Winning While Losing on Multiline Slot Machine Games

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

On multiline slot machine games, small "wins" often amount to less than the spin wager, resulting in a monetary loss to the gambler. Nevertheless, these monetary losses are still accompanied by "winning" (and potentially reinforcing) audio-visual feedback. Dixon, Harrigan, Sandhu, Collins, and Fugelsang (2010) termed these potentially reinforcing losses as losses disguised as wins, or LDWs. Dixon et al. previously showed that novice gamblers appear to somatically miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses. Two studies are presented which investigated whether novice gamblers would *psychologically* miscategorize LDWs as wins as well. In both studies, we investigated participants' categorizations of LDWs using two measures. First, we asked participants to recall how many times they had won during a playing session and predicted that if participants miscategorize LDWs as wins, then they should conflate LDWs and wins in memory. In Study 1, participants played 200 spins on a real slot machine game with either relatively fewer or relatively many expected LDWs. We found that participants who experienced more LDWs during the playing session recalled winning significantly more often than participants who experienced fewer LDWs, despite how many actual wins the participant experienced, or how much they won or lost overall. In Study 2, we found that participants recalled winning significantly more often in simulator games with more rather than fewer LDWs, despite identical numbers of real wins and identical payback percentages in both games. We referred to this type of memory error as the *LDW overestimation effect*. The second measure we used to investigate participants' categorizations of LDWs was more immediate and direct. We evaluated whether participants would miscategorize LDWs as wins or correctly categorize these outcomes as losses by simply asking them to *verbally label* slot machine spin outcomes. In both studies, we found that the majority of participants miscategorized LDWs as wins rather than correctly categorizing the outcomes as losses. Implications for problem gambling are discussed.

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Chapter 1: INTRODUCTION

The Pathways Model of Problem Gambling (see Blaszczynski & Nower, 2002, for a review) identifies three major pathways culminating in pathological gambling. Common to all three pathways is the role of classical and operant conditioning. Interestingly, *Pathway 1: Behaviourally Conditioned Problem Gamblers* identifies a subset of gamblers who alternate between regular and excessive gambling due of the effects of conditioning, distorted cognitions regarding game probabilities, and poor judgment or decision making. Importantly, individuals need not have any type of premorbid psychopathology that renders them more susceptible to gambling problems. Rather, they can enter this subgroup of problem gamblers at any time simply by chance exposure to gambling. Thus, if problematic gambling can develop in otherwise "healthy" individuals, then the characteristics of the gambling games themselves must also play an integral component in the development and maintenance of problem gambling.

Slot machines have been linked to pathological gambling in countries across the globe (e.g., Fisher & Griffiths, 1995). Universally, the majority of pathological and problem gamblers presenting in treatment report that it was slot machines [or electronic gaming machines] that were their predominant form of gambling (e.g., Fisher & Griffiths, 1995). Given the obvious link between slot machines and problematic gambling, further research is necessary to uncover how the characteristics of these games either induce gambling episodes or encourage continued gambling.

The allure of slot machines is not surprising given that they follow the principles of both classical and operant conditioning (see Czerny, Koenig, & Turner, 2008, for an overview). Classical conditioning principles state that getting a win on a slot machine spin can serve as an unconditioned stimulus that automatically leads to elevations in physiological arousal. Thus, these natural and uncontrollable arousal responses to winning money constitute the *unconditioned responses* in gambling. In fact, Brown (1986) argues that such elevations in physiological arousal are **the** primary reinforcer regulating individuals gambling behaviour. After multiple spins on a slot machine, secondary machine characteristics, such as particular sights and sounds that accompany the win (i.e., *conditioned stimuli*) can also become associated with elevations of physiological arousal in response to winning. Ultimately, these sights and sounds themselves can subsequently lead to elevations in physiological arousal (i.e., *conditioned responses*).

Operant conditioning principles state that positive reinforcers in slot machine games, such as winning money, lead to increases in response behaviour that preceded the reinforcer (e.g., the pulling of a lever, or the pressing of a "spin" button). Slot machines are often referred to as following a variable ratio (VR) reinforcement schedule (e.g., Haw, 2009). VR schedules are highly implicated in the development and maintenance of addictions because they lead to behaviours that are highly resilient to extinction - individuals do not know when they will get a reward, but know that they must continue responding in order to get it (e.g., see Czerny et al., 2008, for an overview).

Although one will commonly read that slot machines follow a VR schedule, this is in fact a misperception. Slot machines actually follow a random ratio (RR) reinforcement schedule. In a RR reinforcement schedule, each outcome is independent of all prior outcomes and the probability of getting a particular outcome on any given spin remains constant (e.g., Haw, 2008). Some gamblers, though, interpret successive losses as harbingers of upcoming wins – they believe that eventually the machine *must* payout. On the other hand, some gamblers are reported to be aware that slot machines outcomes are random events but use flawed heuristics to evaluate the probability of slot machine outcomes (Czerny et al., 2008). For instance, problem gamblers have been reported to use Tversky and Kahneman's (1990) representativeness heuristic – where a belief in "local representativeness" (i.e., that local sequences represent global distributions) can lead to the belief that randomness is "self-correcting" or that random distributions need to be "balanced out" (Czerny et al., 2008). Both of the aforementioned beliefs lead to a misunderstanding of gambling probabilities commonly referred to as the gamblers fallacy – the belief that a series of consecutive losses increases one's probability of winning in the future (e.g., Czerny et al., 2008). The gamblers fallacy illustrates an important point regarding the allure of slot machine games –

namely, it is not only the inherent characteristics of these games that contributes to their allure, their allure also largely depends on gamblers' interpretations (or misinterpretations) of slot machine characteristics.

The slot machines that one can find in casinos are of two general types: mechanical reel slot machines and more modern video slot machines. The traditional one-armed bandits are referred to as mechanical reel slot machines since they have three mechanical flywheels that are set into motion by the pull of a mechanical lever (Turner, 2008).

Video slot machines use computer animations with sophisticated graphics to simulate the spinning reels. When one spins and wins, the machine will play high fidelity "winning songs" that celebrate the win. Often they employ touch screens to enable the player to choose how they will play, and seemingly to be able to stop individual reels at particular locations.

Both mechanical reel and video slot machines use a random number generator (RNG) to determine the stopping places of the reels (and hence) whether one wins or losses on a spin (Turner, 2008). Essentially, whether one wins or losses on a spin depends on the random number that is chosen - the symbols on the reels (and where they appear) are simply there to display RNG results to the gambler in an engaging fashion. Importantly, machines run their RNGs continuously. Once the spin button on the slot machine is pushed (or a relic lever is pulled), the machine polls the current RNG values, which determines the outcome. Thus, slot machine spin outcomes are determined even prior to when the reels start spinning. To reiterate, the spinning reels and whatever other bells and whistles the machine may have are simply there to display RNG results to the player and make the game enjoyable.

One of the most salient differences between the simplest mechanical reel games, and modern video games involves the number of lines that can be wagered on. In the simple mechanical reel game, you spin the reels, and hope that a winning combination of symbols will fall on a physical payline lying across the three reels. Since there is only a single payline, and only three reels, these games are quite easy to follow: if a winning combination of symbols falls on the payline, you win, and if it does not you lose your entire spin wager. However, on modern video slot machines players can wager on more than one line. With a push of an appropriate button, players can wager on 2, 3, 5, 10 or 15 lines. (Some games even allow players to wager on thousands of lines at a time). Although it may be possible to keep track of two or three lines played at once, it is markedly more difficult (for example) for the player to keep track of whether an outcome is a win on any one of 9 different lines (Figure 1.1; 5-reel slot machine simulator, copyright Game Planit Interactive Corp).

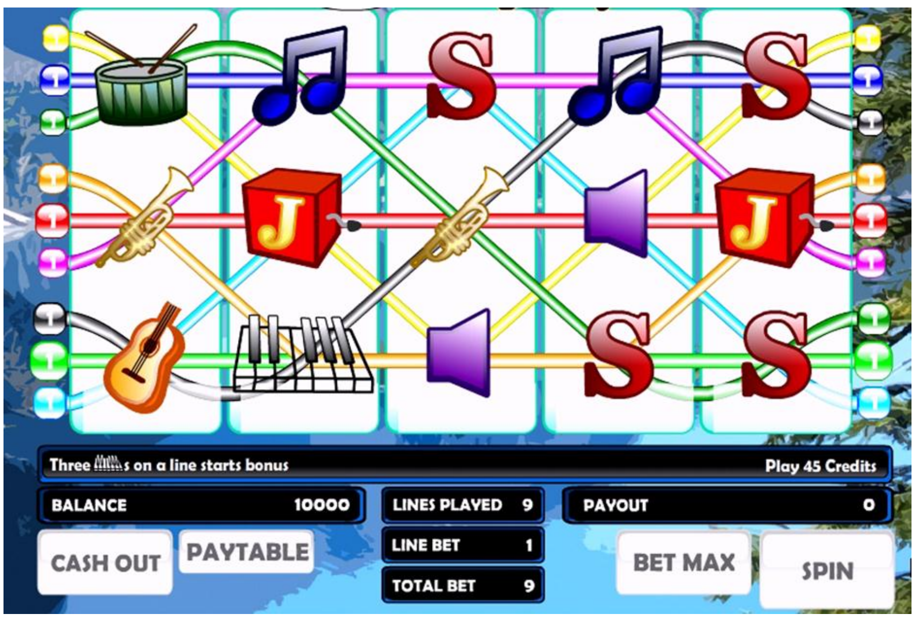

Figure 1.1 Screenshot of the 9 playable lines on a 5-reel slot machine simulator.

