played a game with many LDWs than a game with few LDWs. This, we did not find. Subjective arousal and mood did not differ between the groups. Contrary to our expectations desire was higher (overall) amongst participants who played the few LDW game than amongst those who played the many LDW game. We are cautious about interpreting this finding however, as pre-game (baseline) desire to gamble was slightly higher among the few LDW group compared to many LDW group. That being said - this baseline difference fell short of significance. As such, one should entertain other possible explanations for this finding. The most plausible alternative involves the magnitude of the actual wins in the fewer LDW game. To equate the payback percentages and numbers of actual wins between the games, we had to include larger wins in the few LDW game because there were more regular losses (i.e., the extra LDWs in the many LDW game resulted in more spins where one did not lose their entire spin wager). These larger wins could in turn have influenced participants' desire to continue gambling. Furthermore, our controlled slot machine games are highly constrained compared to actual slots games. Multiline games normally include LDWs, in addition to a mixture of smaller and larger awards. Thus, LDW frequency could potentially have an influence on both desire to gamble and mood if they were interspersed in the more complicated and exciting prize structure (including bonus games) that is found on actual slots.

Contrary to our hypotheses, we failed to find any significant differences between players' persistence in the few and many LDW games. As a conservative measure, though, we used a sample of young novice gamblers who purportedly would have very little experience playing slot machines (if any) and thus, would have little to no pre-existing learning of slots reinforcement schedules. In fact, only 37% of participants in this study persisted to gamble at all. Many participants were also playing to receive course credit, which may have been their primary motivation for participating in the playing session. As potentially their first experience being in a "casino", there were also only three machines, where moderate to larger wins did not occur. In a naturalistic setting, casinos have hundreds to thousands of machines where novices can clearly see that slots rewards are essentially everywhere because LDWs (the most frequent outcome besides losses) are accompanied by flashing lights and salient sounds. As first time players, our casino and prize structures may not have been sufficient to get players to persist during the extinction phase, despite the reinforcement rate during the short playing session. Another factor that may have influenced players' motivation to continue gambling is the payback percentage. We used the lowest payback percentage available on slots games in Ontario, which is 85%. It is possible that the novice sample we used may have been more sensitive to the expected value of the game (i.e., payback percentage) than the frequency of rewards. At the point where participants were given the choice to persist or stop gambling, they were down by three dollars and may not have wanted to chance losing the $17 remaining on the machine.

Another possible account for the lack of difference in persistence between games is that of a "framing" effect. Experiencing very frequent small wins could perhaps make medium or larger prizes seem less likely to occur to the player, which could in turn affect their behaviour to continue (or not continue) gambling. From an operant conditioning perspective, the auxiliary nature of the rewards should not matter, but we know from the gambling literature that gamblers prefer a mixture of large and small rewards. It is also possible that 30% LDWs may lead to a reinforcement rate that is too frequent. At this reinforcement rate, players could experience a "reward" on virtually every second spin. At this point, the game may no longer appear as if it is occurring on a random reinforcement schedule and could perhaps appear more "fixed".

A final possible account is that very frequent LDWs may actually lead players to start correctly categorizing LDWs as monetary losses, thus eliminating the LDW miscategorization and LDW-triggered win-overestimation effect. One study (Templeton et al., 2015) supports this hypothesis. In this study players played on each of two commercially available machines - one with a moderate number of LDWs and one with a high number of LDWS. Although players overestimated wins in both games, their overestimation was significantly greater for the machine with the moderate number of LDWs. Thus, there may be a "sweet spot" for LDW miscategorization and reinforcement.

In the subsequent experiment, we sought to address some of these shortcomings by: (1) using a community sample of experienced gamblers (i.e., those with pre-existing "learning" of slots schedules), (2) having games with a positive expected value (payback percentage) so that all participants are more likely to persist; and (3) adding a game with a moderate number of LDWs (a potential "sweet spot"), in addition to games with few and many LDWs.

3.2 Experiment 2

3.2.1 Research Questions & Hypotheses

The first goal of this experiment was to see if we could replicate the findings that novices verbally miscategorize LDWs as wins with a community sample of experienced gamblers. Given that previous research has shown that experienced gamblers show the LDW-triggered win overestimation effect, we predicted that the majority of experienced gamblers might also verbally miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses. We also sought to replicate the finding that gamblers physiologically and behaviourally miscategorize LDWs as wins by measuring players' autonomic arousal to outcomes (losses, LDWs, and wins) via skin conductance responses (SCRs); their post-reinforcement pauses (PRPs) following these same outcomes; and the mechanical force with which they initiated the next spin (via a spin button) following these outcomes (as outlined in the introduction to this thesis all three measures showed an equivalence between wins and LDWs with commensurate differences between LDWs and regular losses). We predicted that gamblers would show higher SCRs to LDWs than regular losses; longer PRPs following LDWs than regular losses; and higher mechanical force following LDWs than regular losses. In sum, these predictions would replicate and extend the findings that gamblers, as a whole, miscategorize LDWs as wins.

The second goal of this experiment involves players' gambling experiences. We used the same subjective arousal and emotional valence manikins and desire to gamble items from Experiment 3.1 to see if, overall, a short playing session on a multiline slot is sufficient to increase one's arousal, mood, and desire to gamble. Second, given that there is little research on gambling persistence, we added a second established measure of gambling urge (the Gambling Urge Scale; GUS) to explore gamblers' craving to continue gambling after they voluntarily decided to stop playing.

Regarding LDWs and subjective experience, we remind the reader that we failed to find significant differences between players' subjective arousal, mood, and desire to gamble when they played a game with few LDWs or many LDWs. Given that research has previously shown that too high a percentage of LDWs can lead to a diminished LDW-triggered win overestimation effect, we propose that there may be an optimum reinforcement rate for LDWs, or a "sweet spot". As such, we added a game with a moderate amount of LDWs patterned after the LDW reinforcment rate of a commercially available slot machine game. We propose that if there is such a "sweet spot", then gamblers' may show higher subjective arousal, mood, desire to gamble, and urge in this moderate LDW game than in a few and many LDW game. Finally, we added a scale with measures of in-game experiences. This measure was originally designed to measure in-game experiences for video games, which we modified to pertain to gambling experiences. This measure has several subscales (see Method), including measures of positive and negative affect. We predicted that players may report experiencing greater positive affect and less negative affect if they played the moderate LDW game compared to the few and many LDW games.

Finally, our central question was: are LDWs reinforcing and do they affect gambling behaviour? Specifically, do LDWs lead gamblers to continue gambling despite financial loss? In this experiment, we measured gamblers' persistence during a losing streak after playing a few, moderate, or many LDW game. If there is a sweet spot for LDW reinforcement, then we predict that gamblers may persist for longer in the moderate LDW game than in low or high LDW games. We also predicted that experienced gamblers might be more likely to persist than the novices who participated in Experiment 1 (Section 3.1). If previous experience playing slot machines does affects one's reinforcement sensitivity, then gamblers' with greater problem gambling symptomatology (where one could conjecture that they have more slots experience as well) may persist for longer than gamblers with less problem gambling symptomatology.

3.2.2 Method

Participants

Recruitment/Selection

One hundred and forty-eight participants were recruited from the general Kitchener-Waterloo community (Canada) using the online classified website Kijiji. Participants were 19 years of age or older; not in treatment for problem gambling; and played slots at least once in the past year. They were given $10 for participating in the one-hour in lab study, and $20 to play a slot machine in the lab's "casino" (see procedure). They were informed they could keep their ending balance on the machine at the end of the session up to a maximum of $40. In actuality, the most they could receive is $23. Eighteen participants were excluded from any further analyses due to technical/equipment malfunctions or incomplete data, leaving a final sample of 132 participants. Up to two participants were tested in the lab's casino at any given time with multiple researchers present. All methods and procedures were approved by the University of Waterloo's Office of Research Ethics.

Canadian Problem Gambling Index.

Near the beginning of the session, the Canadian Problem Gambling Index was administered using the Quatrics online survey platform. The CPGI was used to measure participants' slots play over the past year, problem gambling severity levels (via the PGSI), age, and gender. Using the interpretive cut-offs proposed by Currie, Hodgins, and Casey (2013), 53 participants were deemed non-problem gamblers (PGSI =0), 55 low-risk gamblers PGSI 1 to 4), 15 moderate risk gamblers (PGSI 5 to 7), and 9 problem gamblers (PGSI > 7). Ages ranged between 18 and 54 (M = 30.17, SD = 12.04) and included 58 (44%) females.

Apparatus

Slot Machine Simulator/Cabinet

We used the same Sands of Splendor (SoS) simulated slot machine described in Experiment 1 (See Figures 3.1 and 3.2).

Slots Game Designs

The game design was similar to that employed in Experiment 1 (Section 3.1.2). Participants started with 2000 credits on the machine. They wagered one credit on 20 lines for a total spin wager of 20 credits. During the 100 spins, all participants experienced 19 actual wins. There were, however, several important deviations from Experiment 1. Firstly, three LDW conditions were used: few (n = 5) LDWs, moderate (n = 12) LDWs, and many (n = 27) LDWs. Outcomes in the first 100 spins were randomly interspersed so that there were similar numbers of wins and LDWs in each 25-spin block. Secondly the end balance after 100 spins on both versions was 2300 credits ($23 CAD), amounting to a payback percentage of 115%. Characteristics of the few, moderate, and many LDW versions of the game are shown in Figure 3.4. Finally in the persistence phase of the design, participants experienced a loss on spin one, a small win (32 credits) on spin two, and losses on all subsequent spins.

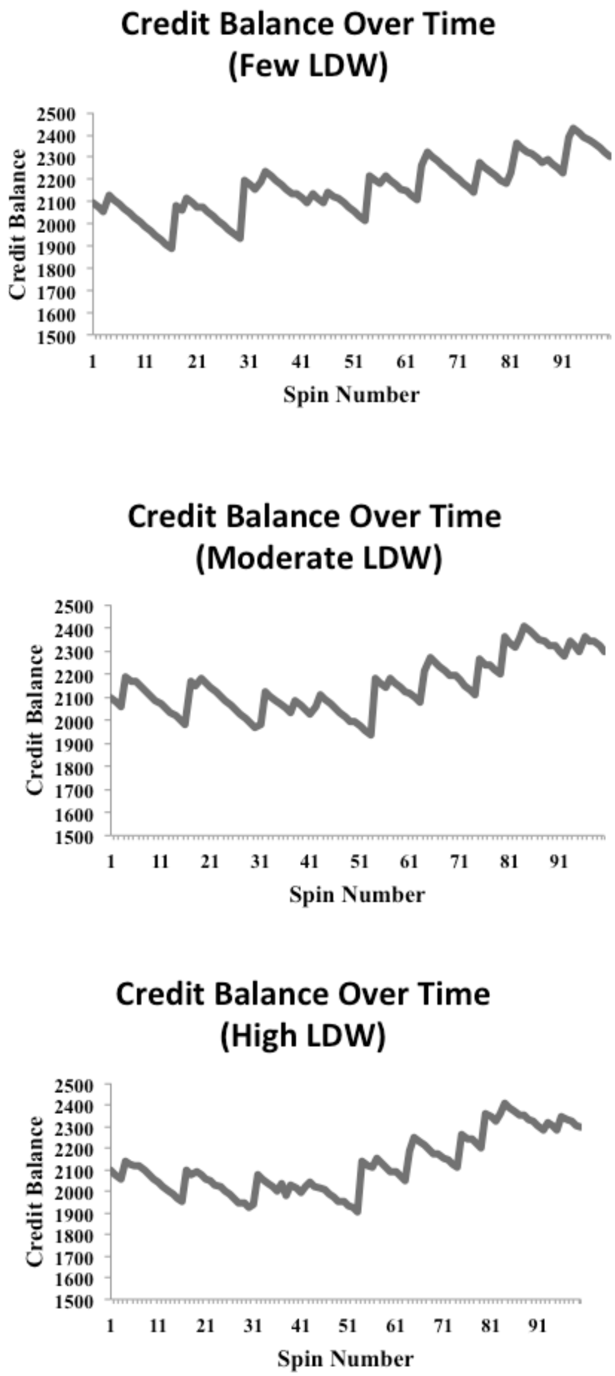

Figure 3.4 Credit balances for each of the LDW games (few, moderate, many) during the 100-spin playing session.

Event Marking

Event markers, such as when the reels started spinning and when and what type of outcome (i.e., win, LDW, loss) were sent from the simulator game to a LabJack data acquisition (DAQ) device. The signals (event markers) from the LabJack were relayed to an AD instruments Powerlab (model 8/30), and recorded by LabChart 7 software on a G4 Mackintosh PowerBook.

Force Transduction

A force transduction plate was mounted under the spin button on the slot's cabinet. The signal from the transducer was relayed to the PowerLab and recorded by the LabChart software.

Skin Conductance Responses (SCRs)

We recorded participants' skin conductance levels (SCLs) using non-gelled SCL electrodes attached to the upper phalanges of their left index and ring fingers. These SCL electrodes were relayed to the PowerLab, which was equipped with a GSR amplifier. SCRs were computed offline using LabChart analysis software.

Materials

Slot Machine Tutorial

Prior to the playing sessions, participants watched a narrated version of the tutorial used in Experiment 1 (See Section 3.1.2). The PowerPoint slides were imported into Camtasia 2 to create an animated video with voice-over narration. The final product was 7 minutes and 16 seconds long. This tutorial explained how SoS worked and explained the various counters on the bottom of the display. They were informed that they were betting on

20 lines, at one credit/penny per line, for a total spin wager of 20 credits/20 cents. We showed them the bet and paid counter and informed them that this box would display the amount of credits acquired, if any.

Scales

Gambling Urge Scale (GUS; Raylu & Oie, 2004). The gambling urge scale measures feeling and thoughts related to emotional, physiological, and motivational states while gambling. The scale includes 6 items measured on a 7-point Likert Scale anchored at zero. An example item is "All I want to do is gamble".

The Game Experience Questionnaire (GEQ; IJsselsteijn, de Kort, and Poels, 2013). We used the 14 item in-game version of the gaming experience questionnaire. This questionnaire was originally designed to measure individual's experiences while playing a game, such as a video game. It measures individual's experiences while playing a game along seven dimensions: (1) positive affect (e.g., "I felt content") and (2) negative affect (e.g., "I felt bored"); (3) tension ("I felt frustrated"); (4) flow (e.g., "I felt completely absorbed"); (5) immersion (e.g., "I found it impressive"); (6) competence (e.g., "I felt skillful"); and (7) challenge (e.g., "I had to put a lot of effort in to it). We modified the questionnaire by asking participants to reflect how they felt while gambling rather than gaming.

Measures

Subjective arousal and mood. Participants used the self-assessment manikins (described in section 3.1.2) to rate their arousal from low (left) to high (right) and their emotional valence from happy (left) to sad (right).

Desire to Gamble. Participants used a paper visual analogue scale (described in section 3.2.1) to rate their desire to gamble by placing a hash mark on a 100 mm line.

LDW Categorization Questions. At the end of the playing session, participants were asked to categorize 10 slots spins using the following instructions: "Please spin the reels of the slot machine 10 times. For each spin, please circle whether you gained credits/money or lost credits/money." There were two LDWs, two wins, and four losses in the 10 categorization spins.

Procedure

Participants were greeted at a waiting area in a room adjacent to the study "casino". A researcher gave the participants an informed consent form outlining the study and highlighted key points including eligibility (which was confirmed), remuneration, and risks. They then followed the same remuneration procedures described in section 3.2.1. Prior to entering the casino, participants washed their hands in a public washroom so that we could maximize the quality of the SCL recording.

Once in the casino, participants sat at a laptop station. They completed some scales for reasons peripheral to this study[13] They went to the "cashier" area where they watched the slots tutorial. After the tutorial, participants sat at the slot machine, and we attached the skin conductance electrodes to their left index and ring finger of their left hand. They were asked

[13] Depression, Anxiety, and Stress Scale (DASS 21; Lovibond and Lovibond, 1995)**;** Positive and Negative Affect Schedule (PANAS; Watson, Clark, and Tellegan,1988); Gambling Related Cognitions Scale (GRCS; Raylu and Oei, 2004); Gambling Motivation Scale (GMS; Chantal, Vallerand, Vallieres, 1994)

to rest their hand on their lap while playing the game to minimize movement artifacts during play.

We reminded participants of the key features of the game by pointing to the relevant information on the screen. They were informed that they would be wagering 20 cents per spin for 100 spins and would be asked some additional questions. They were also informed that they did not need to count the spins; rather, a researcher would come over when there were two spins remaining. They were instructed that they could not change their wager or the number of lines played during the game; that the game was preset to a balance of 2000 credits or $20; and that they could keep the remaining balance on the machine (if any) up to a maximum of $40.

Prior to playing, participants were administered the gambling urge scale, and the subjective arousal, emotional valence, and desire to gamble items. Participants played 98 spins, and then the researcher came over to inform them they had two spins left. At 100 spins, the researcher administered the arousal, valence, and desire to gamble items. As in the previous experiment the researcher handed participants an instruction “ticket” that stated "At this point during the playing session, you can continue to play for as long as you wish or can choose to stop playing at any time." "Once you have decided to stop playing, please bring this ticket back to the casino desk area." The researcher then left the playing area. Participants read the instruction ticket and continued to play (or stopped immediately if they wished). After finishing play they returned to the cashier area. The researcher then brought the participant back to the machine and re-administered the GMS scale, and the arousal, valence, and desire items using paper copies of the questionnaires. They were also asked to write down how many times they thought they won more than they wagered in the first 100 spins[14] to write why they chose to stop playing when they did[14]; and complete the GEQ. After completing these measures, participants were brought to a different slot machine and asked to play 10 spins and categorize each spin as a gain or a loss.

After the playing session, participants were brought to the laptop stations to complete some additional questionnaires[15] for reasons peripheral to this study. Participants signed a receipt for any cash obtained from the end balance on the machine, and were given their cash; debriefed, and given two responsible gambling brochures; a wallet card and a pencil with the Ontario Problem Gambling Helpline's number on it, and information for a local community crisis/mental health/addiction hotline.

3.2.3 Results

General Analytical Notes

Given the few numbers of moderate risk (MR) and problem (PG) gamblers, we chose to combine those PGSI groups in to one (higher-risk gamblers) category (HRG). Thus we had 3 PGSI groups, non-problem gamblers NPGs, low-risk gamblers (LRG), and higher risk

[14] Participants experienced different numbers of spins because of the persistence trials, which could affect participants' retrospective win estimates. Therefore, we did not include this item in the results section.

[14] This item was included to collect qualitative data to inform future research. This item is not included is not included in the results section.

[15] Rational-Experiential Inventory (REI; Pacini & Epstein,1999); Cognitive Reflections Test (CRT; Frederick, 2005); Actively Open-Minded Thinking (AOT; Stanovich & West, 1997); Adult ADHD self-report scale (ASRS; Kessler, Adler, Ames, et al., 2005); Attention Related Cognitive Errors Scale (ARCES; Carriere, Cheyne, & Smilek, 2008); Barrat impulsibity Scale (BIS-11; Patton, Stanford, Barratt, 1995); The Barratt Impulsivity/Behavioural Activation Scale (BIS/BAS; Carver & White, 1994).

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gamblers (HRGs). As in Experiment 1, our three time-points of interest were prior to the playing session (pre-game), after 100 spins (post-game), and upon quitting play (post-persistence). We used the same outlier rejection, sphericity and heterogeneity of variance corrections, and post hoc procedures as previously noted (see section 3.1.2).

LDW categorization

Participants were deemed LDW miscategorizers if they miscategorized LDWs as wins on both LDW outcomes during the outcome categorization trials following the playing session. As a conservative measure, participants were deemed LDW correct categorizers if they labeled one or both LDWs as losses. In total, seventy percent of participants miscategorized LDWs as wins rather than correctly categorizing them as losses. A one sample z test revealed that significantly more than fifty percent of participants miscategorized LDWs as wins, $z = 4.82$, $p < .001$. Descriptively, there were more "correct" categorizers in the many LDW game (39.0%) than in the few (25.6%) and moderate (26.7%) LDW games. This difference was not statistically significant, $\chi^2(2) = 2.16$, $p = .34$.

Skin Conductance Responses (SCRs)

SCRs were calculated as the maximum skin conductance level during a two second window one second following outcome delivery (when the reels stopped spinning). To pre-process the SCR data, we first performed square root transformations as recommended by Dawson, Schell and Filion (2000). Next, we performed outlier rejection procedures for each outcome (win, LDW, loss) using the sample-size dependent cut-offs proposed by Van Selst and Jolicoeur (1994). Data from 9 participants could not be analyzed due to equipment malfunctions/noise in the data.

Two outliers (identified as having an outlier on the grand mean for wins, LDWs, and/or losses) were removed prior to analyses (1 NPG, 1 LRG). Participants' SCRs following wins, LDWs, and losses were submitted to a repeated measure ANOVA, with outcome type as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 11.08$, $p = .004$, Greenhouse-Geisser $\varepsilon = .92$. Greenhouse Geisser corrections were applied to the ANOVA. The main effect of outcome type was significant, $F(1.82, 220.40) = 6.27$, $p = .003$, $MSE = .015$, $\eta_P^2 = .05$. Bonferroni corrected paired samples t-tests revealed that SCRs following wins were significantly larger than following losses, $t(120) = 3.32$, $p = .001$, $SE = .016$, $M_{diff} = .054$. SCRs following wins were not significantly larger than following LDWs, $t(120) = 1.82$, $p = .072$, $SE = .017$, $M_{diff} = .03$. SCRs following LDWs were not significantly larger than following losses, $t(120) = 1.88$, $p = .062$, $SE = .013$, $M_{diff} = .024$.

Participants' SCRs to LDWs in each game were compared using an univariate ANOVA with LDW game played as the between subjects factor. Descriptively, participants' in the moderate LDW game had higher SCRs to LDWs ($M = .45$, $SD = .30$) than in the few LDW ($M = .26$, $SD = .30$) and in the many LDW ($M = .25$, $SD = .13$). These differences did not reach statistical significance, $F(2, 118) = 1.55$, $p = .23$, $MSE = .35$ ($\eta_P^2 = .026$, *Power* = .32).

Post Reinforcement Pauses (PRPs)

PRPs were calculated as the time between outcome delivery (when the reels on the game stopped spinning) and the initiation of the following spin (when the participant pressed the spin button). To pre-process the PRP data, we performed outlier rejection procedures for each outcome (win, LDW, loss) using the sample-size dependent cutoffs proposed by Van Selst, and Jolicoeur (1994).

Data from 9 participants could not be analyzed due to equipment malfunctions/noise in the data. Two outliers (identified as having an outlier on the grand mean for wins, LDW, and/or losses) were removed prior to analyses (1 NPG, 1 LRG). Participants' PRPs following wins, LDWs, and losses were submitted to a repeated measure ANOVA, with outcome type as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 244.60$, $p < .001$, Greenhouse-Geisser $\varepsilon = .53$. Greenhouse-Geisser corrections were applied. The main effect of outcome was significant, $F(1.07, 128.21) = 506.37$, $p < .001$, $MSE = 3.64$, $\eta_P^2 = .81$. Bonferroni corrected paired samples t-tests showed that wins had significantly longer PRPs than LDWs, $t(120) = 21.51$, $p < .001$, $SE = .22$, $M_{diff} = 4.62$, and losses, $t(120) = 23.74$, $p < .001$, $SE = .22$, $M_{diff} = 5.21$. Importantly, LDWs also had significantly longer PRPs than losses, $t(120) = 12.75$, $p < .001$, $SE = .05$, $M_{diff} = 5.21$.

Participants' PRPs following LDWs from each group were compared using a univariate ANOVA with game played as the between subjects factor. Descriptively, participants' PRPs following LDWs were shorter in the high LDW group (M = 2.94, SD = .92) than in the few LDW (M = 3.20, SD = .82) and moderate LDW (M = 3.17, SD = 1.05) groups. These differences, however, did not reach statistical significance, F(2, 118) = .94, p = .40, *MSE* = .88 (η_P^2= .016*, Power* = .21).

Force

Peak force was calculated as the maximum force minus the minimum force in a half second window prior to when the reels started spinning (i.e., when participants pressed the spin button). To pre-process the force data, we performed outlier rejection procedures for each outcome (win, LDW, loss) using the sample-size dependent cuttofs proposed by Van Selst, and Jolicoeur (1994). Data from 9 participants could not be analyzed due to equipment malfunctions/noise in the data.

Three outliers (identified as having an outlier on the grand mean for wins, LDWs, and/or losses) were removed prior to analyses (2 NPG, 1LRG). Participants force following each outcome (win, LDWs, losses) was submitted to repeated measures ANOVA, with outcome type as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 39.69$, $p < .001$, Greenhouse-Geisser $\varepsilon = .78$. Greenhouse-Geisser corrections were applied. The main effect of outcome was significant, $F(1.56, 185.13) = 13.17$, $p < .001$, *MSE* = .001, η_P^2= .10. Bonferroni corrected paired samples t-tests showed that force following wins was significantly lower than following losses, $t(119) = 5.53$, $p < .001$, *SE* = .023, M_{diff} = .001. Force was also significantly lower following LDWs than losses, $t(119) = 4.88$, $p < .001$, *SE* = .0023, M_{diff} = .001. Importantly the force following wins and LDWs was indistinguishable, $t(119) = .026$, $p = .98$, *SE* = .0032, *M* = .000081.

Participants force following LDWs from each group were compared using an univariate ANOVA, with LDW game played as the between subjects factor. Descriptively, participants' force was higher in the moderate LDW group (M = .17, SD = .09) than in the few (M = .14, SD = .08) and many (M = .16, SD = .08) LDW games. These differences did not reach statistical significance, $F(2, 117) = 1.01$, $p = .37$, ($\eta_P^2 = .017$, *Power* = .22).

Subjective Arousal

Eight outliers were removed prior to analyses (3 NPGs, 2 LRGs, and 3 HRGs). Participants' arousal scores were first submitted to 3 (Group: NPG, LRG, HRG) by 3 (Game: few LDWs, moderate LDWs, many LDWs), by 3 (Time point: pre-game, post-game, post-persistence) mixed ANOVA, with time point as the repeated measures factor. There was a main effect of time-point, $F(2, 230) = 60.69$, $p < .001$, $MSE = .79$, $\eta_P^2 = .35$. There was also a main effect of PGSI group, $F(2, 115) = 4.25$, $p = .017$, $MSE = 4.35$, $\eta_P^2 = .069$. All other effects were not significant, all $Fs < 1.58$, $ps > .13$.

To explore the main effect of time-point, we determined which arousal time-points were different using Bonferonni corrected paired samples t-test ($p/3 = .017$). All contrasts were significant. Arousal was highest post-game. Post-game arousal was significantly higher than pre-game, $t(123) = 10.52$, $p < .001$, $SE = .12$, $M_{diff} = 1.25$, and post-persistence, $t(123) = 8.34$, $p < .001$, $SE = .12$, $M_{diff} = .90$. Arousal was also significantly higher post-persistence than prior to pre-game, $t(123) = 3.18$, $p = .002$, $SE = .11$, $M_{diff} = 3.6$. To explore the main effect of PGSI group, we ran Tukey HSD post-hoc comparisons. HRGs had significantly higher arousal overall than NPGs, M_{diff} = .83, SE = .31, p = .024. The other comparisons were not significant, both M_{diffs} < .54, ps > .20.

Emotional Valence

Six outliers were removed prior to analyses (3 NPG, 1 LRG, 2 HRG). Participants' valence scores were first submitted to 3 (Group: NPG, LRG, HRG) by 3 (Game: few LDWs, moderate LDWs, many LDWs), by 3 (Time point: pre-game, post-game, post-persistence) mixed ANOVA, with time-point as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 7.57$, p = .023, Greenhouse-Geisser ε = .94. There was a main effect of time-point, $F(1.88, 218.11) = 21.78$, p < .001, MSE = .91, η_P^2= .16. To explore the main effect of time-point, we conducted Bonferroni corrected paired-samples t-tests. All contrasts were significant. Mood was most positive post-game. Post-game mood was more positive than prior to the game, $t(125) = 3.96$, p < .001, SE = .10, M_{diff} = .41, and post-persistence, $t(124)$ = 6.40, p < .001, SE = .12, M_{diff} = .78. Mood was significantly more negative post-persistence than prior to the game, $t(124) = 2.83$, p < .006, SE = .13, M_{diff} = .37. The interaction between PGSI status and time-point was not significant, $F(3.76, 218.11) = 2.16$, p = .079, MSE = .91. All other effects were not significant, all Fs < 1.58, ps > .14.

Desire to Gamble

No outliers were removed prior to analyses. Participants' desire scores were first submitted to 3(Group: NPG, LRG, HRG) by 3 (Game: few LDW, moderate LDW, many LDW) by 3 (Time-point: pre-game, post-game, post-persistence) mixed ANOVA, with time-point as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2)$ =

20.84, $p < .001$, Greenhouse-Geisser $\varepsilon = .86$. There was a main effect of time point, $F(1.73, 210.67) = 26.74$, $p < .001$, $MSE = 234.24$, $\eta_P^2 = .18$. All other effects were not significant, all $Fs < 1.88$, $ps > .12$.

To explore the main effect of time-point, we ran paired-samples t-tests evaluated against a Bonferroni correction of p/3 = .017. All contrasts were significant. Desire was highest post-game. Desire post-game was higher than prior to the game, $t(130) = 5.73$, $p < .001$, $SE = 1.43$, $M_{diff} = 8.18$, and post-persistence, $t(131) = 8.05$, $p < .001$, $SE = 1.76$, $M_{diff} = 14.18$. Desire was also significantly lower post-persistence than prior to the game, $t(130) = 3.12$, $p = .002$, $SE = 1.98$, $M_{diff} = 6.18$.