To assist the player in determining whether they won or lost, modern slot machines provide highly salient feedback. On multiline video slot machine games, if the gambler gets a “winning” combination of symbols on one or more paylines, the machine comes to life, *celebrating* the win with winning sights and sounds. Coloured lines join the symbols in the winning combination, symbols within the winning combination may become animated, and the gambler’s winnings are counted up, both visually in a win (or paid /payout) counter, and aurally by a salient "rolling" sound (e.g., sounds reminiscent of the tinkling of coins falling atop one another). When a gambler fails to get a winning combination, however, the machine goes into an abrupt state of quiet in both the auditory and visual domains.

Research suggests that gamblers not only use the multiline functionality on modern slot machines, but also attempt to *optimize* their winnings by wagering the minimum amount (i.e., the lowest possible stake) on the maximum number of playable lines per spin (Livingstone, Woolley, Zazryn, Bakacs, & Shami, 2008). Livingstone (2010) remarks that gamblers cite using this "mini-max" strategy in order to avoid missing out on any potential winning combinations, while risking (i.e., wagering) the least amount possible. Unfortunately, this optimization strategy is no more effective than playing on a single line. The alignment of the symbols to the randomly selected outcomes (virtual reel mapping) ensures that regardless of strategy, the player will ultimately lose in the long run.

Interestingly, when a player wagers on multiple lines on a video slot machine, many "wins" often amount to less than the total spin wager, resulting in a monetary loss to the gambler. Nevertheless, these monetary losses are still accompanied by "winning" (and potentially reinforcing) audio-visual feedback. For instance, a gambler who bets 5 cents on each of 15 lines (for a total spin wager of a $.75) but only "wins" back 25 cents would still see their "winnings" being counted up, and would still see flashing lines outlining their "winning" combinations, regardless of the fact that their spin has put them in the hole by 50 cents. Dixon Harrigan, Sandhu, Collins and Fugelsang (2010) refer to these potentially reinforcing losses as *losses disguised as wins*, or LDWs (see also the, "fake wins" referred to by Wilkes, Gonsalvez, & Blaszczynski, 2010).

Table 1.1 shows the features shared by real wins, LDWs, and losses. As shown in this table, flashing lines, winning sounds, and credits being counted up are all features that are common to actual wins and LDWs – the only thing that distinguishes between these two types of outcomes is that for actual wins the players wins money, while for LDWs the players lose money. Contrasting the two types of losses (regular losses and LDWs), there are many distinguishing features – flashing lines, sounds, and credits being counted up always accompany LDWs, but never accompany actual losses. In fact, one can see that monetary loss is the sole feature shared by LDWs and regular losses. In sum wins and LDWs share many features, and LDWs and losses share few features. Figure 1.2 shows a screen shot of an actual win, a LDW, and a regular loss from a slot machine simulator, which allows the player to wager on up to 9 lines. As can clearly be seen in this figure, LDWs are remarkably (visually) similar to actual wins, while also being dramatically dissimilar to regular losses. Looking at the LDW and win in this figure, one can see that in both cases a "winning line" was celebrated on the machine, while the LDW resulted in a loss of 1 credit, and the actual win resulted in a gain of 91 credits.

As previously discussed, the allure of slot machine games not only depends on their inherent structure, but also on gamblers' *interpretations* of the machine characteristics. While LDWs are in fact monetary losses, they are remarkably (perceptually) similar to actual wins. Given this perceptual similarity, Dixon et al. (2010) explored whether novice gamblers would somatically categorize LDWs as wins or losses. Previous research has shown that physiological arousal can inform human decision making, even prior to conscious awareness. For instance, in the renowned Iowa gambling task (IGT; e.g., Bechara, Damasio, Damasio, & Anderson, 1994), individuals must learn to differentiate between good (low-risk) decks with steady and small payouts, and bad (high risk) decks with large wins but even larger punishments. The interesting finding using the IGT is that individuals begin to show large anticipatory skin conductance responses (SCRs) prior to choosing cards from the bad decks and also begin to behaviourally choose the safer decks much sooner than they are even consciously able to differentiate between bad and good decks. Bechara et al. (1994) referred to these early anticipatory SCR responses as somatic markers, which are believed to be used to physiologically inform decision making (somatic marker hypothesis; Bechara, Damasio, Tranel, & Damasio, 1997).

Table 1.1 Similarity amongst wins, LDWs, and regular losses

	flashing lines	sounds	credits counted up	money won
Win	+	+	+	+
LDW	+	+	+	-
Loss	-	-	-	-

Figure 1.2 Screenshots of a slot machine simulator showing a win (top), LDW (middle), and regular loss (bottom).

Dixon et al. (2010) explored whether novices would show equivalent somatic markers to wins and LDWs. They recorded participants' skin conductance responses (SCRs) following wins, LDWs, and regular losses while playing Lobstermania. They found that even though LDWs resulted in the players losing money, they showed greater SCRs for LDWs compared to regular losses. In this study players also appeared to somatically miscategorize LDWs as wins - participants' arousal responses following both real wins and LDWs were statistically indistinguishable. As previously discussed, Brown (1986) argues that gambling-related increases in physiological arousal may be the primary reinforcer regulating gambling behaviour. As a result, Dixon et al.'s results suggest that LDWs in multiline games may increase the allure of these games in two ways. First, LDWs may induce elevations in (reinforcing) arousal and second, LDWs, via somatic miscategorization, may lead gamblers to feel as if they are winning more often than they actually are.

If gamblers miscategorize LDWs as wins, then LDWs may have a substantial influence on the allure of multiline games, especially since LDWs in multiline games can be even more frequent than real wins. For instance, Dixon et al. (2010) showed through simulations of Lobstermania, that LDWs are more frequent than real wins when the player bets on 6 or more lines. If the exciting flashing lights and "winning" sounds are thought of as reinforcing, then, a gambler playing 15 lines on Lobstermania would (on average) receive reinforcement following a spin on 32% of spins (14% following actual wins plus 18% following LDWs). By contrast, a gambler playing on only one line would only be expected to receive reinforcement on 5% of spins (note that these are all wins - LDWs only occur on when playing multiple lines). Thus, playing multiple lines substantially increases the reinforcement rate of the game, whilst keeping the amount paid out to the gambler constant.

While Dixon et al. previously showed that novices somatically miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses, research has yet to show whether gamblers would *psychologically* miscategorize (e.g., verbally label) these outcomes as wins as well. Theories of (psychological) categorization posit that people will categorize an entity as belonging to one category as opposed to another based on similarity. For example, if a child sees a furry, barking, tail-wagging four legged creature it has never seen before, it will categorize it as a dog, based on its similarity to other furry, barking four-legged creatures it has stored in memory (see Goldstone, 1994, for an overview). Given that LDWs and wins share many features, and LDWs and losses share few features (Table 1.1), the central question of this thesis is whether gamblers would psychologically miscategorize LDWs as wins (despite the cost to the gambler) rather than correctly categorizing these outcomes as losses. This thesis presents two studies that explored this question.

In Study 1, two measures were employed to explore how individuals categorize LDWs while playing on an actual slot machine of the type that can be found in Ontario casinos. First, participants played 200 spins on either a 3-line Lobstermania game that is expected to have few LDWs or a 6-line Lobstermania game that is expected to have relatively frequent LDWs. Participants were subsequently asked to estimate how many times they won during their playing session. If participants miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses, then one would predict that participants' would conflate LDWs and wins in memory. As such, participants who experienced more LDWs during the playing session should recall winning more often than participants who experienced fewer LDWs, despite how many actual wins the participant experienced, or how much they won or lost overall. The second measure was more immediate and direct. We evaluated whether participants would miscategorize LDWs as wins or correctly categorize these outcomes as losses by simply asking them to *verbally label* slot machine spin outcomes. Given the marked perceptual similarity between LDWs and actual wins, one would predict that the majority of participants would incorrectly label LDWs as wins rather than correctly labeling these outcomes as losses.

Study 2 was a replication and extension of Study 1 with two key modifications that allowed for greater empirical control (the downside of using an actual slot machine is that the results for each participant are inherently variable – by using a simulator we can remove these sources of variance). First, participants played a slot machine simulator that allowed us to exactly control the characteristics of the few vs. many LDW games. Second, a repeated measures design was employed in order to directly evaluate whether the same individuals would estimate winning more often in games with more LDWs compared to games with fewer LDWs. In two experiments, we evaluated whether participants would recall winning more often in a game with more rather than fewer LDWs. If participants miscategorize LDWs as wins due to the marked perceptual similarity between LDWs and actual wins, then one would predict that participants would estimate that they won significantly more often in a game with more rather than fewer LDWs.