Urge

The gambling urge scale was only administered at two time-points (pre-game, post persistence) in order to reduce the time in between the 100 spin playing session (post-game) and the persistence phase. Three outliers were removed (1 ARG, 2 HRGs). Participants' urge scores were submitted to a 3 (Group: NPG, LRG, HRG) by 3 (Condition: few LDWs, moderate LDWs, many LDWs), by 2 (time point: pre-game, post-persistence) mixed ANOVA, with time point as the repeated measures factor. The main effect of time point was significant. Urge was significantly lower following the persistence phase than prior to the game, $F(2, 123) = 35.10$, $p < .001$, $MSE = 25.84$, $\eta_P^2 = .23$. There was also a main effect of PGSI status, $F(2, 123) = 29.71$, $p < .001$, $MSE = 84.65$, $\eta_P^2 = .30$. To explore the main effect of PGSI status, we performed Tukey HSD post hoc comparisons. HRGs had significantly higher urge than NPGs, $M_{diff} = 12.27$, $SE = 1.60$, $p < .001$, and low-risk gamblers, $M_{diff} =$

9.45, *SE* = 1.59, $p < .01$. Low risk gamblers (marginally) did not report significantly higher urge than NPGs, M_{diff} = 2.82, SE = 1.25, $p = .067$. All other effects were not significant, $Fs <$ 1.86, $ps > .12$.

Table 3.2 Descriptive statistics for participants' physiological and behavioural responses to losses, LDWs, and wins

	Losses		**LDWs**		**Wins**	
	M	SD	M	SD	M	SD
PRPs	2.5	1.0	3.1	0.9	7.7	3.0
Force	.17	.09	.16	.08	.15	.09
SCRs	.30	.59	.32	.59	.35	.64

Table 3.3 Descriptive statistics for participants' subjective experiences prior to the 100-spin playing session (pre-game), after the 100-spin playing session (post-game), and after the persistence phase (post-persistence)

	Pre-Game		**Post-Game**		**Post-Persistence**	
	M	SD	M	SD	M	SD
Arousal	4.7	1.2	5.9	1.6	5.1	1.4
Emotional Valence	7.0	1.3	7.4	1.2	6.7	1.5
Desire to Gamble	49	27	57	28	43	27
Urge	17	9	n/a	n/a	13	7

Gambling Experience

Each of the seven subscales of the gaming experience questionnaire (competence, immersion, flow, tension, challenge, negative affect, and positive affect) were analyzed by submitting them to separate univariate ANOVAs with LDW game and PGSI status as the between subjects factors. For tension, there was a main effect of PGSI status, $F(2, 119) = 4.42$, $p = .014$, $MSE = .40$. Tukey post hoc comparisons showed that HRGs had significantly higher tension during the game than NPGs, $M_{diff} = .48$, $SE_{diff} = .16$, $p = .01$. The other pairwise differences were not significant, $M_{diffs} < .30$, $ps > .16$. For positive affect, there was also a main effect of PGSI status, $F(2, 120) = 3.74$, $p = .027$, $MSE = 1.01$. Tukey post hoc comparisons showed that HRGs had significantly higher positive affect during the game than LRGs, $M_{diff} = .69$, $SE = .25$, $p = .019$. The other pair-wise comparisons were not significant, $M_{diffs} < .52$, $ps > .099$. All other main effects and interactions amongst the seven ANOVAs were not significant, all $Fs < 1.01$, $ps > .34$.

Persistence

Persistence was calculated as the number of spins following the win on spin 2 during the persistence phase (i.e., after the initial 100 spins). Six outliers were removed prior to analyses (1 NPG, 2 LRG, and 3 HRG). Eight participants (6.1%) chose not to continue playing after 100 spins (i.e., did not persist). Participants' persistence scores were first submitted to a 3 (Group: NPG, LRG, HRG) by 3 (Game: few LDWs, moderate LDWs, many LDWs) univariate (between subjects) ANOVA. There was a significant main effect of game played, $F(2, 117) = 3.15$, $p = .047$, $MSE = 71.37$. The main effect of PGSI status was not significant, *MSE* = 71.37, *F*(2, 177) = 1.40, *p* = .25, but the interaction between game played and PGSI status was significant, *F*(4, 117) = 2.65, *p* = .037, *MSE* = 71.37.

To explore the main effect of game played, we performed Tukey HSD post hoc comparisons. Persistence was nominally highest in the medium LDW game (*M* = 12.53, *SD* = 9.99). It was, however, not significantly higher than the low LDW condition (*M* = 11.79, *SD* = 9.08), M_{diff} = .74, *SE* = 1.85, *p* = .92, but was significantly higher than in the high LDW condition (*M* = 8.05, *SD* = 6.79), M_{diff} = 4.49, *SE* = 1.81, *p* = .039. All other pair-wise comparisons were not significant, all M_{diff} < 3.75, *ps* > .12.

There appears to be an inverted "U" function involving the frequency of LDWs for participants with a higher PGSI status. Concretely, for those high in PGSI status, games with moderate numbers of LDWs seem to trigger more persistence than games with few LDWs or games with high numbers of LDWs. To explore this interaction, we first conducted separate univariate ANOVAs for each PGSI group in order to conduct polynomial contrasts. The main effect of game for HRGs approached significance, *F*(2, 18) = 3.17, *p* = .066, *MSE* = 91.17, and importantly the quadratic relationship was significant, *SE* = 3.44, *p* = .028 whereas the linear contrast was not (*p* = .43). The main effect for NPGs was also significant, *F*(2, 49) = 3.97, *p* = .025. There appeared, however, to be a different relationship for NPGs, whereby the fewer the LDWs experienced, the higher the persistence. In this case, the linear contrast was significant, *SE* = 1.93, *p* = .007 whereas the quadratic contrast was not *p* = .71). The main effect for low-risk gamblers (LRGs) was not significant, *F*(2, 50) = 1.09, *p* = .34, *MSE* = 74.26, nor were the linear (p = .31) nor quadratic (p = .32) contrasts.

To further explore the different patterns of persistence among players with different levels of gambling problems we conducted separate one-way ANOVAs for each game to see if any game in elicited a main effect of gambling status. This main effect of gambling status was significant only for the medium LDW condition $F(2,42) = 4.15$, $p = .023$, $MSE = 87.30$. Both other games led to non-significant main effects of gambling status *Fs* were < 2.02 and *ps* were >.15. Tukey's HSD contrasts revealed that HRGs persisted for significantly longer than NPGs in the medium condition, $M_{diff} = 10.88$, $SE = 3.78$, $p = .017$. The others contrasts were not significantly different, both M_{diffs} were < 7.01 and *ps* were > .18.

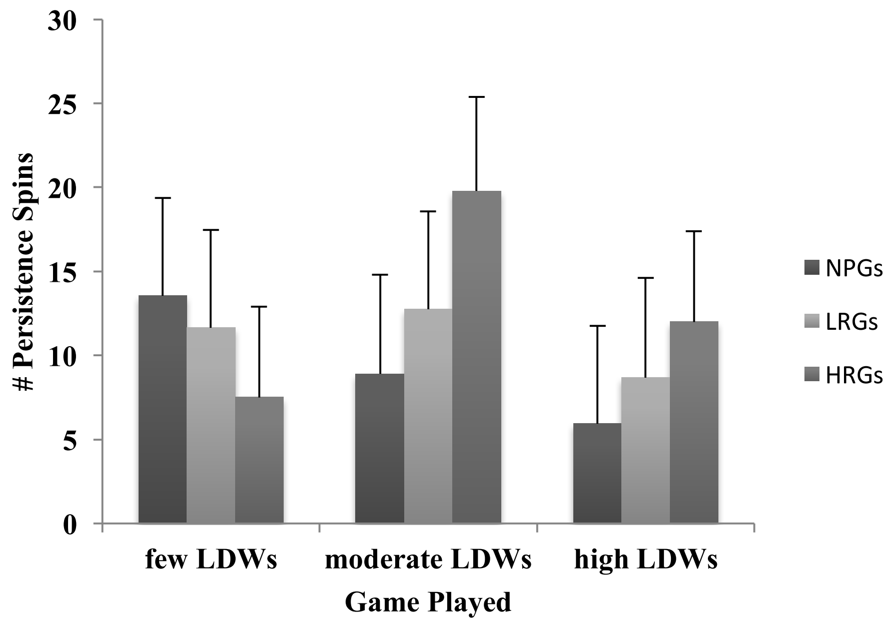

Figure 3.5 Number of persistence spins played by each problem gambling severity (PGSI) group in each losses disguised as wins (LDW) game. Error bars represent Masson and Loftus (2003) 95% confidence intervals.

3.2.4 Discussion

In this experiment we sought to provide converging evidence that participants physiologically, behaviourally, and verbally miscategorized LDWs as wins rather than correctly categorizing these outcomes as losses. Although certain lines of evidence more strongly support this conclusion than others, when taken together we would argue that there is support for this conclusion. Participants' autonomic arousal (measured by SCRs) following actual wins and LDWs were statistically indistinguishable. While participants' SCRs following LDWs were descriptively higher following LDWs than losses this effect was only marginally significant. Previous research has shown a difference between losses and LDWs, and thus, potentially a difference would have been observed here had a larger sample size been used. For our PRP analysis we showed the classic titration for post-reinforcement pauses - the longest PRPs were observed after wins, followed by LDWs, then losses with all three means being significantly different from one another. Here we place emphasis on the significant difference between losses and LDWs – both outcomes represent costs to the player. Insofar as PRPs are seen as a measure of *reward*, these results suggest that players may have miscategorized LDWs as small wins rather than regular losses – a finding consistent with the results of Dixon et al. (2014). One could argue that the strongest behavioural evidence that players miscategorize LDWs as wins comes from the force data. Here we show that losses are treated differently from both wins and LDWs and further that there is no statistical difference between wins and LDWs. Contrary to our expectations, participants showed the opposite pattern with force than has previously been shown in the literature. Normally, the titration pattern for force follows that observed for SCRs and PRPs -

the force following regular losses is less than the force following LDWs, which is equivalent to small wins. In this experiment, players' applied the largest force after regular losses, and smaller (statistically equivalent) forces for LDWs, and regular wins. Given the deviance from the expected pattern we are cautious in interpreting this result. Nonetheless at least for this sample, across these 100 spins, players treated LDWs differently from losses, and equivalently to wins. The final and arguably the strongest piece of evidence that players miscategorized LDWs as wins in this experiment, was that a strong majority (70%) of participants on a spin-by-spin basis (at their own pace) verbally miscategorized LDWs as monetary gains rather than correctly categorizing LDWs as monetary losses. In sum, these results are disconcerting because they suggest that the majority of players believe they are winning money on net losses. This finding is especially troubling given that in multiline games, LDWs occur at a higher frequency than actual wins.

Given that research has shown lower LDW-triggered win overestimations (i.e., more accurate estimates) when there are many LDWs in a slots game (Templeton et al., 2015), then one may infer that participants perhaps are correctly categorizing at least some of the LDWs as losses in the many LDW game. Descriptively, fewer participants' in this study miscategorized LDWs as wins in the many LDW game compared to the fewer LDW and moderate LDW games. These differences, however, did not reach statistical significance.

Contrary to our hypotheses, we failed to find any significant between-LDW group differences between players' subjective experiences (arousal, mood, desire to gamble, urge, or in game gambling experiences). As expected overall, participants' gambling urge was higher prior to the game than after deciding to quit during the losing streak. Furthermore, we found that overall the short 100-spin playing session on the slot machine was sufficient to increase players' arousal, mood (positive affect), and desire to gamble. Subjective arousal was still higher post-persistence than prior to the playing session, but mood and desire to gamble were significantly lower after quitting during the losing streak than prior to the session. We also found some individual differences with regards to problem gambling status. High-risk gamblers showed higher gambling urge overall and greater tension during the game than non-problem gamblers (but not low risk gamblers). High-risk gamblers also showed higher positive affect during the game than did low-risk gamblers.

There were three primary goals of this study. First, we wanted to replicate the findings that players do miscategorize LDWs as wins rather than correctly categorizing LDWs as losses. Second, we wanted to show that from a classical conditioning point of view LDWs are rewarding. This was evidenced by the longer PRPs to LDWs than regular losses and the equivalent autonomic arousal to LDWs and wins. Finally, the main purpose of this study, was to assess from an operant conditioning point of view, whether LDWs are in fact reinforcing. The best means to test whether LDWs are reinforcing is to see whether different numbers of LDWs (i.e., adjusting the reinforcement rate) during a game affects participants' persistence during a losing streak (i.e., a classic resistance to extinction paradigm). Given that the pathways model of problem gambling states that gambling problems can develop via classical and operant conditioning alone (Pathway I), we predicted that players with more problem gambling symptomology would show greater sensitivity to the reinforcement rates of the game than players with fewer problems. We found different persistence patterns for the LDW games depending on PGSI status. Non-problem gamblers showed a linear trend where they persisted for longest in the game with the fewest LDWs, followed by the medium, then high LDW game. We conjecture that this pattern may occur as a direct result of the win sizes in each game. To offset the large number of full losses in the game with the fewest LDWs, the sizes of the actual wins had to be largest in this game. Actual win sizes were lower in the medium game and lowest in the game with the most LDWs. It may be that early in one's gambling career, win size is more salient than win frequency. For the low-risk gamblers, we found no difference across the games - thus, diverging from the linear trend shown by NPGs. Importantly, for high-risk gamblers, there appeared to be a "sweet spot" for LDW reinforcement. They showed higher persistence following the moderate LDW game than the few and many LDW games. One reason for this optimum reinforcement rate may be a "framing" effect, where too many very small wins (LDWs in this case) may make larger wins seem less likely. This is an empirical question that should be evaluated in future research. In sum, it appears as if the reinforcing nature of slots games may involve tradeoffs between the auxiliary nature of the rewards (i.e., win magnitude) and the schedule of reinforcement. Perhaps, early in one's career, classical conditioning of higher arousal to larger wins is what is considered primarily reinforcing. Then, with experience, once secondary reinforcement patterns are acquired (e.g., where winning lights and sounds can lead to automatic elevations in physiological arousal), then this form of overgeneralization may make reinforcement patterns more important for players.

One limitation of this experiment is we used a stringent resistance to extinction paradigm; wherein, there were only full losses in the losing streak. This type of streak is unlikely (on average) to occur on actual multiline games. What's more probable is that players would experience losing streaks with LDWs (the second most common outcome) interspersed within the streaks. To address this issue, in the subsequent experiment, all players played a moderate LDW game (the "sweet spot" for HRGs), followed by a losing streak with few or moderate LDWs interspersed in the streak. As with this experiment (and Experiment 3.1), participants chose to play for as long as they wished or could quit at any time. Here, we truly tested whether LDWs could make players gamble for longer despite financial loss.

3.3 Experiment 3

3.3.1 Research Questions & Hypotheses

First, we wanted to once again replicate the results that players' physiologically, behaviourally, and verbally miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses. As with the previous experiment, we hypothesized that participants would show similar skin conductance responses to wins and LDWs and larger post reinforcement pauses to LDWs than regular losses. We once again sought to measure the force with which players initiated new spins following the different types of outcomes (losses, LDWs and wins). Next, we wanted to replicate the observation that a short 100-spin playing session on a slot machine is sufficient to increase one's subjective arousal, mood (positive emotional valence), desire to gamble, and gambling urge. Given that there are few studies looking at gambling persistence in general, we also wanted to show that quitting a playing session does in fact correspond with a decrease in these subjective experiences. We also evaluated whether in-game experiences (measured by the games experience questionnaire) differed amongst those who played the game with few LDWs in the extinction period versus the game with moderate LDWs during the extinction period. Crucially, our main research question was whether LDWs could prolong gambling despite financial loss. We predict that because LDWs are treated like rewards from a classical conditioning point of view, then experiencing a moderate number of LDWs *during* a losing streak may make players gamble for longer than if they experienced fewer LDWs.

3.3.2 Method

Participants

Recruitment/Selection

Sixty-nine participants were recruited from the general Kitchener-Waterloo community (Canada) using online classifieds on Kijiji. Participants were 19 years of age or older; not in treatment for problem gambling; and played slots at least once in the past year. They were given $10 for participating in the one-hour in lab study, and $20 to play a slot machine in the lab's casino. They were informed they could keep their ending balance on the machine at the end of the session up to a maximum of $40. In actuality, the most they could receive is $23. One participant was excluded from any analyses due to technical/equipment malfunctions and subsequent incomplete data. All methods and procedures were approved by the University of Waterloo's Office of Research Ethics.

Canadian Problem Gambling Index

We used the same methods for administering the CPGI as described in Section 3.2.1. Using the interpretive cut-offs proposed by Currie, Hodgins, and Casey (2013), 28 participants were deemed non-problem gamblers (NPGs), 31 low-risk gamblers (LRGs), 4 moderate risk gamblers (MRGs), and 5 problem gamblers (PGs). Ages ranged between 20 and 70 (M = 34.28, SD = 14.78) and included 29 (43%) females.

Slot Machine Simulator/Cabinet

We used the same simulated slot machine described in Experiments 1 and 2 (Figures 3.1 and 3.2)

Slots Game Designs

The game design was similar to that employed in Experiments 1 and 2. Participants started with 2000 credits on the machine. They wagered one credit on 20 lines for a total spin wager of 20 credits. During the first part of the playing session, all participants played a *moderate* LDW game (the center of the inverted U for higher risk gamblers in Experiment 2). They experienced 14 wins, 19 LDWs, and 67 losses. Outcomes in the first 100 spins were randomly interspersed so that there were similar numbers of wins and LDWs in each 25-spin block. The end balance after 100 spins on both versions was 2300 credits ($23 CAD), amounting to a payback percentage of 115%. Crucially, during the *persistence* phase, we interleaved LDWs into the losing streak. There were two between-subjects conditions: a losing streak with few (N = 2) LDWs and a losing streak with a moderate number (n = 19) of LDWs. In both conditions, participants experienced a loss on spin one, and a small win (32 credits) on spin two. The remaining LDWs and losses for each condition were randomly disbursed over the next 100 losing spins, with the constraint that in the condition with 19 LDWs there would be similar numbers of LDWs in each 25 block of 25 spins in the persistence phase. Characteristics of these conditions are shown in Figure 3.6.

Event Marking

We used the same procedure described in section. 3.2.2.

Force Transduction

We used the same procedure described in section. 3.2.2.

Skin Conductance Responses (SCRs)

We used the same procedure described in section. 3.2.2.

Materials

Slot Machine Tutorial

We used all of the same materials described in section. 3.2.2

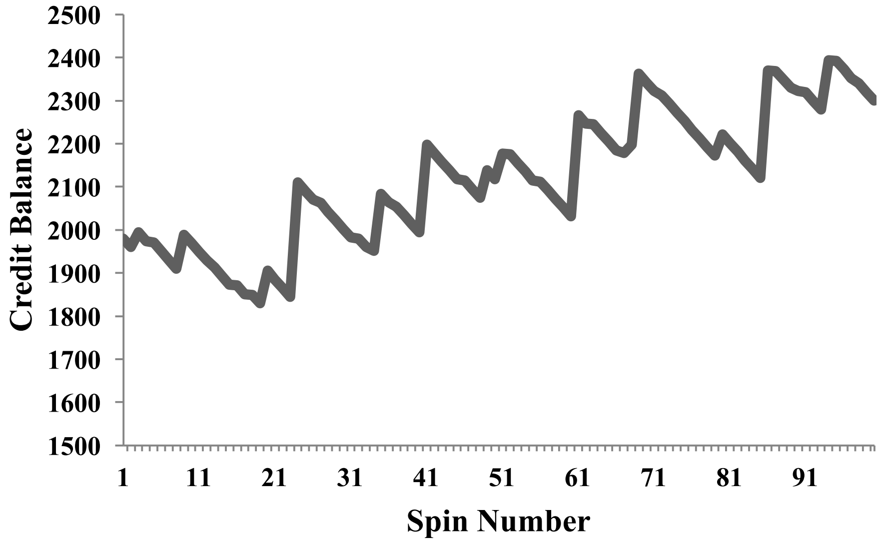

Figure 3.6 Credit balance over time for the 100-spin moderate LDW game

Scales

We used all of the same scales described in section. 3.2.2.

Measures

We used the same measures described in section. 3.2.2.

Procedure

We used the same procedure described in section. 3.2.2.

3.3.3 Results

General Analytical Notes

Given the sample size and relatively limited range of players with any gambling problems for this experiment, we did not include PGSI group as a factor in our analyses of variances. For the analyses of variance we used the same outlier rejection, sphericity and heterogeneity of variance corrections, and post hoc procedures as previously noted (see sections 3.1.2 and 3.2.2).

Skin Conductance Responses (SCRs)

SCRs were calculated as the maximum skin conductance level during a two second window half a second following outcome delivery (when the reels stopped spinning). To pre-process the SCR data, we first performed square root transformations as recommended by Dawson, Schell and Filion (2000). Next, we performed outlier rejection procedures for each outcome (win, LDW, loss) using the sample-size dependent criteria proposed by Van Selst, and Jolicoeur (1994). Data from 6 participants could not be analyzed due to equipment malfunctions.

Three outliers (identified as having an outlier on the grand mean for wins, LDWs, and/or losses) were removed prior to analyses (2 NPGs, 1 LRG). Participants' SCRs following wins, LDWs, and losses were submitted to a repeated measure ANOVA, with outcome type as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 12.23$, $p = .002$, Greenhouse-Geisser $\varepsilon = .84$. Greenhouse-Geisser corrections were applied to the ANOVA. The main effect of outcome type was not significant, $F(1.68, 97.23) = .40$, $p = .64$, $MSE = .011$, $\eta_P^2 = .007$.

Post Reinforcement Pauses (PRPs)

PRPs were calculated as the time between outcome delivery (when the reels on the game stopped spinning) and the initiation of the following spin (when the participant pressed the spin button). To pre-process the PRP data, we performed outlier rejection procedures for each outcome (win, LDW, loss) using the sample-size dependent criteria proposed by Van Selst, and Jolicoeur (1994).

Data from 6 participants could not be analyzed due to equipment malfunctions. Three outliers (identified as having an outlier on the grand mean for wins, LDW, and/or losses) were removed prior to analyses (1 NPG, 2 LRGs). Participants' PRPs following wins, LDWs, and losses were submitted to a repeated measures ANOVA, with outcome type as the repeated factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 144.07$, $p < .001$, Greenhouse-Geisser $\varepsilon = .52$. Greenhouse-Geisser corrections were applied. The main effect of outcome was significant, $F(1.03, 54.71) = 87.12$, $p < .001$, $MSE = 12.78$, $\eta_P^2 = .62$. Bonferonni corrected ($p/3 = .017$) paired-samples t-tests showed that wins had significantly longer PRPs than LDWs, $t(53) = 7.75$, $p < .001$, $SE = .62$, $M_{diff} = 4.78$, and losses, $t(53) = 10.64$, $p < .001$, $SE = .59$, $M_{diff} = 6.23$. Importantly, LDWs also had significantly longer PRPs than losses, $t(58) = 16.78$, $p < .001$, $SE = .09$, $M_{diff} = 1.47$.

Force

Peak force was calculated as the maximum force minus the minimum force in a half second window prior to when the reels started spinning (i.e., the window during which participants pressed the spin button). To pre-process the force data, we performed outlier rejection procedures for each outcome (win, LDW, loss) using the sample-size dependent criteria proposed by Van Selst, and Jolicoeur (1994). Data from 6 participants could not be analyzed due to equipment malfunctions.

Three outliers (identified as having an outlier on the grand mean for wins, LDWs, and/or losses) were removed prior to analyses (3LRGs). Participants force following each outcome (win, LDWs, losses) was submitted to repeated measures ANOVA, with outcome type as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 23.93$, $p < .001$, Greenhouse-Geisser $\varepsilon = .75$. Greenhouse-Geisser corrections were applied. The main effect of outcome was not significant, $F(1.49, 86.38) = 1.93$, $p = .16$, $MSE = .000$, $\eta_P^2 = .032$.

LDW categorization

As with Experiment 3.2, participants were deemed LDW miscategorizers if they miscategorized LDWs as wins on both spins during the outcome categorization trials following the playing session. As a conservative measures, participants were deemed LDW correct categorizers if they labeled one or both LDWs as losses. Seventy-one percent of participants miscategorized LDWs as wins rather than correctly categorizing them as losses. A one sample z test revealed that significantly more than fifty percent of participants miscategorized LDWs as wins, $z = 3.26$, $p < .001$. There was no difference in the number of mis or correct categorizers in the different LDW conditions (few LDWs in losing streak, moderate LDWs in losing streak), $\chi^2(1) = 1.64$, $p = .20$.

Arousal

Three outliers were removed prior to analyses (1 NPGs, 2 LRGs). Participants' arousal scores were first submitted to a 2 (Game: few LDWs, moderate LDWs), by 3 (Time point: pre-game, post-game, post-persistence) mixed ANOVA, with time-point as the repeated measures factor. The main effect of time-point was significant, $F(2, 126) = 18.14$, $p < .001$, $MSE = .72$, $\eta^2_P = .22$. No other effects were significant, all $Fs < .052$, $ps > .88$. To explore the main effect of time-point, we determined which arousal time-points were different using Bonferonni corrected paired samples t-tests *(p/3* = .017). All contrasts were significant. Arousal was highest post-game, and was significantly higher than pre-game, $t(64) = 5.87$, $p < .001$, $SE = .15$, $M_{diff} = .89$, and post-persistence, $t(64) = 3.11$, $p = .003$, $SE = .14$,

M_{diff} = .43. Arousal was also significantly higher post-persistence than prior to playing the game, $t(64) = 3.07$, $p = .003$, $SE = .15$, $M_{diff} = .46$.

Emotional Valence

Three outliers were removed prior to analyses (2 NPGs, 1 LRG). Participants' valence scores were first submitted to a 2 (Game: few LDWs, moderate LDWs), by 3 (Time point: pre-game, post-game, post-persistence) mixed ANOVA, with time-point as the repeated measures factor. The main effect of time-point was significant, $F(2, 126) = 16.42$, $p < .001$, $MSE = .65$, $\eta_P^2 = .21$. No other effects were significant, all *Fs* < .34, *ps* > .66. We determined which valence time-points were different using Bonferonni corrected *(p/3* = .017) paired samples t-tests. Valence was most positive post-game, and was significantly more positive than pre-game, $t(64) = 4.51$, $p < .001$, $SE = .13$, $M_{diff} = .59$, and post-persistence, $t(64) = 5.43$, $p < .001$, $SE = .15$, $M_{diff} = .79$. Valence was not significantly more positive post-persistence than prior to playing the game, $t(64) = 1.36$, $p = .18$, $SE = .15$, $M_{diff} = .20$.

Desire to Gamble

Desire to gamble was calculated by measuring the participants' hash marks on the 100mm “desire to gamble” line. One outlier (NPG) was removed prior to analyses. Participants' desire to gamble scores were first submitted to a 2 (Game: few LDWs, moderate LDWs), by 3 (Time point: pre-game, post-game, post-persistence) mixed ANOVA, with time-point as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 6.27$, $p = .043$, Green House Geisser $\varepsilon = .91$. The main effect of time-point was significant, $F(1.83, 116.92) = 24.75$, $p < .001$, $MSE = 184.18$, $\eta_P^2 = .28$. No other effects were significant, all *Fs* < .46, *ps* > .50. To compare desire at each time-point (pre-game, post-game, post-persistence), we conducted Bonferonni corrected *(p/3* = .017) paired-samples t-test. All contrasts were significant. Desire was highest post-game. Desire post-game was higher than prior to the game, $t(65) = 3.49$, $p = .001$, $SE = 2.00$, $M_{diff} = 6.99$, and post-persistence, $t(65) = 7.44$, $p < .001$, $SE = 2.13$, $M_{diff} = 15.85$. Desire was also significantly lower post-persistence than prior to the game, $t(65) = 3.46$, $p = .001$, $SE = 2.57$, $M_{diff} = 8.87$.

Gambling Urge

The gambling urge scale was only administered at two time-points (pre-game, post persistence) in order to reduce the time in between the 100 spin playing session (post-game) and the persistence phase. One outlier was removed (1 LRG). Participants' urge scores were first submitted to a 2 (Game: few LDWs, moderate LDWs), by 2 (Time point: pre-game, post-persistence) mixed ANOVA, with time-point as the repeated measures factor. The main effect of time-point was significant (Gambling urge pre-game ($M = 46.48$, $SD = 23.75$) was higher than post persistence ($M = 37.52$, $SD = 23.30$), $F(1, 65) = 16.19$, $p < .001$, $MSE = 23.61$, $\eta_p^2 = .20$. No other effects were significant, all *Fs* < .89, *ps* > .35.

Game Experience

The two LDW groups' (few LDWs during losing streak, moderate LDWs during losing streak) scores on each of the seven subscales on the GEQ were compared using separate independent-samples t-tests. Only one t-test was significant - that for negative affect. Participants who experienced few LDWs during the losing streak reported significantly more

Table 3.4 Descriptive statistics for participants physiological and behavioural responses to losses, LDWs, and wins

	Losses		LDWs		Wins	
	M	SD	M	SD	M	SD
PRPs	1.4	0.6	2.8	1.1	7.6	4.1
Force	.15	.07	.14	.06	.14	.06
SCRs	.23	.10	.24	.12	.24	.17

Table 3.5 Descriptive statistics for participants' subjective experiences prior to the 100-spin playing session (pre-game), following the 100-spin playing session (post-games), and following the persistence phase (post-persistence).