Chapter 2: POSITIVE REINFORCEMENT HIDES LOSS IN MULTILINE SLOT MACHINE GAMES

We explored whether gamblers would psychologically miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses due to the marked similarity between real wins and LDWs and the marked dissimilarity between LDWs and regular losses. We explored this possibility by having participants play one of two games on Lobstermania. Based on the programming documents (PAR sheets) for games which we have obtained through the freedom of information act, we can calculate the expected number of times that players (on average) will encounter wins, LDWs and losses while playing Lobsermania.

Table 2.1 shows the expected percentages for Lobstermania gamblers' playing sessions of a 3-line game versus a 6-line game. Participants playing 6-lines or 3-lines should (on average) experience similar numbers of real wins (8.1% and 8.7%, respectively) during a playing session, while participants playing the 6-line game should experience more LDWs (10.7%) than participants playing the 3-line game (3.8%). As such, we predict that, if players psychologically miscategorize LDWs as wins, then they should also recall winning more often in games with more LDWs (i.e., the 6-line game) as compared to games containing fewer LDWs (i.e., the 3-line game), despite similar numbers of real wins and similar payback percentages. We also predict that if participants psychologically miscategorize LDWs as wins, then when asked to verbally categorize LDWs as wins or losses, the majority of participants should verbally miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses. Finally, given Dixon et al.'s (2010) finding that LDWs are more arousing than regular losses, we hypothesized that participants may report that games with more LDWs are more subjectively arousing, exciting, and enjoyable than games with fewer LDWs.

Table 2.1 Expected percentages of wins and LDWs on the 3-line and 6-line Lobstermania Games.

	3-lines	**6-lines**
Wins	8.1%	8.7%
LDWs	3.8%	10.7%

2.1 Experiment

2.1.1 Method

Participants

Forty-seven undergraduate students (27 females) from the University of Waterloo participated in this study for financial remuneration. Ages ranged between 19 and 25 years, with a mean age of 19.9 years. Participants self-declared that they had *never* played a slot machine before and were not in treatment for problem gambling. All methods and procedures were approved by the University of Waterloo's Office of Research Ethics.

Apparatus

Participants played a 50₵ (CAD) version of Lucky Larry's Lobstermania. The game has five virtual reels, with three symbols visible on any reel at any given time. Players can play up to 15 lines per spin, at up to 5 credits per line, for a possible maximum (max) bet wager of 75 credits per spin. Players normally acquire credits in the game by getting three or more identical symbols in a row from left to right on one (or more) paylines.

Design

Participants were randomly assigned to play either a 3-line (fewer expected LDWs) or a 6-line (more expected LDWs) Lobstermania game. To ensure identical spin wagers, participants playing six lines were instructed to bet 1 credit per line (for a total spin wager of 6 credits); while, participants playing 3 lines were instructed to bet 2 credits per line (for total spin wager of 6 credits). Figure 2.1 show schematics of the 3-line (left panel) and 6-line (right panel) Lobstermania games.

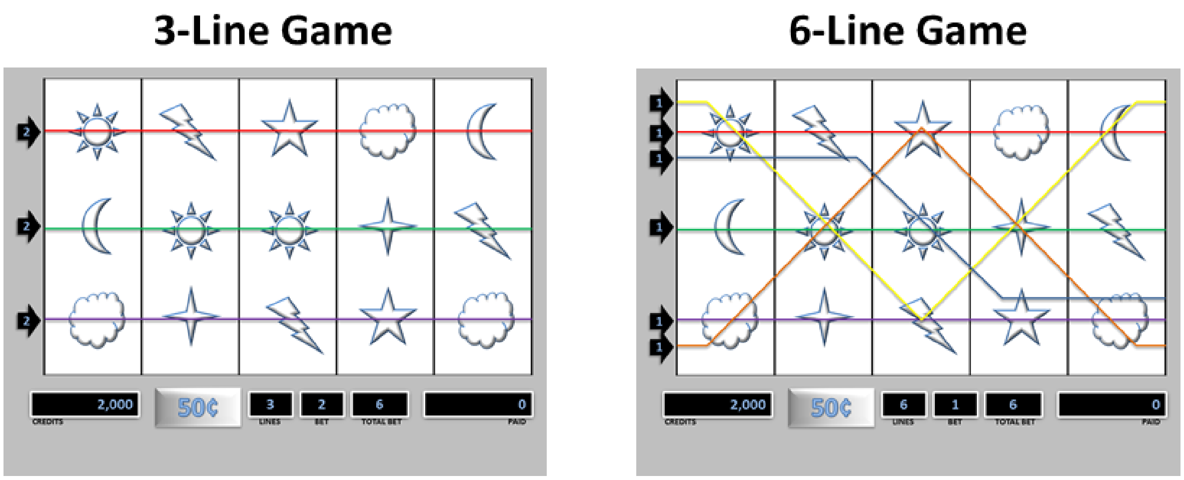

Figure 2.1 In multiline games players can bet on multiple lines. The schematic depictions above show the positions of the counters, and playable lines on a typical modern video multiline game. The left panel shows the three playable lines when players select a 3-line game, the right panel shows the 6 playable lines when players select a 6-line game. Typically three identical symbols (from left to right) on any given line lead to a credit gain. (Note the symbols above are of our own design).

Procedure

Upon arrival, participants read an information letter and signed a consent form. Participants were then seated on a stool in front of the slot machine and given a detailed Lobstermania tutorial. The experimenter explained that the slot machine had five reels and that they could spin the reels on the machine by pressing the spin button on the cabinet. Participants were shown the various pay tables and help menus available on the machine and informed that they could acquire credits in the game by getting three or more symbols in a row from left to right on a payline. The experimenter subsequently explained all of the various counters on the machine (Figure 2.1), starting with the leftmost “credit” counter and ending with the right-most “win” counter. The experimenter explained that the “credit” counter displayed their starting balance (and constantly updating running total) in slot machine credits. The starting balance on the machine was pre-set to 1,600 credits and participants were given four $50 bills to insert into the machine, which brought the starting balance on the machine to 2000 credits. Participants were instructed to increase the number of lines on the machine to 3 or 6 lines (depending on randomized group assignment) and to bet either 2 (3-line) or 1 (6-line) credits per line, for a total wager of 6 credits. The experimenter reiterated that they were betting 6 credits per spin and pointed to the *win* counter and explained this counter would show how many credits they acquired on a spin, if any. Participants were informed that they would receive $10 for their time (60 minutes) and could receive up to an additional $20 based on their performance during the gambling session. (Participants were informed in the information letter that the amount that they would receive would be calculated by taking the cubed root of their ending balance on the slot machine).

Participants were asked to play 200 spins on the machine by pressing the spin button on the game cabinet. Participants were instructed that they could spin as quickly or as slowly as they would like, but to please wait for any sound to go away before spinning again. Participants were informed that they would be asked some questions following the playing session. During the playing session, the experimenter manually recorded each spin outcome (e.g., win, loss, or LDW) and the amount of credits acquired (if any). Following the 200 spins, participants were verbally asked the following questions: (1) Please rate your level of enjoyment while playing the slot machine - that is - give me a number between 1 and 10, where 1 is not enjoyable and 10 is extremely enjoyable; (2) Please rate your level of excitement while playing the slot machine - that is - give me a number between 1 and 10, where 1 is not exciting and 10 is extremely exciting; (3) Please rate your level of arousal while playing the slot machine. You can think of arousal like riding a roller coaster, where your heart rate may increase or your hands may become clammy. Thinking about arousal in this way, please rate your level of arousal on a scale from 1 to 10, where 1 is not arousing and 10 is extremely arousing; and (4) In this part of the session you had 200 spins. Of these 200 spins please estimate the number of times on which you won - that is give me a number between 1 and 200.

Following the main playing session and questions, participants played an additional 50 spins on the machine. They were asked to spin the reels on the slot machine a number of times, and for each spin, to tell the experimenter what they were thinking as they were spinning and finally to report whether the spin was a win or a loss ("think-out-loud protocol"; e.g., Ladouceur, Gaboury, Dumont, & Rochette, 1988; Gaboury & Ladouceur, 1989; Ladouceur & Gaboury, 1998). Participants were asked to pause after each spin until the experimenter asked them to spin again. For each of the 50 spins, the experimenter recorded participants' free reports, spin categorization (i.e., as win or loss), actual spin outcome (e.g., win, loss, or LDW), and the amount of credits acquired on the spin, if any.

At the end of the session, participants were asked to answer some additional questions. These questions served as pilot research for future studies, and as such, are not discussed in the present paper. At the end of the experiment, participants were asked if they had any questions, were given a feedback form and two responsible gambling brochures.

2.1.2 Results

Estimated Number of Wins during the 200-Spin Playing Session

Participants' win estimates (estimated number of wins out of 200 spins) were submitted to separate (3-line group, 6-line group) recursive outlier rejection procedures using the sample-size dependent cut-offs [(+/- 2.40)(SD)] proposed by Van Selst and Jolicoeur (1994). Three participants' win estimates were rejected during this procedure because they reported winning 80, 70, and 70 times during the 200 spins, despite only experiencing 26, 30, and 22 reinforced (wins plus LDWs) spins, respectively.