	Pre-Games		Post-Game		Post-Persistence	
	M	SD	M	SD	M	SD
Arousal	4.4	1.3	5.3	1.4	4.9	1.4
Emotional Valence	6.8	1.1	7.4	1.1	6.6	1.4
Desire to Gamble	46	23	53	26	37	23
Urge	15.6	7.6	n/a	n/a	12.2	6.3

negative mood during play than participants who experienced a moderate number of LDWs, $t(66) = 2.80$, $p = .007$, $M_{diff} = .91$, $SE_{diff} = .33$.

Persistence

Two outliers (2 MRGs) were removed prior to analyses. Mean persistence spins from each group (few LDWs during losing streak, moderate LDWs during losing streak) were compared using an independent-samples t-test. Equality of variances was violated, $F = 13.15$, $p = .001$. Participants persisted for significantly longer when moderate ($M = 25.63$, $SD = 22.39$) rather than few ($M = 16.18$, $SD = 14.10$) numbers of LDWs were interspersed during the losing streak, $t(46.79) = 2.49$, $p = .017$, $M_{diff} = 14.07$, $SE_{diff} = 5.66$, $\eta_P^2 = .56$.

3.3.4 Discussion

Contrary to our expectations, (and to our findings in the previous experiment) we failed to find a significant difference in players' SCRs to wins, LDWs, and losses. We believe the most likely reason for this null result is the lower sample size in this study. In terms of our behavioural in-game measure, players' PRPs suggest that they found LDWs more rewarding than regular losses - players showed the highest PRPs following wins, followed by LDWs, which were significantly longer than following regular losses. We failed to find any significant differences in the mechanical force applied to spins following losses, LDWs, or wins.

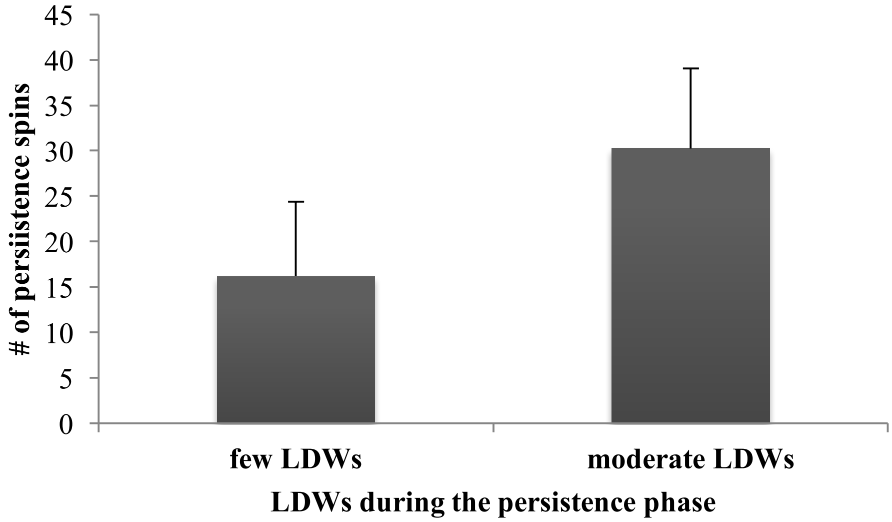

Figure 3.7 Participants' numbers of persistence spins with few LDWs during the losing streak or a moderate number of LDWs during the losing streak. Error bars represent Masson and Loftus (2003) 95% confidence intervals.

Regarding verbal categorization, a large majority of participants (71%) verbally categorized LDWs as monetary gains rather than monetary losses. Thus, players PRP results and verbal categorization results converge to show that players in this study behaviourally and verbally miscategorize LDWs as wins.

Players' subjective experiences (arousal, mood, desire to gamble, and gambling urge) did not differ between the two LDW groups. One would not expect players' subjective experiences to differ prior to the game (i.e., at baseline), or after the game, because all participants played the same initial 100-spins. One may have expected, though, that players' would have reported higher arousal, mood, desire to gamble, and urge after playing a losing streak with a moderate number of LDWs than a losing streak with few LDWs, but we failed to find such differences. It is possible, that overall, LDWs do not affect such subjective experiences. It is also possible that LDWs do affect players' overall arousal, mood, desire to gamble, and gambling urge, but that players' are not cognitively privy to such changes in their experiences (i.e., changes may occur, but not at a conscious level). One measure, however, did capture differences in players' in game experiences - the negative affect subscale of the games experience questionnaire. Interestingly, participants who experienced a moderate number of LDWs during the losing streak experienced less negative affect (i.e., better mood) than participants who experienced few LDWs. These results hint at the possibility that LDWs may in fact modulate affective states - a result we will further discuss in the General Discussion in Chapter 5.

Finally it is likely that measures of many of the subjective experiences like arousal, positive affect, and desire to gamble were confounded with how long players persisted. That is, it may well have been the case that *during* the extinction phase arousal and positive affect and desire to gamble may all have been higher in the game with more LDWs than the game with few LDWs. Higher arousal, positive affect, and certainly urge to continue play may have contributed to longer play. These effects would dissipate over time, however, and by the end of the losing streak (when such experiences were measured) may have subsided to levels comparable to those for the game with only 2 LDWs.

As with the previous experiment (and in line with Experiment 3.1), we showed that a short 100-spin playing session was sufficient to increase one's subjective arousal, improve one's mood, and increase one's desire to continue gambling. Arousal was maintained slightly higher than prior to the gambling session, but mood and desire to gamble slightly lowered (as one would expect) after players' decided to quit playing during the losing streak. Gambling urge was also significantly lower after players quit during the losing streak than prior to the game. These results, taken with the results from Experiments 3.1 and 3.2, show that even a short-run on a multiline slot machine can lead to arousal, affective, and urge changes - a potential contributor to the addictive qualities of these games.

The central hypothesis in this study was whether LDWs during a losing streak could lead players to gamble for longer despite financial loss. This is precisely what was found. Players' persisted for longer if they played a game with a moderate number of LDWs in the losing streak to a game with few LDWs during the losing streak. We argue that this finding is even more important than the persistence results observed in Experiment 3.2, because long losing streaks consisting of only regular losses on multiline games would be exceedingly rare. By contrast, given that LDWs in multiline games are quite frequent (more frequent than wins) long losing streaks containing LDW are far more likely to be experienced than long losing streaks containing only regular losses. Crucially these results offer evidence that LDWs are in fact behaviourally reinforcing. Where this becomes disconcerting is that two hallmarks of a gambling problem with slots are continuing to gamble despite financial loss and chasing losses. These results show that LDWs during losing streaks may contribute to prolonged play. Players, may believe they are winning when in actuality they are losing (consistent with the LDW-triggered win overestimation effect we have observed) and players may be reluctant to quit while they feel they are still winning. One limitation of this study is that there were few problem gamblers. Future research would benefit from extending these results to samples with a greater range of PGSI scores.

Even if LDWs are reinforcing, the question remains whether players actively *choose* to play games with LDWs? Previous research has shown that players do prefer games with more lines, and while it is true that games with more lines contain more LDWs there are alternative reasons why players may choose to play more lines. For example players cite the frustration of seeing a winning combination on an unplayed line as reason for playing all possible lines. Players may also play more lines because it increases the chances of activating exciting bonus games. In the following study, we directly asked whether LDWs affect players' game choices and preferences by having all players play 20-line games. By playing 20 lines (the maximum for this game) players cannot “miss-out” on unplayed lines and by not including bonus rounds we remove this potential confound. Our key manipulation is that some of the games will contain LDWs and some will not have LDWs.

This study directly allows us to measure the effect of LDWs on game preference and game selection, in the absence of any potential confounds.

Chapter 4

GAME PREFERENCES

4.1 Experiment

4.1.1 Research Questions & Hypotheses

Previous research has shown that gamblers can differentiate between tight slot machines (those with games that payout less or have a smaller payback percentage) and loose slot machines (those with games that payout more or have a higher payback percentage) (Dixon, Fugelsang, MacLaren, and Harrigan, 2013). To gamble optimally, players should choose and prefer games where they lose less money. If such games existed, they should certainly choose games where they are winning money over games where they are losing money. On most slot machine games, there is a certain level of volatility. There are times when a player is "up", and other times when a player is "down". While all slot machines are programmed such that a player loses in the long run, one may predict (given that there are a lot of erroneous cognitions surrounding slots games), that players may choose to continue playing a game if they are winning or "up" rather than a game where they are losing or "down". In this experiment, participants were able to play four different games. The four games appeared in the four quadrants of a single display. Players could play whichever game they wanted to on a spin-by-spin basis for 100-spins. Two games had negative expected values (85% payback percentage games) and two had positive expected values (115% payback percentage games). After 100 spins, players were given the choice to play whichever (of the four) games they wanted for 10 additional spins and then could play for as long as they wished or quit at any time. (Unbeknownst to players, all subsequent spins were losses). Participants also rated how much they preferred playing each of the four games. We predicted that participants would choose to continue playing the games with positive payback percentages where they were "up" over games with negative payback percentages where they were "down". We also predicted that participants would subjectively prefer the positive payback percentage games to the negative payback percentage games and that they might persist for longer on those games.

Central to this thesis, though, is how players interpret LDWs and how they affect players' behaviours and experiences. If LDWs are not rewarding, then one may expect participants' to choose and prefer playing any game that had the better payback percentage. Of the four games on the display, as discussed, two had 85% payback percentages over 100 spins and two had 115% payback percentages over 100 spins. For the 85% payback percentage games, one had no LDWs and one had a moderate number of LDWs. For the 115% payback percentage games, one also had no LDWs and one had a moderate number of LDWs. If LDWs are not rewarding, then one would expect players to choose and prefer playing either of the two 115% payback percentage games (i.e., of those who opt for the 115% games roughly half the players should choose one game the other half of the players the other game). If players find LDWs rewarding, however, then they should choose and prefer games with LDWs to games with no LDWs. Thus, concretely, among those who opt for the 115% games far more should choose the game with the LDWs than the game without the LDWs.

Although our central predictions involved LDWs effects on player’s game choices and preferences, as a more exploratory hypothesis we also proposed that they might persist for longer if they chose to play a game with LDWs than if they chose to play a game without LDWs. We were cognizant that several factors would work against being able to show this persistence effect. The most prominent of these was our decision to allow players the freedom to sample the games as they wished. This would lead to large amounts of variability in the reinforcement schedules experienced by the players. Also the very act of switching between games may prime players to "change state" a mind set that may work against showing persistence effects. As such, our primary goal was to show that LDWs would work in conjunction with high payback percentages and lure players into preferentially choosing (and preferring) the 115% payback percentage with a moderate number of LDWs. Although we predicted that most players would be sensitive to payback percentage, for the minority of players who failed to choose a high payback percentage game, if LDWs are seen as rewarding, then these players would choose to play a LDW game over a no LDW game even if they are "down" or losing money (i.e., among those who opted for an 85% game more would choose the one with a moderate number of LDWs, over the 85% game with no LDWs). In sum, we predict that if both payback percentage and LDW frequency affect players' game choices, preferences, and behaviours, then the majority of participants should choose to play the 115% payback percentage game with a moderate number of LDWs, and would report preferring this game. They might also persist for longer if they chose to play this game.

4.1.2 Method

Participants

Recruitment/Selection

Thirty-six undergraduate students were recruited from the Department of Psychology's Research Experience Group. Data from 3 participants was discarded prior to analyses due to equipment malfunctions and/or missing data, leaving a final sample of 33 participants. At the beginning of the term, students completed a general battery of on-line pre-screen questions, which determined eligibility to view ads and sign-up for studies. To participate in this study, students had to: (1) be 19 years of age or older (2) not be in treatment for problem gambling; and (3) have played a slot machine at least once in the past 12 months. Participants were tested in a single session with one researcher present. Participants were given the option to receive 10 dollars, 5 dollars plus half a course credit, or one course credit for their time. They were also given 20 dollars to play the slot machine and were informed that they could keep the cash remaining on the machine (end balance) up to a maximum of 40 dollars once the playing session was over. In actuality, the most they could receive is $24. All study procedures/methods were reviewed and approved by the university's Office of Research Ethics.

Canadian Problem Gambling Index

Near the beginning of the session, we administered the Canadian Problem Gambling Index using the Quatrics online survey platform. The CPGI was used to measure participants' slots play over the past year, problem gambling severity levels (via the PGSI), age, and gender. PGSI and demographic data was missing for one participant. Using the interpretive cut-offs proposed by Currie, Hodgins, and Casey (2013), 16 participants were deemed non-problem gamblers (PGSI =0) and 16 low-risk gamblers (PGSI 1 to 4). Ages ranged between 19 and 29 (M = 21.16, SD = 1.82) and included 24 (72.7%) females.

Apparatus

Slot Machine Simulator

We used the same slot machine simulator game (Sands of Splendor; SoS) used in Chapter 3 (Sections 3.1.2, 3.2.2, 3.3.2). The games were displayed on a Dell (Inspiron ONE2330) touch screen computer. In the first part of the playing session, four SoS games were displayed on the screen in the upper left and right, and lower left and right quadrants of the screen at any given time (see Figure 4.1). In the second part of the playing session, one SoS game was displayed full-screen on the monitor. Participants interacted with the game by touching the spin buttons(s) on the screen using their dominant hand.

Slot Machine Cabinet

To maximize ecological validity, we built a custom slot machine cabinet (see Figure 4.1). This cabinet was designed to make only the touch-screen portion of the monitor visible to participants. We placed custom-made glass on top of the cabinet. The graphics of the glass were patterned after SoS's desert theme. A light was installed to illuminate the cabinet's glass, as one would see on a real slot's cabinet.

Slots Game Designs

Sounds in the game (type, length) were patterned after those described in Chapter 3 (Sections 3.1.2, 3.2.2, 3.3.2). In the first part of the playing session, we used a two by two design for the four games, with payback percentage (85%PB, 115%PB) and LDW frequency (no LDWs, moderate LDWs) as the factors. We will refer to these four games as 85%PB no LDWs, 85%PB with LDWs, 115%PB no LDWs, and 115%PB with LDWs from hereon in. Each game had 19 real wins. In the no LDW games, there were zero LDWs. In the two

Figure 4.1 Picture of the four game simulator and slot machine cabinet

moderate LDW games, there were 14 LDWs. All participants started with 2000 credits on each game ($20). The two 85%PB payback percentage games would have ended with 1700 ($17) credits had participants played 100 spins exclusively on these games. The two 115%PB payback percentage games would have ended with 2300 credits ($23) after 100 spins.

Figure 4.2 shows the credit balances (and win/LDW sizes) over time for the 4 different games. The median credit size and sound length for wins/LDWs in the 85%PB no LDW game were 74 credits and 6.2s, respectively. The median credit size and sound length for wins/LDWs in the 85%PB with LDW condition were 33 credits and 3.97s, respectively. The median credit size and sound length for wins/LDWs in the 115%PB no LDW condition were 84 credits and 8.34s, respectively. And the median credit size and sound length for wins/LDWs in the 115%PB with LDW condition were 52 credits and 5.05s, respectively. Since LDWs lead to net losses (players get back less than their 20 cents per spin wager) we had to include larger wins in the no LDW conditions to maintain the payback percentages at fixed rates of 85% and 115%.

It is possible for the four games to be displayed in one of 24 possible orders on the screen. We randomly sampled four of these possible orders, and randomly assigned

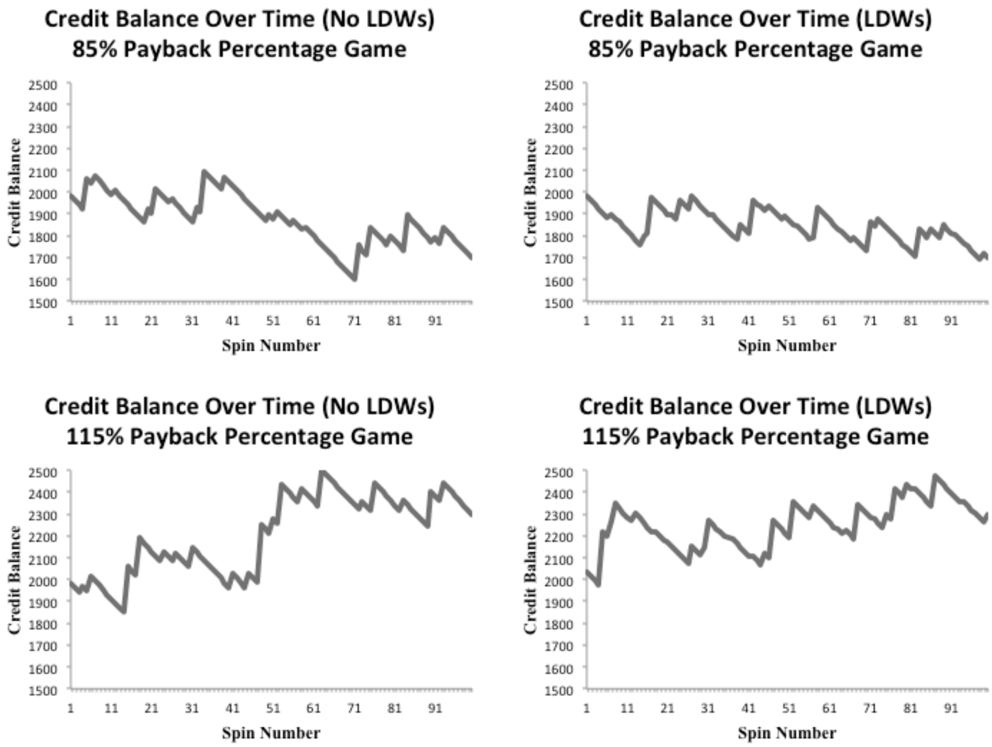

Figure 4.2 Credit balances for the four different games (85%PB no LDWs, 85%PB LDWs, 115%PB no LDWs, 115%PB LDWs) during the first part of the playing session.

participants to play one of these four orders. This was done to help control for preferences for games due to the location on the screen (if any). The orders were as follows (in order from upper left, upper right, lower left, and lower right of screen): (1) 85%PB no LDWs, 115%PB with LDWs, 115%PB no LDWs, 85%PB with LDWs, (2) 115%PB with LDWs, 85%PB no LDWs, 85%PB with LDWs, 115%PB no LDWs, (3) 85%PB with LDWs, 115%PB no LDWs, 85%PB no LDWs, 115%PB with LDWs, (4) 115%PB no LDWs, 85%PB with LDWs, 115%PB with LDWs, 85%PB no LDWs.

Prior to this playing session, participants played five practice spins on each game to familiarize them with the games. In the two no LDW games, there was one win in the five spins. In the two LDW games, there was one win and one LDW. After the 100 spin playing session, participants had to choose to play one of the four games (extinction phase where persistence was measured; see procedure). They had to play 10 spins, after which they could play for as long as they wished or quit at any time. These 10 spins were modeled after their respective games during the 100 spin playing session. There were two moderate sized wins (88 - 96 credits) in the 85%PB percentage games. There was one moderate win (96-99 credits), and one larger win (118 to 124 credits) in the 115%PB percentage games. The two LDW games also had one LDW (9 - 12 credits) in the 10 spins. These spins were included for two reasons: (1) to familiarize participants with playing one game on the screen, and (2) to make it appear as if they were playing the same game that they chose during the 100 spin session. All outcomes following these 10 spins, however, were losses.

Skin Conductance Responses (SCRs)

SCRs were recorded but not analyzed. The game requires participants to make a considerable number of movements to touch the four games on the display, which could generate a large number of movement artifacts in the SCR data.

Materials

Slot Machine Tutorial

We used the same tutorial described in Chapter 3 (Section. 3.2.2).

Scales

We used all of the same scales described in Chapter 3 (Section. 3.2.2). All scales were administered online using the Qualtrics survey platform.

Measures

We used the same measures described in Chapter 3 (Section. 3.2.2). Scales were administered online using the Qualtrics survey platform. We added the following *game preference* item: "How would you rate your preference for the highlighted game (below) on a scale from 0 (I did not enjoy this game at all) to 100 (I enjoyed this game the most). There was a picture of the four games below each question, with a yellow box highlighting the game of interest. The participant answered this question four times, with each question pertaining to the games in the following screen order: upper left, upper right, lower left, lower right. Participants responded to the question by sliding a bar on a 100mm visual analogue scale.

Procedure

Participants came to a waiting area in a room adjacent to the study room. A researcher gave the participants an informed consent form outlining the study and highlighted key points including eligibility (which was confirmed), remuneration, and risks. After reading and signing consent forms, participants washed their hands in a public washroom so that we could maximize the quality of the SCL recording (not analyzed in this study).

Once in the study room, participants sat at a desk with a desktop computer. They completed the same pre-game scales used in Chapter 3 that were collected for reasons peripheral to this experiment. Then participants watched the slots tutorial. After the tutorial, participants sat at the slot machine, and we attached the skin conductance electrodes to the index and ring fingers of their non-dominant hand. They were asked to rest their hand on the slot machine's cabinet below the screen to minimize movement artifacts during play.

We reminded participants of the key features of the games by pointing to the relevant information on the screen (see Chapter 3). They were first told that there were four games on the machine, and that they would be wagering 20 cents per spin on any game that they played. They were informed that they could only play one game per spin; that they would be playing 100 spins in total and would be asked some questions before and after the playing session. They were also informed that they did not need to count the spins; rather, a researcher would let them know when there were two spins remaining. They were instructed that they could not change their wager or the number of lines played during the game; that the game was preset to a balance of 2000 credits or $20 per game; and that they could keep the remaining balance on a game at the end of the playing session (if any) up to a maximum of $40.

Prior to playing, the researcher attached the SCL electrodes to the index and ring fingers of the participants' dominant hand. Participants completed the gambling urge scale, and the subjective arousal, emotional valence, and desire to gamble items on the computer adjacent to the slot machine. Participants played 5 practice spins on each game, starting with the upper left corner, followed by the upper right, lower left, and lower right corners. Participants were then informed that they would play 100 spins, and could play whatever game they would like on each spin. Participants played 98 spins on whichever game they wanted per spin, and then the researcher informed them when they had two spins left. At 100 spins, the researcher asked participants "which game would you like to keep playing". The researcher recorded their responses then administered the arousal, valence, and desire to gamble items on the computer adjacent to the slot machine. They then rated how much they enjoyed playing each of the four games.

While participants completed the aforementioned questions, the researcher loaded the participant's "preferred" simulator game on to the slot machine. The researcher set the starting balance on the participant's new game to the end balance of the game they chose to play in the previous 100-spin session. This value was rounded up to the nearest 100 credits (due to programming limitations). For example, if the participant chose to play the 85%PB no LDW game, and the end balance on this game was 1,623 credits, then the start balance of the new game was set to 1,700 credits.

Participants were instructed to play 10 spins on the new game. After these spins, the researcher handed participants a chit that stated, "at this point during the playing session, you can continue to play for as long as you want. You can choose to stop playing at any time." The researcher stated that where it says slot machine that means the game you chose to play. The chit also stated that once they were finished, to gently remove the SCL electrodes. While the participant played, the researcher recorded the number of persistence spins. Once the researcher heard them remove the SCL electrodes, participants were informed that the playing session was over. The researcher re-administered the GMS scale, and the arousal, valence, and desire items on the computer adjacent to the slot machine. Participants then completed the GEQ, and some additional questionnaires[16] for reasons peripheral to this study. Participants signed a receipt for any cash obtained from the end balance on the machine and given their course credit and/or cash for participating in the study. They were debriefed, and given two responsible gambling brochures; a wallet card and a pencil with the problem gambling helpline's number on it, and information for a local community crisis/mental health/addiction hotline.

4.1.3 Results

General Analytical Notes

Given the small sample size and relatively limited range of players with any gambling problems for this experiment, we did not include PGSI group as a factor in our analyses of variances. For the analyses of variance we used the same outlier rejection, sphericity and heterogeneity of variance corrections, and post hoc procedures as previously noted in Chapter 3 (see sections 3.1.2 and 3.2.2). We included the subjective arousal, emotional

[16] Rational-Experiential Inventory (REI; Pacini & Epstein,1999); Cognitive Reflections Test (CRT; Frederick, 2005); Actively Open-Minded Thinking (AOT; Stanovich & West, 1997); Adult ADHD self-report scale (ASRS; Kessler, Adler, Ames, et al., 2005); Attention Related Cognitive Errors Scale (ARCES; Carriere, Cheyne, & Smilek, 2008)

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valence, desire to gamble, and urge items as in Chapter 3. Our only a priori hypotheses regarding these items, was that we would replicate our previous findings that mood, desire, and urge are generally lower once participants stop persisting; whereas, arousal levels are generally maintained. As expected, overall, players' arousal, mood, and desire to gamble were indeed lower after the persistence phase than following the 100-spin playing session. Mood and gambling urge were also significantly lower following the persistence phase than prior to the 100-spin playing session. These results are included in Appendix A, and are not further discussed hereafter.

Game Choice

Figure 4.3 shows the proportions of participants who chose to play each of the four games. One participant chose to play the 85%PB no LDW game, five participants chose to play the 85%PB moderate LDW game, eight chose to play the 115%PB no LDW game, and 19 participants chose to play the 115%PB moderate LDW game. We first analyzed the frequency of participants' game choices using a chi-square goodness-of-fit test (with the expected value set to 25% for each game choice). This test was significant, $X^2(3) = 21.67$, $p <$ .001 indicating that equal numbers of participants did not choose each of the four games. If one looks at figure 4.3, it is clear that the majority of individuals chose to play the 115%PB with LDWs game.

Next, we ran pairwise comparisons using restricted chi-squared tests (with null hypothesis expected values of 50%, or chance). The key comparison was between the two most popular games (the 115% with LDWs and the 115% without LDWs). Significantly more participants chose to play the 115% LDW game over the 115% no LDW game $X^2(1) =$

.4.48, p = .034. By extension, the 115% LDW game was also chosen significantly more often than the remaining two games which were chosen by even fewer participants. Importantly, there was no significant difference between the proportions of participants who chose to play the 115% no LDW game and the 85% LDW game, $X^2(1) = .69$, $p = .41$. Significantly more participants chose to play the 115% no LDW game over the 85% no LDW game, $X^2(1) = 5.44$, $p = .02$. There was no significant difference in the proportions of participants who chose to play the 85% no LDW game and the 85% LDW game, $X^2(1) = 2.67$, $p = .10$.

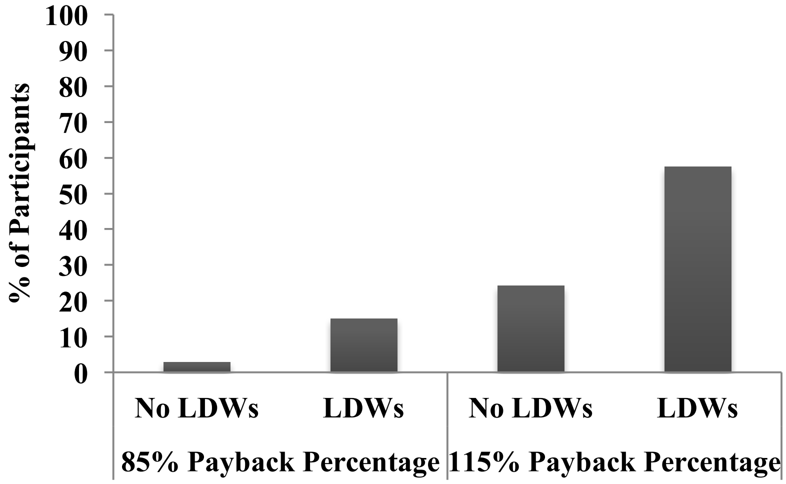

Figure 4.3 Proportions of participants who chose to play each of the four games (85%PB no LDWs, 85%PB moderate LDWs, 115% no LDWs, 115% moderate LDWs) following the 100 spin playing session.

Game Ratings

Figure 4.4 shows participants' mean preference ratings for each of the games. One outlier (1 ARG) was removed prior to analyses. Participants' enjoyment ratings for each game were analyzed with a two-way ANOVA with payback percentage (85%, 115%) and LDW frequency (Zero LDWs, moderate LDWs) as the repeated measures factors. There was a significant main effect of payback percentage, $F(1, 26) = 60.80$, $p < .001$, $MSE = 324.63$, $\eta^2_P = .70$. Overall, participants preferred playing the higher payback games ($M = 36.04$, $SE = 3.11$) to the lower payback percentages games ($M = 63.07$, $SE = 3.01$). There was not a significant main effect of LDW frequency, $F(1, 26) = 1.34$, p = .26, $MSE = 214.07$, $\eta^2_P = .049$, but there was a significant payback percentage by LDW frequency interaction, $F(1, 26) = 25.43$, $p < .001$, $MSE = 271.79$, $\eta^2_P = .49$.

To explore the interaction, we conducted paired-samples t-test evaluated against a Bonferroni correction of p/2 = .025. For each payback percentage condition (85%, 115%), we compared the mean enjoyment ratings for the zero and moderate LDW games. For the 85% games, there was not a significant difference in participants' enjoyment during the zero LDWs game ($M = 40.89$, $SD = 20.14$) and the moderate LDWs game ($M = 30.39$, $SD = 19.66$), $t(27) = 2.34$, $p = .027$, $M_{diff} = 10.50$, $SE_{diff} = 4.49$. For the 115% payback percentage games, participants enjoyed playing the moderate LDWs game ($M = 74.59$, $SD = 19.80$) more than the zero LDWs game, ($M = 53.28$, $SD = 19.62$), $t(28) = 4.77$, $p < .001$, $M_{diff} = 21.31$, $SE = 4.47$.