Table 2.2 shows the mean observed ending balances (in credits), numbers of observed wins, and numbers of observed LDWs for the remaining participants in the 3-line and 6-line groups. The 3-line and 6-line groups' observed ending balances, wins, and LDWs were compared using independent samples t-tests.[1] As expected, participants who played the 6-line (many LDW) experienced significantly more LDWs during the playing session than participants who played the 3-line (fewer LDW) game, $t(42) = 10.10$, $p < .001$. Contrary to our expectations, however, participants who played the 6-line (many LDW) game also experienced more real wins during the playing session than participants who played the 3-line (fewer LDW) game, $t(42) = 2.22$, $p < .05$. Given this significant difference, numbers of real wins were statistically controlled for in all subsequent win-estimate analyses. Finally, as expected, the two groups did not differ in how much they won or lost during the playing session, $t(42) = .39$, $p = .701$, since the number of lines played has no effect on the payback percentage[2] (Harrigan, Dixon, MacLaren, Collins, & Fugelsang, in press).

[1] As discussed, the downfall of using a real slot machine is that the results for each participant are inherently variable. Given that our participants only played 200 spins on the slot machine, and that the expected values of the 3-line and 6-line games are based on the computer analysis of the 259 440 000 possible outcomes on Lobstermania (Dixon et al., 2010), we compared the two groups' *observed* numbers of wins, LDWs, and ending balances during the playing session using inferential statistics.

[2] While this may seem counterintuitive at first, it is important to note that increasing the number of lines played also increases one's spin wager, and as a result, the amount that can be lost per spin.

Table 2.2 Mean observed slot machine outcomes during the 200-spin playing session. Standard deviations are shown in brackets.

	3-lines	**6-lines**
# LDWs (/200 spins)	7.0 (2.5)	19.1 (4.9)***
# Wins (/200 spins)	16.4 (4.0)	19.0 (3.8)*
End Balance (credits)	2040.9 (561.7)	2117.6 (721.9)

* $p < .05$, ** $p < .01$, *** $p < .001$

Given the marked audio-visual similarity between wins and LDWs, we predicted that participants would conflate LDWs and wins in memory, leading participants who experienced more LDWs during the playing session to recall winning more often than participants who experienced fewer LDWs. We tested our prediction using two different methods. As a first assay, we analyzed whether participants playing the many LDW (6-line) game estimated winning significantly more often than participants playing the fewer LDW (3-line) game by submitting participants win estimates to a single hierarchical linear regression model, entering each participants' observed number of actual wins into the model first (as a "nuisance" variable), followed by the game that the participant played (i.e., 3-lines or 6-line). Our analysis revealed that participants in the many LDW (6-line) group estimated that they won significantly more often than participants in the 3-line group, despite how many times they player actually won, $R^2_{change} = .184$, $F_{change}(1, 41) = 9.32$, $p = .004$ (Figure 2.2). The final regression model with both parameters was significant, $F(2,40) = 5.85$, $p = .006$. Model parameters and statistics are reported in Table 2.3.

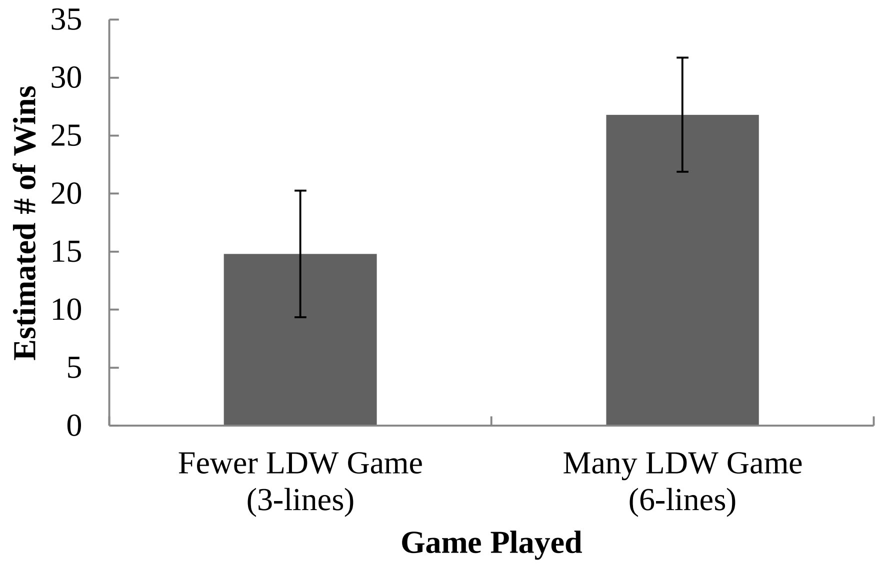

Figure 2.2 Participants' win estimates after playing either 200 spins on a many LDW (6-line game) or a fewer LDW (3-line) game. Error bars represent 95% Confidence Intervals for Between Subjects Designs (Masson & Loftus, 2003).

Table 2.3 Regression coefficients and statistics from the model predicting participants' win estimates from observed numbers of actual wins and game played (3-lines with few LDWs or 6-lines with many LDWs).

	B	**spr**	**t**	**p**
Wins (#/200 spins)	.220	.074	.473	.649
Game Played	11.42	.430	3.05	.004

Next, we examined whether experiencing more LDWs during a playing session would lead to more recalled wins following the playing session, regardless of which game was played (3-line or 6-line), or how many actual wins were experienced, or how much was won or lost overall during the playing session. To evaluate whether LDWs had a significant, and unique, influence on participants' recalled numbers of wins, we submitted participants' estimates from both groups into a single hierarchical linear regression model, entering each participants' observed number of actual wins and ending balance (in credits) into the model first (as "nuisance" variables), followed by each participants' observed number of LDWs. Our analysis revealed that the more LDWs experienced, the higher one's estimated number of wins, despite how many times the player actually won money or how much the player won or lost overall, R^2_{change} = .172, F_{change} (1, 40) = 9.59, p = .004. The final regression model with all three parameters was significant, $F(3,40) = 5.29$, p = .004. Model parameters and statistics are reported in Table 2.4.

Thus far, we have shown that participants who experience more LDWs during a playing session recall winning more often than participants who experienced fewer LDWs. Next, we evaluated whether LDWs lead players to recall winning significantly more often than they actually did during a given playing session – that is – whether LDWs lead players to *overestimate* how many times they won. The purpose of this additional analysis was to evaluate whether participants *within* a given group would also recall winning significantly more often than they had due to the presence of LDWS. To evaluate the possibility of an *LDW overestimation effect*, we subtracted the observed number of actual wins from the participant's estimated number of wins (i.e., the larger the resulting value the bigger the overestimation effect). The overestimation effect values for the 3-line (few LDWs) group were compared to the overestimation values for the 6-line (many LDWs) group using an independent t-test. The overestimation values for the 6-line group (M = 7.79) was significantly greater than the overestimation values for the 3-line group (M = -1.60), $t(37.6) = 2.73$, p = .01 . Next, we submitted the overestimation values from the 3-line (few LDW) group and 6-line (many LDWs) to one-sampled t-tests, evaluating whether the size of the observed overestimation effects were significantly greater than zero. The analyses revealed that participants who played the 3-line game with relatively fewer LDWs did not significantly overestimate how many times they won during the playing session, $t(19) = -.88$, p = .39., while participants who played the 6-line game with relatively more LDWs did significantly overestimate how many times they won during the playing session, $t(23) = 2.67$, $p = .014$.

Table 2.4 Regression coefficients and statistics from the model predicting participants' win estimates from observed numbers of real wins, ending balance on the slot machine, and number of LDWs experienced during the 200 spin playing session.

	β	**spr**	**t**	**p**
Wins (#/200 spins)[3]	.11	.038	.241	.811
End balance (credits)	.005	.271	1.78	.082
LDWs (#/200 spins)	.759	.440	3.10	.004

Subjective Experience

We surmised that if players miscategorized LDWs as wins, then participants who experienced more LDWs during the playing session may have found the game more subjectively arousing, exciting, or enjoyable than participants who experienced fewer LDWs during the playing session. Our analyses, however, failed to reveal any significant difference between the many LDW (6-line) and fewer LDW (3-line) groups' subjective playing experience (all *ts* < .90, all *ps* >.98).

Verbal Categorization of Losses Disguised as Wins

Following the 200-spin playing session, we evaluated whether participants would verbally miscategorize LDWs as wins or correctly categorize these outcomes as losses. Four participants never experienced an LDW during the 50-spin "think-out-loud protocol", and as such, were removed from

[3] Note that the variability in the numbers of observed wins across participants was quite small (SD = 4.04).

subsequent analyses. Three additional participants were also excluded from subsequent analyses, as they failed to use the words “win”, “gain”, or “loss” (e.g., said “yay” instead) in their verbal categorizations.

As shown in Figure 2.3, only 17.5% (N = 7) participants correctly categorized LDWs as losses during the 50-spin “think-out-loud” protocol; whereas, 82.5% (N = 33) miscategorised LDWs as wins. To gain a more conservative measure, we analyzed the free-reports given by participants on spins that were LDWs. Using these reports, “LDW miscategorizers” were subdivided into two groups: *uncertain* miscategorizers and *unaware* miscategorizers. *Uncertain* miscategorizers were those participants who always miscategorized LDWs as wins but *at any time* seemed uncertain about their miscategorization (e.g., “a win, I think”). Conversely, *unaware* miscategorizers were those participants who always miscategorised LDWs as wins and *never* seemed uncertain about their miscategorization (e.g., “yay, a win of 2, about time!”). *Uncertain* and *unaware* subcategorization was done by two independent coders and there was substantial agreement amongst coders, Cohen’s Kappa = .669, $p < .001$. The more conservative of the two subcategorizations (i.e., the one that places the fewest people in the unaware micategorization group) is reported in Figure 2.3 (uncertain miscategorizers are shown with a stacked, hatched, bar). As shown in Figure 2.3, only 39% (N = 13) of miscategorizers ever voiced any uncertainty about their miscategorization, while 61% (N = 23) of miscategorizers appeared certain that LDWs were wins. Thus, over half of our sample (57.5%) **never** showed any indication that LDWs were in fact financial losses.

2.1.3 Discussion

We assert that the positive reinforcement in multiline video slot machine games may be very effective at hiding monetary loss. Participants in our study who experienced many LDWs recalled winning significantly more often than participants who experienced fewer LDWs, regardless of how many times they actually won. We assert that this misremembered win frequency is one source of evidence suggesting that participants psychologically miscategorize LDWs as wins rather than correctly categorizing these outcomes as the losses that they truly are.

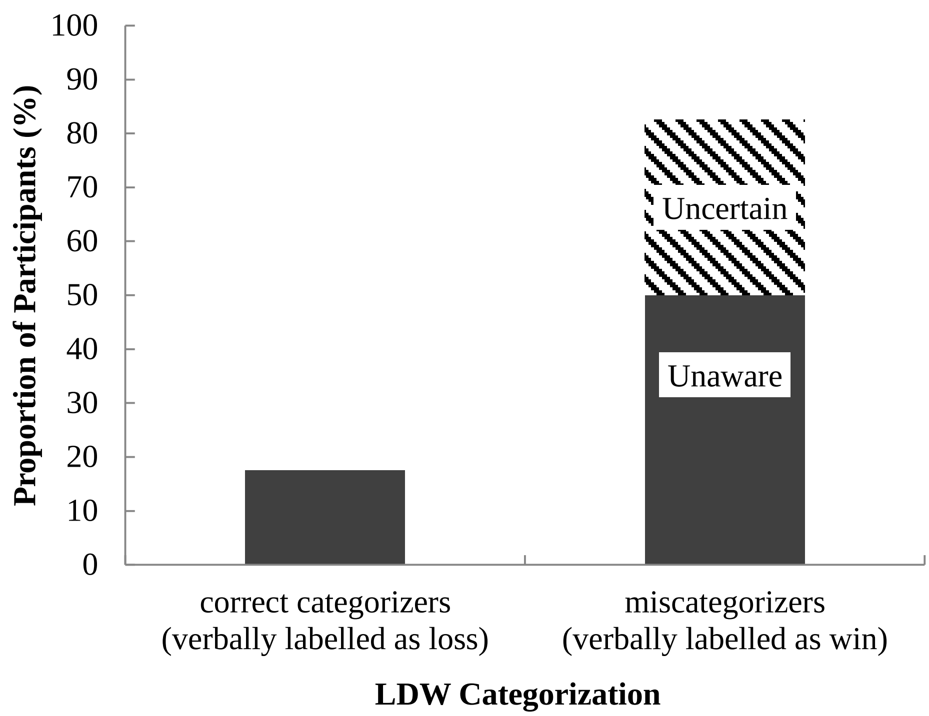

Figure 2.3 Participants' verbal categorization of LDWs during the 50-spin "think-out-loud" protocol. The left bar represents the proportion of participants who correctly labeled LDWs as losses and the right bar represents the proportion of participants who miscategorized LDWs as wins. The right bar (LDW miscategorizers) is further subdivided into the proportion of participants who ever seemed uncertain about miscategorizing LDWs as wins (uncertain miscategorizers; hatched portion) and those participants who never showed any indication that LDWs were not wins (unaware miscategorizers; solid portion).

We argue that the similarity in celebratory audio-visual feedback accompanying both wins and LDWs leads to perceptual conflation of LDWs and real wins, and as a result, to participants' psychological miscategorization of LDWs as wins. As such, we predicted that experiencing LDWs during a playing session should lead participants in the many LDW game to show a significantly larger overestimation of win frequency than participants in the fewer LDW game and in fact found that participants playing the many LDW game significantly overestimated how many times they won compared to participants playing the fewer LDW game.

Although we contend that gamblers miscategorize LDWs as wins, leading many individuals to estimate that they won significantly more often they actually had, some limitations in our study require further investigation. Specifically, given that we used a real slot machine, we were unable to control for extraneous variables, such as the number of bonus rounds (if any) the participant experienced during the playing session or the size of individual (and potentially large) wins. These sources of variability would show up as error variance, and possibly reduce effect sizes.

As another point of discussion, participants in this study were asked to estimate how many times they "won" during a playing session and to categorize spin outcomes as either "wins" or losses. We contend that it is possible that different participants may have interpreted a "win" in one of several different ways - a spin where the machine provides audio-visual feedback, a spin where the machine returns anything greater than 0 credits, or a spin that returns more than the amount wagered. Gaboury and Ladouceur (1987) previously showed that using a "think out loud" protocol during a playing session was an informative means of evaluating gamblers' erroneous cognitions (e.g., illusion of control) during a playing session. Using a similar protocol, we found that over half of our participants may have been completely taken in by the audio-visual reinforcement given by the machine, potentially relying solely on this information to decide if they had won or lost. We take this finding as a second line of evidence that positive reinforcement in multiline games can effectively hide loss from gamblers during a playing session.

Given that we found that the majority of novice gamblers miscategorize LDWs as wins, we also presumed that gamblers may find games with more LDWs more subjectively arousing, exciting, or enjoyable than games with fewer LDWs. Once again the fact that we assessed players playing an actual slot machine may have undermined our attempts to demonstrate these relationships. Whilst playing on an actual machine may be more enjoyable, or arousing than playing on a simulator, the fact that we did not have precise empirical control over the outcomes (number of actual wins, losses, LDWs, size of wins, and bonus round entries) may have all contributed to error variance. This is especially the case concerning certain structural characteristics like bonus round entries – extremely interactive and exciting departures from regular game play, which may have distorted arousal and excitement ratings. In short, in order to assess whether gamblers find games with many LDWs more arousing, exciting, and enjoyable than games with few LDWs, one needs a design with greater empirical control.

Chapter 3: REMEMBERING WINNING DESPITE LOSING ON MULTILINE SLOT MACHINE GAMES

In Study 1, we showed using a real slot machine, that the majority of novice gamblers miscategorize LDWs as wins using two measures: (1) the number of wins participants recalled during a playing session and (2) participants' verbal categorizations of LDWs. With regards to number of wins recalled, we argued that participants' LDW miscategorization was evident because participants who experienced more LDWs during a playing session recalled winning significantly more often than participants who experienced fewer LDWs during the playing session. We also showed that gamblers exposed to many LDWs recalled winning significantly more often than they actually won (the LDW overestimation effect). We contended that these results indicate that players miscategorized LDWs as wins, leading them to conflate LDWs and wins in memory.

The overarching goal of Study 2 was to assess whether we could replicate the LDW overestimation effect observed in Study 1 using a repeated measures design and a slot machine simulator that allowed us to control the structural characteristics of the "fewer" and "many" LDW games. Employing a repeated measures design also afforded us the opportunity to evaluate whether participants would report that they preferred playing a game with more LDWs rather than fewer LDWs. If gamblers do in fact miscategorize LDWs as wins, then one would predict that they would prefer playing the game with "more" rather than "fewer" wins. Finally, given Dixon et al.'s (2010) finding that LDWs are more arousing than regular losses, we hypothesized that participants may show higher levels of physiological arousal, or report greater subjective arousal, excitement, or enjoyment, while playing a slot machine simulator game with more LDWs rather than fewer LDWs.

3.1 Experiment 1

3.1.1 Method

Participants

Seventeen undergraduate students from the University of Waterloo participated in this experiment for financial remuneration. Two of these participants failed to meet our inclusion criteria that they must be free from any gambling problems. Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) scores indicated that one was at-risk for problem gambling, and the other was a problem gambler. The 15 remaining participants (10 females) were between the ages of 19 and 24 (M = 20.93). Participants gambling habits (e.g., frequency and type of gambling) were assessed using the Canadian Problem Gambling Index (CPGI; Ferris & Wynne, 2001) which revealed that all participants were novice slot machine gamblers - 14 had never played a slot machine in the past 12 months and one had played once during this time-frame. All methods and procedures were approved by the University of Waterloo's Office of Research Ethics.

Apparatus

Slot Machine Simulator. Figure 3.1 shows a screenshot of the slot machine simulator used in this experiment (copyright Game Planit Interactive Corp). This simulator is a multiline game (with high fidelity graphics) that allows a gambler to wager on up to 9 lines per spin, at up to 5 credits per line, for a possible max-bet wager of 45 credits. As shown in Figure 3.1, the simulator has five reels, with three symbols visible on a reel at any given time. Gamblers interact with the simulator (i.e., choosing the number of lines played, spinning the reels, etc.) by clicking on various icons with a mouse. The simulator was run on a PC (hp workstation xw8000) and displayed on a 19 inch monitor (Samsung SyncMaster 912N). The monitor was placed on a desk, with two speakers (Labtec Spin-75) located on either side of the monitor.