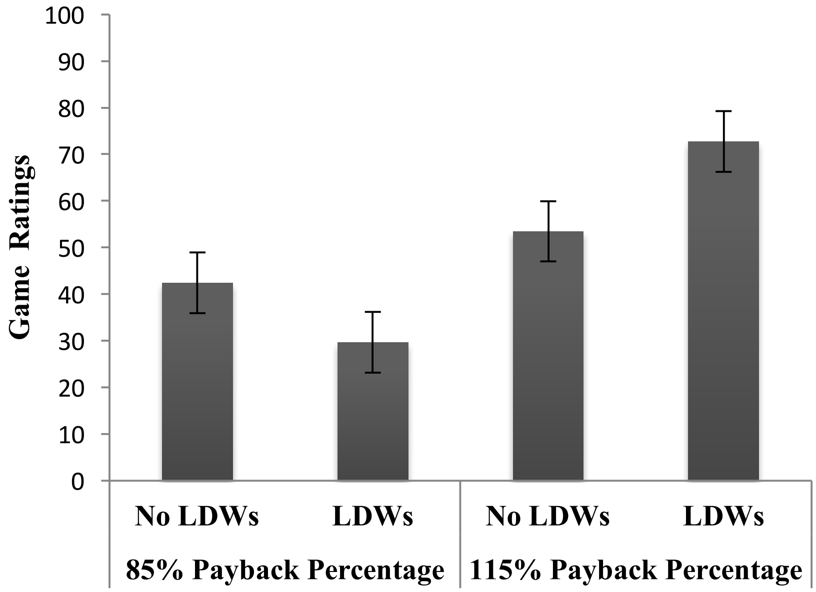

Figure 4.4 Participants' mean enjoyment ratings for each of the four games (85%PB no LDWs, 85%PB LDWs, 115%PB no LDWs, 115%PB LDWs). Error bars represent Masson and Loftus (2003) 95% confidence intervals.

Persistence

Zero outliers were removed prior to analyses. Only one participant played the 85%PB zero LDW game and was removed from further analyses, as contrasts could not be made with this single individual (persistence: $M = 40$). The remaining participants' persistence scores from their chosen game were first analyzed using a univariate ANOVA, with game chosen (85%PB moderate LDWs, 115%PB no LDWs, 115%PB moderate LDW) games as the between subjects levels. While a trend was observed wherein persistence was highest for those who chose the 115% moderate LDW game ($M = 17.00$, S$D = 12.35$), followed by the 115%PB no LDW game ($M = 10.88$, $SD = 4.58$), then the 85% moderate LDWs ($M = 7.40$, $SD = 5.08$) games, the main effect of game choice was not significant, $F(2, 29) = 2.26$, $p = .12$, $MSE = 103.24$, $\eta_P^2 = .14$. Statistical power for this analysis was only .42.

4.1.4 Discussion

As predicted, payback percentage and LDW frequency both had an effect on players' game choices and game preferences. The majority of players chose to play the high payback percentage game with LDWs over all other games. Importantly, we found no significant difference between the number of players who chose to play the no LDW game with a high (winning) payback percentage and the low payback percentage game with LDWs. These results suggest that LDWs, which are monetary *losses*, do in fact affect players' gambling behaviours (specifically, their game selections). We also found that gamblers preferred playing the games that had a positive expected value (115% payback percentage) over games that had a negative expected value (85% payback percentage). One limitation of our design, however, is that participants could play as many spins as they wished on each game, and may not have played a sufficient number of spins on a given game to experience these positive or negative expected values. For instance, if one only played five spins on the 115% few LDW game, they could be "down" after those five spins. This being said, as predicted, we did find that gamblers preferred playing the games where they were expected to win money (high payback percentage) over games where they were expected to lose money (low payback percentage). Here, there was an interaction with whether the game had LDWs or not. When players were losing, they did not report preferring the game with LDWs over the game with no LDWs. While winning, however, they preferred playing the games with LDWs to the game with no LDWs. These results suggest that LDWs do affect players' preferences when they are winning, or perhaps, "up" on a game. Finally, while not significant, we showed that players may persist to gamble for longer if they are "up" and are experiencing LDWs. In sum, the results of this experiment, in addition to those found in the previous chapters, suggest that players somatically, behaviourally, and cognitively (via verbal labeling) miscategorize LDWs as wins rather than correctly categorizing them as losses; that players find LDWs rewarding and reinforcing, which affect their gambling behaviour despite financial loss; and that LDWs affect players' game choices and preferences.

There are some limitations to this study. First, we only used a sample of relatively inexperienced gamblers. We did this as a first assay to see how payback percentage and LDWs could influence players' game choices and preferences with minimal pre-existing experience or gambling habits. Future research should evaluate whether these results/effects would hold for a sample of more experienced gamblers, and those with various levels of problem gambling symptomatology. Given that experienced gamblers show a LDW-triggered win-overestimation effect, and prefer playing the maximum number of playable lines on multiline games (which have more LDWs), we would predict that they would also choose to play games with more LDWs than games with fewer LDWs while they are up or "winning".

Recall, that we failed to show any difference in players game preferences (between the no LDW and moderate LDW games) when players were losing money. In Ontario, payback percentages on games vary between 85% and 98%. We used the minimum payback percentage available, so players were losing 15%. Given that the average payback percentage is around a 93% in Ontario, it would be interesting to see whether we would observe a shift in players' preferences at this payback percentage- namely, whether they would start preferring the LDW over no LDW game if they were still losing, but not as much. It is possible that there was a "floor" effect, where players just did not prefer the losing games all together. Another limitation of this study is that, while players are "up" at times, no slots game actually has a positive payback percentage. Future research should evaluate whether the preference for the LDW over no LDW games while winning would still hold if at a higher than 85% payback percentage - say 98%, or the upper limit - where participants are still losing money. This would allow for a more ecologically valid design. As a first assay though, we do conclude that LDWs do have some effects on players' game choices and player preferences. And, in the previous chapters we did show that LDWs could encourage gamblers to gamble for longer despite financial loss.

Chapter 5

GENERAL DISCUSSION

5.1 Slots Play

One question we addressed is whether a short playing session on a slot machine is sufficient to affect one's subjective experience. In experiments 3.1, 3.2, and 3.3, we measured participants' subjective arousal, mood (emotional valence), and desire to gamble prior to the playing session, following 100 spins, and after they decided to quit playing during an extinction phase. For novice players, a short playing session was sufficient to increase one's subjective arousal, and this arousal was maintained even after they decided to quit playing. Mood and desire to gamble in this novice sample, however, were not affected by the short playing session. Given that arousal has been argued to be the primary reinforcer of gambling behaviour (Brown, 1986), it is possible that new players are most sensitive to large wins where such wins lead to elevated arousal. With no previous experience, novice players may not experience gambling cravings, as measured by the desire to gamble item. The game may also not be sufficient to modulate a more complicated construct such as mood in this sample. Thus, perhaps it is the quick elevation in (rewarding) arousal that first contributes to players' hedonic experiences, and the allure of slots games. It is only later, with experience, once classical conditioning may affect players, that slots can induce gambling cravings and modulate one's mood.

In Experiments 3.2 and 3.3, we used a sample of experienced gamblers, and found that a short playing session on the slot machine was sufficient to modulate one's subjective arousal *and* one's subjective mood *and* one's desire to gamble. Arousal was maintained even after players quit during the extinction phase, as we observed with the novice sample. Mood and desire, however, subsided by the time that players quit during the extinction phase. Young et al. (2009) found that a short (25 spin) playing session was sufficient to increase one's desire to gamble and that this desire was maintained after 50 spins and upon quitting during the extinction phase. We found that desire significantly lowered after participants quit during the extinction phase, but our initial playing session was twice as long (100 spins). Thus, most players in Young et al.'s study would have quit playing prior to the completion of our initial playing session so it is possible that desire subsided in our study by time players decided to quit. Young et al also found individual differences in their sample - high-risk players reported greater desire to gamble overall. While we failed to replicate this finding, we did find that high-risk players reported higher urge on the Gambling Urge Scale, which is a related construct. Thus it is possible that this measure was more sensitive to participants' subjective experiences in our sample of experienced players. We also had few high-risk and problem gamblers in our studies, so it is possible that with a greater range of problem gambling symptomatology (i.e., higher power), that we would have also found that overall higher-risk gamblers would have reported greater desire to gamble overall.

We also found other individual differences in our players' experiences. High-risk gamblers showed higher tension, greater positive affect, and higher gambling urge during the 100 spin playing session. In these cases, slots in addition to having a positively reinforcing effect (evidenced by one's increase in arousal) may also have a negatively reinforcing effect. High-risk gamblers may be more prone to negative emotions, such as anxiety and depression, either as a result of gambling-related problems or a premorbid/comorbid depression and anxiety. Thus, slots may offer an avenue to these players to increase one's positive affect (see Dixon, Stange, Larche, Graydon, Fugelsang, and Harrigan, 2017).

5.2 Winning While Losing on Slot Machines

Overall we showed that players miscode LDWs as small wins. The majority of novices (Experiment 2.1 and 3.1) and experienced (Experiments 3.2 and 3.3) players verbally miscategorize LDWs as net gains, which replicates and extends the findings of Jensen et al. (2013) who showed using a "think-out-loud" protocol that the majority of novices are unaware that they are losing money on these outcomes and Jensen et al (2012) who showed that the majority of novices verbally miscategorize LDWs as wins. The fact that experienced gamblers miscategorize LDWs as monetary gains is rather surprising. One would presume that experienced gamblers would perhaps be more aware of the amount they bet and won on each spin, and realize that they were losing money on LDWs. A few factors may contribute to this miscategorization amongst experienced players despite their experience with slots. First, one's spin wager is immediately subtracted while the reels start spinning. The visually larger moving reels and salient game sounds may distract players from the relatively boring running total counter (which subtracts the spin wager upon spin initiation), making them less likely to attend to the amount wagered (and lost) per spin. Thus, any amount received thereafter on a spin, which would be celebrated with flashing lights and winning sounds, may simply overgeneralize to a "gain". Fortunately, educating novice players about LDWs (via a brief educational video), appears to be able to correct this LDW miscoding, and as a result, eliminated the LDW-triggered win-overestimation effect. These results offer concrete evidence that LDWs are in fact *miscoded* as wins from the outset, rather than reflecting a memory error per se, because accurate initial LDW categorization led to more accurate win estimates. Furthermore, given that Templeton et al. (2013) found smaller overestimation effects in a game with high numbers of LDWs, we expected to find more correct categorizations in a game with high LDWs. Although descriptively correct categorizations were 12% higher for those exposed to high LDWs (39%) than those exposed to moderate (26.7%) and low LDW rates (25.6%) these percentages were not significant in Experiment 3.2. Even if the failure to find such differences reflects a power problem, arguably the larger issue is that in all three conditions the majority of players miscategorized LDWs as wins.

The fact that participants miscode LDWs as wins leading them to recall winning more often than they really had is even more disconcerting because new research (Jarick, Simpson, Graydon, Harigan, & Dixon, Submitted) showed that wins *alone* lead to overestimates. These authors did not look at LDWs but only the influences of wins and regular losses. They argued that these overestimates are likely caused by the arousal induced by the multisensory processing of salient flashing sights and winning sounds, enhancing memory for these outcomes. Thus, miscoding LDWs as wins may exacerbate this pre-existing win-overestimation effect (i.e., with actual wins only), which could lead players to have very distorted recall of how often they won during a playing session.

Previous research has shown that removing sounds from LDWs and especially adding negative sounds to LDWs lead to more accurate win estimates. These results are hopeful, as they suggest that participants can in fact correctly recall how often they won during a playing session. That being said, it may not be feasible to encourage slots operators to fundamentally change the structural characteristics of all multiline slots. Fortunately, we showed (at least for novices) that a brief educational animation about LDWs could correct this miscoding of LDWs, leading to more accurate win estimates. This animation thus has potential to be used as a responsible gambling (RG) tool for health promotion, and potentially, as a tool for problem gambling counselors as well.

5.3 LDWs - Rewarding and Reinforcing

Overall, we also showed that players might find LDWs rewarding by miscategorizing LDWs at a behavioural level. For example, in Experiment 3.2., we showed that participants treat LDWs as small wins via their post-reinforcement pauses and as wins via the force they exert following these outcomes. While we did not always replicate previous findings showing equivalence between LDWs and small wins concerning SCRs, PRPs, and force, we attribute these limitations to sample size – studies that showed these effects typically tested over 100 participants. A central question in the present research, though, was to assess whether LDWs are *reinforcing*. Using extinction paradigms, we showed that LDWs can in fact lead players to continue gambling despite financial loss, but it may depend on problem gambling symptomatology and the LDW reinforcement rate.

In Experiment 3.2, we showed that there appears to be a "sweet spot" for LDW reinforcement for high-risk gamblers at around 12% over 30%. "Sweet spots" have been observed for another structural characteristic commonly found on mechanical-reeled games - namely, a near miss (e.g., where one gets two jackpot symbols on the payline on the first two reels, and a third jackpot symbol just off the payline on the third reel). Moderate (27%) numbers of near-misses are known to increase gambling persistence compared to games with no near-misses (Côté, Caron, Aubert, Desrochers, & Ladouceur, 2003). Similar to our findings with moderate numbers of LDWs there appears to be a "peak", where participants persist to gamble for longer when they experience near-misses on a moderate number of spins (30% of spins) compared to games with lower (15%) or higher (45%) near-miss rates (Kasinove & Share, 2001). Here, we argue that there may be a peak or "sweet spot" for the reinforcing effects of LDWs as well.

High-risk gamblers would purportedly have more experience playing slots, and thus, would be more sensitive to the reinforcement schedules of these games via learning and conditioning. We found that high-risk gamblers persisted for significantly longer when there was a moderate number of LDWs than if there were few or many LDWs. We did not find these effects for at-risk gamblers or non-problem gamblers. This pattern of results can be interpreted in terms of classical conditioning. Those who play most often would be the ones for whom classical conditioning of wins with salient sights and sounds would preferentially occur. By contrast, those who play less often may react only to the large wins (and not show conditioned responses to LDWs). This could explain why in Experiment 3.2, NPGs showed larger persistence to low LDW games (which contained bigger wins) whereas high-risk gamblers showed longer persistence to moderate LDW games.