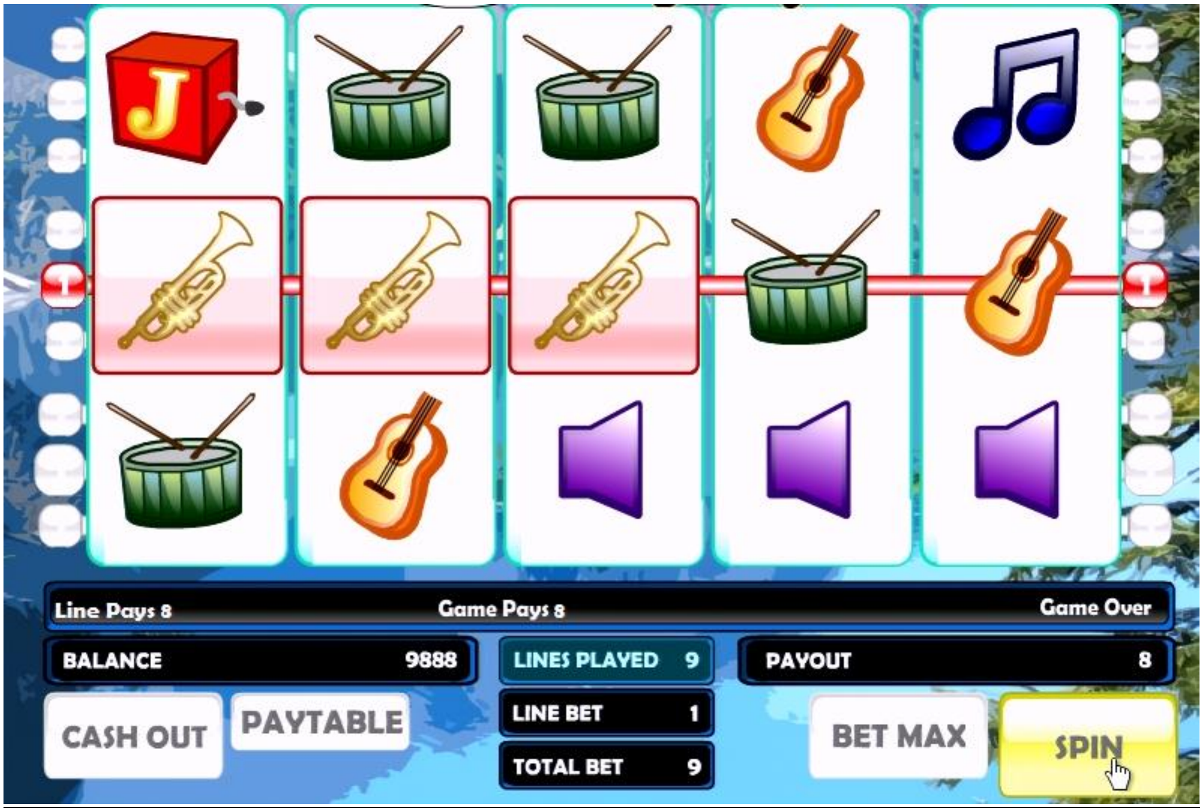

Figure 3.1 Screenshot of the simulator used in Experiment 1 and Experiment 2. The screenshot also shows an example of an LDW.

The simulator played a “spinning reels” sound whenever a spin was initiated. As previously discussed, on actual slot machines both LDWs and wins are typically accompanied by a rolling sound that “counts up” the gamblers’ “winnings”. The rolling sounds used in the simulator were patterned after an actual slot machine. The sound files that were generated ensured that the larger the win, the longer, (and for big wins, the more elaborate) the winning song. The lengths of the sound files for each wins size are shown in Table 3.1.

SCR and HR Recording. In order to compute participants’ average skin conductance levels (SCLs) and heart rate (HR), non-gelled electrodes were attached to the upper phalanges of participants’ left ring and index fingers and three reusable clamp-on HR electrodes to the participants’ left and right biceps and left wrist (ground). Both the SCL and HR electrodes were attached to an eight channel, ADinstruments Powerlab (model 8/30) equipped with Bio and GSR amplifiers. Average SCLs and cyclic heart rate were computed offline using ADinstruments' LabChart 7.0 analysis software. In the case that participants had one or more muscle movement artifact(s) during a game epoch that could not be removed by offline filtering, average SCLs and cyclic heart rate were computed by taking a weighted average of the sub-epochs surrounding the artifact(s).

Table 3.1 Length of "winning" rolling sound depending on "winning" credit size

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**	27.3

Design

Participants played 200 spins (each) on two simulator games: a 3-line game with few LDWs and a 9-line game with many LDWs. Participants were randomly assigned to play either the 3-line or 9-line game first (followed by the remaining game). The specific characteristics of the 3-line and 9-line games are shown in Table 3.2 and in Figure 3.2. As shown in Table 3.2, the 3-line game had fewer LDWs (n = 4) than the 9-line game (n = 46), while both games had identical numbers of actual wins (n = 19).

Table 3.2 Experiment 1 - Game characteristics of the few (3-line) LDW and many (9-line) LDW simulator games used during the playing session.

	Few LDW (3-line) Game	Many LDW (9-line) Game
lines played	3	9
wager per line (credits)	3	1
total spin wager (credits)	9	9
starting balance (credits)	10,000	10,000
ending balance (credits)	9,820	9,820
#spins	200	200
#wins (/200 spins)	19	19
#LDWs (/200 spins)	**4**	**46**

Figure 3.2 Experiment 1 **-** Screenshots of the simulator showing the 3-line game (left) and 9-line line game (right) used during the playing session.

To ensure identical spin wagers in both games, participants bet 3 credits per line in the 3-line game and 1 credit per line in the 9-line game for a total wager of 9 credits on each spin (in both games). The starting balances on both games were pre-set to 10,000 credits. To ensure identical ending balances on the 3-line and 9-line games, LDWs and wins (of different sizes) were chosen for each game, so that after 200 spins players had an identical end balance of 9,820, for a payback percentage of 90% in both games. For each game, ten different random orders of the (same) spin outcomes were created, and participants were randomly assigned to play one of the 10 game orders.

In addition to the 3-line and 9-line games, participants were given 20 practice spins (containing 4 LDWs, 4 wins, and 12 regular losses) prior to each game in order to familiarize them with the respective game. At the end of the playing session, participants played two additional sets of 10 spins on the 9-line game. Each set contained one LDW, one actual win, and eight regular losses. In the first set of 10 spins, the win appeared in the fourth position and the LDW appeared in the seventh position. In the second set of 10 spins, the positions of the win and the LDW were reversed. Set order (i.e., which set they played first) was counterbalanced across participants.

Procedure

After reading information letters and signing consent forms, participants completed a background health and gambling questionnaire. This form verified that participants were: (1) over 19 years of age (the legal gambling age in Ontario), (2) did not have a heart condition that could interfere with the recording of one's heart rate, (3) were not taking anxiolytic medication that could interfere with SCL recordings, and (4) were not in treatment for problem gambling. Participants were seated in front of the simulator (at a distance of approximately 57 cm) and were fitted with heart rate and SCL electrodes. Participants were administered the CPGI during the equipment acclimatization period.

Participants were given a tutorial on the slot machine simulator. The experimenter explained that the slot machine had 5 reels, that there were 3 symbols visible on any reel at any given time, and that they could spin the reels on the slot machine by pressing the spin icon on the monitor with the mouse cursor. Participants were then shown the various pay tables available on the simulator game - akin to the pay tables available on a real video slot machine games.

The experimenter described all of the various counters on the bottom of the simulator display (Figure 3.2). Participants were shown the “running total” counter (pre-set to 10,000 credits) and informed that this counter showed their starting balance in slot machine 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. Unbeknownst to the player, however, all participants received $5 for each game.

The experimenter then explained that they were going to play two different games on the simulator. The experimenter pointed to the “lines played” counter and informed the participant that they were going to play three (or nine) lines in this game. They were shown how to select the number of lines played by clicking on the “line bet” counter. The experimenter explained that because they were playing three (or nine) lines, at three (or one) credit(s) per line, their total spin wager was nine credits. The experimenter reiterated, while pointing to the “total bet” counter that displayed nine credits, that this meant that every time they spun the reels on the slot machine, they were betting nine credits. Finally, the experimenter explained that the “payout” counter would display the total amount of credits acquired on a spin, if any. Participants were informed that they could spin as quickly or as slowly as they would like during the game, but to please wait for any sound to go away, before spinning again.

Participants were asked to play 20 practice spins on the 3-line (or 9-line) 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 then asked to play 200 spins on the 3-line (or 9-line) game. After the game, the experimenter placed a lap top in front of the participant and asked them to answer the following questions: (1) “Please rate your level of arousal while playing the slot machine. Think of arousal in terms of how fast your heart is beating or how clammy your hands feel. Thinking of arousal in this way, please rate your level of arousal on a scale from 1 to 7, where 1 means your experience was not arousing and 7 means it was very arousing”, (2) “Please rate your level of excitement while playing the slot machine - that is - give me a number between 1 and 7, where 1 means your experience was not exciting and 7 means it was very exciting”, (3) “Please rate your level of enjoyment while playing the slot machine - that is - give me a number between 1 and 7, where 1 means your experience was not enjoyable and 7 means it was very enjoyable”, and (4) “In this session you had 200 spins. Of these 200 spins, please estimate the number of times on which you won - that is, give me a number between 1 and 200”.

Participants were given a short break following the first game. After the break, the entire *practice spin – 200 spin playing session - post-game question set* process was repeated for the second 9-line (or 3-line) game. Following the two games, participants were asked to answer the following question on the laptop: “Which game did you prefer playing, the first game with 3 (or 9) lines or the second game with 9 (or 3) lines?” At the end of the playing session, participants were asked to spin the reels on the simulator an additional 10 times, and to report after each spin, whether they won or lost. The experimenter then defined a win for the participant as follows: “A win is when you get more credits on a spin than you wagered, or bet, on the spin”. Participants were asked to spin the reels on the simulator an additional 10 times, and again, to report after each spin, whether they won or lost.

After the experiment, participants were asked to answer some additional questions. These questions served as pilot research for future studies, and as such, are not considered further. At the end of the experiment, participants were debriefed and paid $25. Participants were thanked for their participation, given an executive summary of the experiment, and two responsible gambling brochures.

3.1.2 Results

Win Estimates Following the Few LDW (3-line) and Many LDW (9-line) Games

Given the marked audio-visual similarity between wins and LDWs, we hypothesized that participants would miscategorize LDWs as wins, leading them to conflate LDWs and wins in memory. As such, we predicted that participants would estimate that they won significantly more often in a game with more LDWs (9-line game) than in a game with fewer LDWs (3-line game), despite identical numbers of actual wins and identical payback percentages. We tested this prediction by comparing participants' estimated number of wins following each game using a paired samples t-test. As predicted, participants estimated that they won significantly more often in the 9-line game with 46 LDWs (M = 45.93, SD = 24.06) than in the 3-line game with only 4 LDWs (M = 20.33, SD = 9.34), $t(14) = 4.71$, $p < .002$. As noted in Chapter 2, we refer to this type of memory error as the *LDW overestimation effect*. This effect is illustrated in Figure 3.4 (left bars).

Recall that in each game there were 19 actual wins. The win estimates from each game (3-line, 6-line) were analyzed using one-sampled t-tests, comparing participants' estimated numbers of wins to the actual number of wins experienced in both games (i.e., 19 in both cases). Participants estimates of how often they won in the 3-line game with 4 LDWs (M= 20.33, SD = 9.34) were quite accurate, $t(14) = .55$, $p = .59$. Participants estimates of how often they won in the 9-line game with 46 LDWs, (M = 45.93, SD = 24.06) were by contrast quite inaccurate, $t(14) = 4.34$, $p = .001$. On average, participants overestimated the number of times on which they won in the 9-line game by more than 26 wins. Participants' overestimations are depicted by the hatched bars in Figure 3.4 (left bars).

Game Preference and Game Experience

In terms of game preference, given that participants recalled winning more often during the many-LDW game than the few-LDW game, we predicted that that participants would prefer playing the 9-line game with more "wins" than the 3-line game with fewer "wins". Contrary to our prediction less than half the sample (7 of 15) preferred the many-LDW game. Proportions of participants choosing the many and fewer LDW games are shown in Figure 3.5 (left bars).

In terms of physiological arousal, and excitement and enjoyment, given that participants recalled winning more often in the many LDW (9-line) game than in the fewer LDW (3-line game), we hypothesized that participants may become more aroused while playing the many LDW game, and that they may subjectively rate the many LDW game as being more arousing, exciting, and enjoyable. As shown in Table 3.4 none of these predictions were confirmed. In fact, the only significant difference on any of these measures was that players indicated that they subjectively enjoyed playing the game with **fewer** LDWs more than they enjoyed playing the game with many LDWs (see bottom row of Table 3.4).

Table 3.3 Experiment 1 – Participants' mean heart rate (BMP), skin conductance levels (SCLs), subjective arousal, subjective excitement, and subjective enjoyment while playing the few LDW (3-line) game and many LDW (9-line) game.

	3-Line Game (4 LDWs)		**9-Line Game (46 LDWs)**		**Paired Samples t-tests**		
	M	**SD**	**M**	**SD**	**direction**	**t**	**p**
BPM	77.70	11.39	77.37	10.15	3 > 9	-.29	.78
SCL	.62	5.07	.53	3.84	3 > 9	-.17	.87
Subjective Arousal	3.20	1.61	3.27	1.39	9 > 3	.24	.82
Subjective excitement	3.46	2.03	3.23	1.54	3 > 9	-1.00	.34
Subjective enjoyment	3.67	1.8	3.33	1.84	3 > 9	-2.65	.02*

Verbal Categorization of LDWs

Following the playing sessions, participants categorized 10 spins as either a win or a loss. Seventy percent (N= 12) of the participants in this study verbally miscategorized the LDW as a win rather than correctly categorizing the LDW as a loss (N = 3). Interestingly, after the experimenter subsequently defined a win as one where you win more than you wagered, two participants still miscategorized the LDW in the second set of 10 spins as a win rather than a loss. Given these results, we assert that the positive reinforcement given by multiline slot machine games may be very effective at hiding monetary loss.

3.1.3 Discussion

In Experiment 1, we found that participants estimated that they won significantly more often in a 9-line game with many (n = 46) LDWs than in a 3-line game with fewer (n = 4) LDWs, and that those exposed to many LDWs estimated that they won significantly more often than they actually did. We assert that this significant LDW overestimation effect supports our argument that the majority of individuals miscategorize LDWs as wins rather than correctly categorizing these outcomes as losses due to the marked audio-visual similarity between these outcomes. Despite the fact that participants recalled winning significantly more often in the many compared to fewer LDW games, slightly less than half of the participants in Experiment 1 reported that they preferred playing the game with more rather than fewer "wins". In addition, we failed to find any evidence that the many LDW game was more physiologically arousing, or subjectively arousing, exciting, or enjoyable, than the fewer LDW game.

These latter results at first may seem to undermine our argument that LDWs significantly contribute to the allure of multiline slot machine games. However, one must consider the following: First in order to equate the overall payback percentage of each game, we needed to include a small number of relatively large wins (e.g., of 300 credits) in the 3-line games. Thus, there is a possibility that some participants may have found these salient "larger wins" in the 3-line game overarchingly rewarding, potentially leading them to prefer the 3-line game with the "big wins" over the 9-line game with the more frequent reinforcement, but without any "big wins".

3.2 Experiment 2

The goal of Experiment 2 was two-fold. First, if it is truly the number of LDWs that led participants to recall winning more often in the game with more rather than fewer LDWs, then reducing the number of LDWs in the "many" LDW game should lead to a significant reduction in this LDW overestimation effect. Moreover, reducing the number of LDWs in the "many LDW" game would also allow for a reduction in the size of the larger wins needed in the 3-line game to equate the payback percentage. As such, if participants in Experiment 1 were in fact preferring the 3-line game due to the presence of a few (relatively) big wins, then participants in the current experiment playing a "moderate" LDW game with consequently more moderately sized large wins, should be less likely to report that they preferred playing the 3-line game, and potentially, more likely to report that they prefer playing the game with more LDWs (the 6-line game).

3.2.1 Method

Participants

Sixteen (11 females) undergraduate students from the University of Waterloo participated in this experiment for financial remuneration. Ages ranged from 19 to 31 (M = 21.31). Participants were free from any gambling problems, all having PGSI scores of zero. All participants indicated on the CPGI that they had played a slot machine either twice (N = 1), once (N = 2) or zero times (N = 13) in the past 12 months. All methods and procedures were approved by the University of Waterloo's Office of Research Ethics.

Apparatus

Slot machine simulator. We used the same simulator and methods for creating sound files as previously described in Experiment1.

SCR and HR Recording. All methods were identical to those described in Experiment 1.

Design

The design was identical to Experiment 1, except that the many LDW (9-line) game was replaced with a "moderate" LDW (6-line) game with 26 LDWs. The characteristics of the 3-line and 6-line games are shown in Table 3.5 and in Figure 3.3. To ensure identical spin wagers, participants bet two credits per line in the 3-line game (compared to 3 credits per line in Experiment 1) and one credit per line in the 6-line game, for a total spin wager of 6 credits (in both games). The starting balance on each game was pre-set to 10,000 credits and combinations of the wins and LDWs were chosen such that each game had an ending balance of 9,820 credits (90% payback percentage) following the 200-spin playing session.

Procedure

All procedures were identical to those described in Experiment 1, except that instructions were changed to match the new game characteristics (i.e., number of lines played, wager per line, and total bet).

3.2.2 Results

Win Estimates Following the Few LDW (3-line) and Moderate LDW (6-line) Games

If participants are truly miscategorizing LDWs as wins, then participants' should estimate that they won significantly more often in the 6-line game with 26 LDWs than in the 3-line game with only 4 LDWs. We tested this prediction by comparing participants' win estimates following the 3-line and 6-line games using a paired samples t-test. As predicted, participants estimated that they won significantly more often in the moderate LDW (6-line) game (M = 34.81, SD = 13.90) than in the fewer LDW (3-line) game (M = 23.94, SD = 15.83), despite identical numbers of real wins in both game, $t(15) = 3.80$, $p = .001$ (one tailed). This significant LDW overestimation effect is illustrated in Figure 3.4 (right bars).