One strength and one limitation of this study was the use of an extinction phase solely comprised of losses. Its strength lies in its historical precedence – it is a classic measure of how reinforcing a particular schedule of reinforcement is. Its weakness is that such long losing streaks are exceedingly rare on multiline slot machine games. It is more likely for players, on multiline slots, to experience losing streaks where there are LDWs (the second most frequent outcome) interspersed in the streaks. When we included a moderate number of

LDWs in such streaks (in Experiment 3.3), we found that players persisted for significantly longer than if there were fewer LDWs in the losing streak. Here we argue that both low and higher frequency gamblers would persist longer in the moderate LDW condition, because both groups would miscategorize LDWs as wins. Additionally, those who play more often might also somatically respond to LDWs as wins due to conditioning. For both groups since there were more LDWs in one extinction phase than the other, they persisted for longer. Additionally this type of extinction phase is far more ecologically valid than a streak of regular losses – it is a streak that players would have encountered on the machines that they are used to playing and provides compelling evidence showing that LDWs can in fact reinforce gambling behaviour.

One possibility for this "sweet" spot is the magnitude of the LDWs in these games. In order to equate the payback percentages of games, games with many lines (and many LDWs) need to include a lot of "tiny" LDWs (e.g., 2 or 4 credits). There may then be a "framing effect" where these small LDWs (coded as small wins) may make larger, more exciting wins seem less likely. Previous research on the "sweet spot" for near misses makes a similar argument. Getting too many near-misses may make getting an actual Jackpot or larger win seem less likely, leading to an optimum reinforcement rate for these structural characteristics as well. Future research should investigate what is the "optimum" LDW reinforcement rate, specifically, when does persistence "peak" then start "waning". One could use a similar design to Experiment 4.1., except have four games with the same payback percentage and numbers of actual wins but vary the numbers of LDWs. One could then see which game (i.e., with which LDW reinforcement rate) participants would choose to play, their persistence following selecting their chosen game, and their game preferences for different games with varying numbers of LDWs.

One possibility for why games with a moderate number of LDWs are preferred is because they provide a smoothing of the game experience. If one looks at Figure 3.2, the moderate LDW game leads to a "smoother" experience of gaining credits over time (a more ecologically valid design would have been to have a smoothing experience of losing credits over time) than the few LDW game, which is more "choppy" because there are fewer LDWs and a greater number of larger wins. This "smoothing" experience may make players more likely to enter in what is referred to as "the zone" (Shüll, 2005). Dixon et al. (2014) and Templeton et al. (2015) showed that multiline games are very "absorbing" for individuals with gambling pathology. Some slots gamblers report gambling to escape depression (Abbot & Volbreg, 1996; Getty, Watson, & Frish, 2000), which could lead to problematic gamblers continuing to gamble on slots not only for their positively reinforcing effects (e.g., arousal induced by the machine), but also their negatively reinforcing effects (e.g., to escape depressive rumination, tension, or stress). These negatively reinforcing effects have been referred to as "Dark Flow" (see Dixon et al., 2017). Dixon et al. (2017) showed that there was a positive correlation between Dark Flow and problem gambling severity (measured by the PGSI). Importantly, they also showed that the correlation between problem gambling severity and "dark flow" was greater in a multiline (20-line) game with more LDWs than a 1-line game with no LDWs. The 20-line games in this case would have a "smoother experience" for players (with more frequent small rewards rather than infrequent large rewards) making "zone entry" more likely, and by consequence, allow for greater negatively reinforcing effects.

If one looks at the many LDW game in Figure 3.2, one can see that it has a similar shape to the medium LDW game but that the "tiny" LDWs induce what appears to look like high frequency noise in the larger "smoother" waxing and waning of credits over time. Perhaps these "micro spikes" are potentially frustrating (and arousing) because the small LDWs (coded as small wins) make large wins seem less likely. These "micro spikes" could also potentially interrupt flow by inundating players with too many arousing sights and sounds, leading to arousal "overload" that could increase stress and anxiety. Thus, perhaps a moderate LDW game is optimum for zone entry, and that such zone entry during the initial playing session could also contribute to how long players choose to continue playing during the losing streak. This is an empirical question that could warrant future research. One could use a between subjects design with a large sub sample of problem gamblers and have experienced gamblers play different machines (with number of lines, payback percentage, and number of wins all equated) with different LDW reinforcement rates. One could measure participants' "zone entry", and persistence after each game, and evaluate whether there is an optimum LDW reinforcement rate for inducing zone entry, and whether gambling persistence correlates with such absorption. One could also see if such effects are exacerbated in the sub sample of problem gamblers, and whether "dark flow" and gambling persistence correlate with depression.

5.4 Game Selection

Templeton, Dixon, Harrigan, and Fugelsang (2015) showed that gamblers prefer playing the maximum number of playable lines and Dixon et al. (2014a) showed that gamblers prefer playing a 20-line game over a single line game. Both argued that this preference is likely due to the fact that there are more LDWs when one plays more lines. One confound with this interpretation is that players may simply prefer playing the maximum number of playable lines so that they do not "miss out" on potential winning combinations, some of which may lead to exciting bonus rounds.

In Chapter 4, we conducted (to our knowledge) the first study that directly assessed whether LDWs affect players' game selection and preferences, by giving novice participants the choice to play one of four games on each spin, with each game set to the maximum number of playable lines (20 lines). As a side note, we found it quite remarkable that players appeared to learn the underlying distribution of LDWs and the expected value of each of the four games in as little as 100 spins. Had they not learned these expected values, we would have expected approximately equal numbers of participants to select each game (i.e., that players would just simply select one of the four games based on chance alone). This is not what we found. The majority of participants selected a game with a positive expected value (i.e., where they were winning) and more importantly for this thesis a winning game with a moderate number of LDWs compared to a winning game with no LDWs. We also found that participants preferred playing the winning game with LDWs the most. It would be interesting to conduct secondary analyses on this data looking at where exactly (i.e., how many spins it took) for participants to start perseverating on a game during the acquisition phase to see if this corresponds with their game selection.

As we discussed, one limitation of this study was that games with payback percentages greater than 100% simply do not exist. Future research should replicate this study using payback percentages that are within the range of commercially available games. One should also replicate this study with a sample of experienced gamblers. Given that they may already be more sensitive to the reinforcement rates of games (via learning), they may start showing game selection preferences faster than novices, and may perhaps be more likely to select the games with LDWs at higher frequencies than novices due to classical conditioning effects. Future research should also study which games players actually prefer on the casino floors. From our observations, one commercially available game in our lab has been phased out of one casino and one racino. This was a 20-line game with approximately 30% LDWs. Another game we have in our lab still exists and has offshoots of related games. This game was a 15-line game with approximately 18% LDWs. While admittedly speculative, it could be that the latter game had a more optimum LDW reinforcement rate than the game that has disappeared from the casinos (that we are familiar with). Personal correspondence with a regulator at a recent gambling conference (Anonymous, Discovery Conference, 2017, Toronto, Ontario) suggests that games on the floor follow a natural selection process. They stated that today in Ontario Casinos, most games run on leases, and if they do not perform well in a short period of time, they are removed from the gaming floor. It would be interesting if one could collect game preference data from gamblers' loyality cards to see which games they prefer, and via observation, whether LDWs (at certain reinforcement rates) affect which games survive on the floor or not.

5.5 Future Directions

Our slot machine games were highly constrained. Dow Schüll (2012) remarks that commercially available electronic gaming machines (EGMS) are increasingly complex games that allow for the combination of several structural characteristics (e.g., near misses, LDWs, stop buttons) within each game. The first limitation of our playing session was that participants were not allowed to use the stop button on the machines. (All multiline games we have observed have a stop button). This is a ubiquitous feature of the game, which may induce erroneous cognitions amongst players. Research has shown (Ladouceur and Sevigny, 2005) that allowing players to use the stop button leads to greater persistence during a losing streak (using a resistance to extinction paradigm) than players who are not allowed to use this feature.

Near-misses can also lead to greater persistence despite the fact that they are pure losses (Côté, Caron, Aubert, Desrochers, & Ladouceur, 2003). We have observed that some multiline games have near misses imbedded within the games. Sharman, Aitken, and Clark (2015) looked at the combined effects of LDWs and near misses on positive valence (how happy participants were on a 100 point Likert scale) and motivation to continue gambling (how much participants wanted to continue gambling on a 100 point Likert scale). Participants played a 3-reeled slot machine (with 3 symbols visible on each reel). On each trial, a final spin led to one of three outcomes - a regular loss, a win, or one of two types of near misses. LDWs, in this experiment, occurred independently of the payline - coloured boxes surrounded each of the nine symbols on the reels, and if three coloured boxes matched, then the player got a LDW (in addition to the regular loss, win, or near-miss that occurred on the payline). They found that overall, the LDW group reported being happier after experiencing a certain type of near-miss than the no LDW group. Within the LDW group, they found that participants were happier after experiencing any type of outcome (regular loss, win, or near-miss) if they also experienced an LDW on the trial than if they did not experience a LDW. Finally, difference in positive valence and motivation to continue gambling between two types of near-misses were greater on trials with LDWs than on trials without LDWs (i.e., a LDW by near-miss effect interaction). As an extension to this important study, it would be interesting to see if behaviourally games with LDWs and near misses lead to greater persistence in game play. In other words it would be important from a problem gambling perspective to show that players act on their motivation and actually play longer when exposed to a combination of near-misses and LDWs.

It would also be essential to include bonus games, as these are exciting features (in fact, some gamblers play simply to chase these games) common on multiline slots. It would be interesting to see if including salient bonus games within the beginning of a playing session would make players more sensitive to the subsequent LDW reinforcement rates of these game, perhaps making them gamble for longer despite financial loss.

5.6 Applications

We showed that we could successfully correct novice participants' LDW categorization and eliminate the LDW-triggered win overestimation effect using a brief educational animation about LDWs. Future research should (1) assess whether these effects are retained over time, (2) whether the same effect would be observed with experienced and problematic gamblers, and (3) whether the animation could reduce LDW-triggered persistence despite financial loss. From a practical point of view, how could these animations be made available to players? The Ontario Lottery and Gaming Corporation (OLG) has launched a new responsible gambling initiative called PlaySmart. First, the OLG could make the animation available on their PlaySmart website. Second, when one goes to the OLG's play on line slots tab, there is a button that says, "check out our games". A second button could be included that says "about our games", and the animation could be made available there. PlaySmart is also currently touring onsite casinos in Ontario using two demonstrations to explain the randomness of slot machine outcomes. In future tours, one could demo the LDW animation and potentially reward players (via their loyalty cards) to view the animation. These are just a few examples of the RG health promotion uses for this animation.

In sum the experiments presented above reflect a program of research that seeks to show how losses disguised as wins impact players. The experiments highlight their deceptive nature, as well as show that they can impact how long certain players will gamble, and govern which games people will choose to play. To end on an optimistic note they also show how a simple animation can effectively unmask the disguise borne by these outcomes and give players more veridical insight to their actual playing experience

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Appendix A

Chapter 4 - Subjective Arousal, Mood, Desire to Gamble, and Urge

Arousal

Table 5.1 shows the means and standard deviations for participants' subjective arousal ratings from each of the three time-points (pre-game, post-games, post-persistence). One outlier was removed prior to analyses (1 NPG). Participants' arousal scores were first submitted to a one-way repeated measures ANOVA with time-point (pre-game, post-games, post-persistence) as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 12.68$, $p = .002$, Green House Geisser $\varepsilon = .73$. The main effect of time-point was at significance, $F(1.47, 42.52) = 3.55$, $p = .051$, $MSE = 1.08$. Given that we have previously shown significant main effects of arousal in Chapter 3, we explored this effect by determining which arousal time-points were different using Bonferonni corrected paired samples t-tests *(p/3* = .017). Arousal was significantly lower post-persistence than post-games, $t(30) = 3.65$, $p = .001$, $SE_{diff} = .16$, $M_{diff} = .58$. The other two contrasts were not significant, both *ts* < 1.80, *ps* > .083.

Emotional Valence

Table 5.1 shows the means and standard deviations for participants' subjective emotional valence ratings from each of the three time-points (pre-game, post-game, post-persistence). Three outliers (1 NPG, 2 LRGs) were removed prior to analyses. Participants' emotional valence scores were first submitted to a one-way repeated measures ANOVA with time-point (pre-game, post-game, post-persistence) as the repeated measures factor.

Mauchly's test of sphericity was violated, $\chi^2(2) = 14.99$, $p = .001$, Green House Geisser $\varepsilon = .70$. The main effect of time-point was significant, $F(1.40, 39.27) = 12.98$, $p < .001$, $MSE = .82$. To compare emotional valence at each time-point (pre-games, post-games, post-persistence), we conducted Bonferonni corrected *(p/3* = .017) paired-samples t-test. Emotional valence was more negative post-persistence than prior to the games, $t(28) = 3.64$, $p = .001$, $M_{diff} = .76$, $SE_{diff} = .21$, and post-games, $t(28) = 3.93$, $p = .001$, $M_{diff} = .97$, $SE_{diff} = .25$. There was no difference in emotional valence pre-games and post-games, $t(28) = 1.65$, $p = .11$, $M_{diff} = .21$, $SE_{diff} = .13$.

Desire to Gamble

Table 5.1 shows the means and standard deviations for participants' desire to gamble ratings from each of the three time-points (pre-game, post-game, post-persistence). Zero outliers were removed prior to analyses. Participants' desire to gamble scores were first submitted to a simple one-way repeated measures ANOVA with time-point (pre-games, post-games, post-persistence) as the repeated measures factor. Mauchly's test of sphericity was violated, $\chi^2(2) = 13.35$, $p = .001$, Green House Geisser $\varepsilon = .69$. There was a main effect of time-point, $F(1.38, 31.62) = 4.54$, $p = .03$, $MSE = 288.57$. To compare desire to gamble at each time-point (pre-games, post-games, post-persistence), we conducted Bonferonni corrected *(p/3* = .017) paired-samples t-test. Desire was significantly lower post-persistence than post-games, $t(23) = 3.93$, $p = .001$, $SE_{diff} = 2.84$, $M_{diff} = 11.17$. Neither of the two other comparisons were significant, both *ts* < 1.92, *ps* > .068.

Urge

Urge was measured at two time-points, pre-game and post-persistence. Table 5.1 shows the means and standard deviations for participants' urge scores from both time-points (pre-games, post-persistence). Two outliers were removed prior to analyses (1 NPG, 1 LRG). To compare urge between these two time-points, we conducted a paired-samples t-test. Gambling urge was significantly lower post-persistence than prior to the games, $t(29) = 3.26$, $p = .003$, $SE = 1.14$.

Table 5.1 Means and standard deviations for participants' subjective experiences prior to the playing session (pre-game), after the 100-spin playing session (post-game), and following the persistence phase (post-persistence).

	Pre-Games		**Post-Games**		**Post-Persistence**	
	M	SD	M	SD	M	SD
Arousal	4.9	1.6	4.3	1.8	3.7	1.8
Emotional Valence	6.8	0.5	7.0	0.8	6.1	1.3
Desire to Gamble	37	18	40	21	29	22
Urge	13	7	n/a	n/a	10	5