Next we evaluated whether participants in both the few LDW (3-line) and moderate LDW (6-line) games significantly overestimated how many times they won in each game due to the presence of LDWs. The win estimates from each game (3-line, 6-line) were analyzed using one-sampled t-tests, comparing participants' estimated numbers of wins to the actual number of wins experienced in both games (i.e., 19 in both cases). Participants did not significantly overestimate how many times they won in the 3-line game with only 4 LDWs, $t(15) = 1.25$, $p = .23$, but did significantly overestimate how many times they won in 6-line game with 26 LDWs, $t(16) = 4.55$, $p < .001$. Participants' overestimation effects are depicted by the hatched portion of the right bars in Figure 3.4.

If LDW frequency can influence how many wins a participant will recall during a playing session, then we hypothesized that the LDW overestimation effect observed in this experiment should be significantly smaller than the LDW overestimation effect observed in Experiment 1 since, the 6 line game

(26 LDWs) had fewer LDWs than the 9-line (46 LDWs) game in Experiment 1. To assess whether the LDW overestimation was indeed significantly reduced in Experiment 2, we compared the size of the LDW overestimation effect observed in Experiment 1 (i.e., individuals' estimates from the 9-line game minus their estimates from the 3-line game) to the size of the overestimation effect observed in Experiment 2 (i.e., individuals' estimates from the 6-line game minus their estimates from the 3-line game) using an independent samples t-test. This t-test revealed that reducing the number of LDWs from 46 in the "many" LDW game in Experiment 1 to 26 in the "moderate" LDW game in Experiment 2 did in fact lead to a significant reduction of the LDW overestimation effect, $t(29) = 2.44$, $p = .021$ (Table 3.3).

Game Preference and Game Experience

With regards to game preference, given that participants recalled winning more often in the moderate-LDW (6-line) game than the few-LDW (3-line) game, we predicted that that participants would prefer playing the 6-line game with more "wins" than the 3-line game with fewer "wins". Indeed, the vast majority of participants (N = 13) reported that they preferred playing the moderate LDW game, while fewer participants (N = 3) preferred playing the fewer LDW (3-line) game. Proportions of participants choosing the many and fewer LDW games are shown in Figure 3.5 (right bars).

With regards to physiological arousal and subjective experience, given that participants recalled winning more often in the many LDW (6-line) game than in the fewer LDW (3-line game), we hypothesized that participants may become more aroused while playing the moderate LDW game, and that they would subjectively rate the moderate LDW game as being more arousing, exciting, and enjoyable. As shown in Table 3.6, none of these predictions were confirmed (note that the t-tests for excitement and arousal ratings are based on 14 degrees of freedom due to participant rating omissions).

Table 3.4 Experiment 2 - Game characteristics of the few (3-line) LDW and moderate (6-line) LDW simulator games used during the playing session.

	Few LDW (3-line) Game	**Moderate LDW (6-line) Game**
lines played	3	6
wager per line (credits)	2	1
total spin wager (credits)	6	6
starting balance (credits)	10,000	10,000
ending balance (credits)	9,820	9,820
#spins	200	200
#wins (/200 spins)	19	19
#LDWs (/200 spins)	**4**	**26**

Figure 3.3 Experiment 2 - Screenshots of the simulator showing the 3-line game (left) and 6-line game (right) used during the playing session.

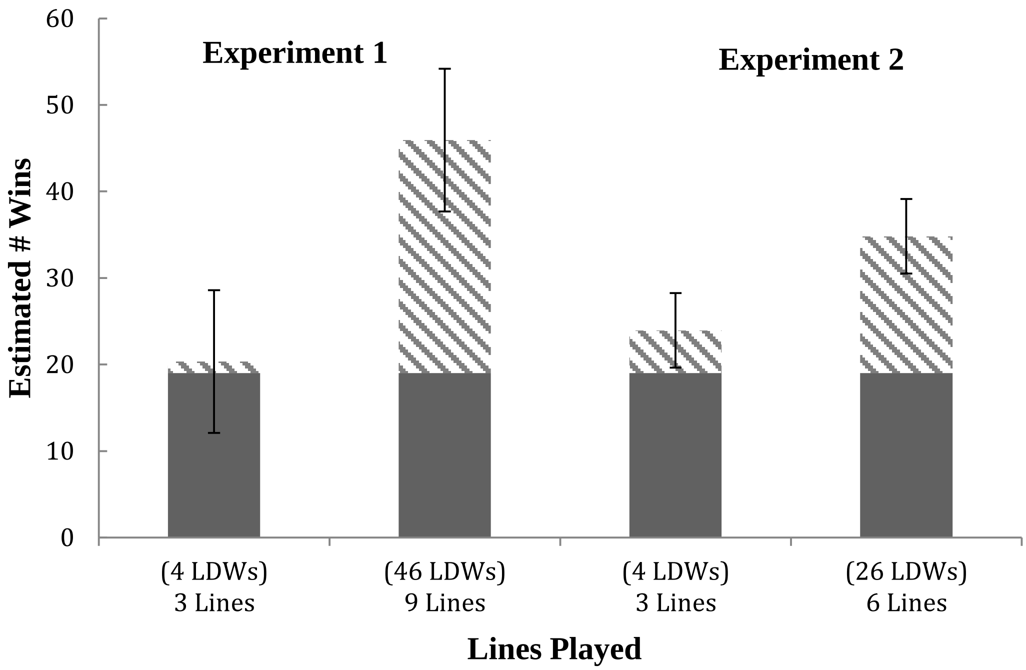

Figure 3.4 Participants' average estimates of the number of wins in Experiment 1 and Experiment 2. The two leftmost bars represent participants' win estimates after playing the few LDW (3-line) and many LDW (9-line) games in Experiment 1. The two rightmost bars represent participants' win estimates after playing the few LDW (3-line) and moderate LDW (6-line) games in Experiment 2. The solid portion of each bar represents the number of actual wins that participants experienced in all games (n=19). The hatched portion of each bar shows participants' overestimations in each game. Error bars represent 95% Confidence Intervals for Repeated Measures Designs (Masson & Loftus, 2003).

Table 3.5 Size of the *LDW Overestimation Effects* observed in Experiment 1 and Experiment 2.

	Experiment 1 (4 vs. 46 LDW games)		**Experiment 2** (4 vs. 26 LDW games)
Estimates from game with **more** LDWs	45.93		34.81
Estimates from game with **fewer** LDWs	20.33		23.94
LDW Overestimation Effect (**more** – **fewer**)	25.60	**>**	10.87

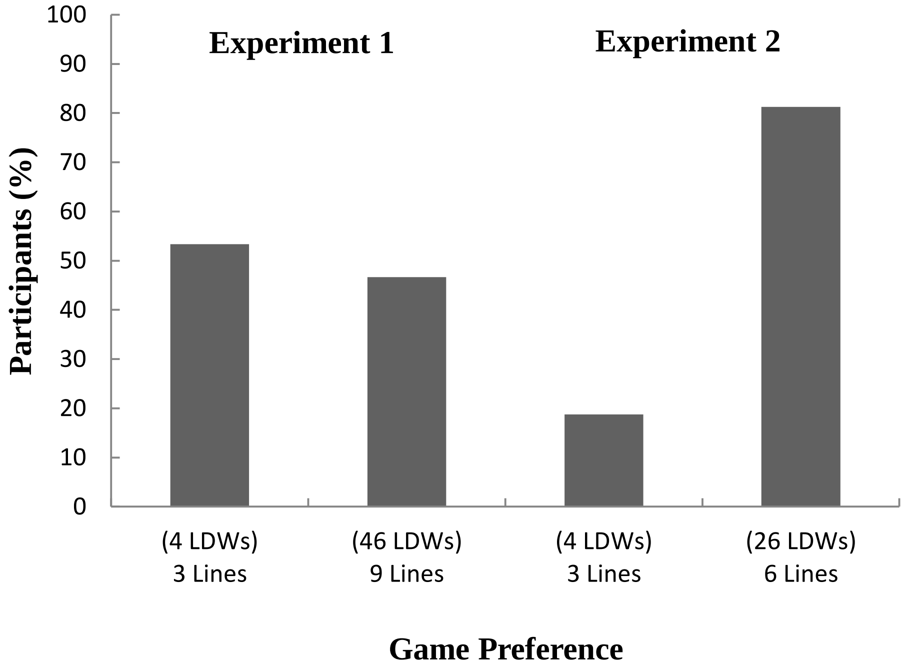

Figure 3.5 Participants' game preferences in Experiment 1 and 2. The two leftmost bars represent the proportion of participants in Experiment 1 who reported that they preferred playing the few LDW (3-line) game or the many LDW (9-line) game, respectively. The two rightmost bars represent the proportion of participants in Experiment 2 who reported that preferred playing the few LDW (3-line) game or the moderate LDW (6-line) game, respectively.

Table 3.6 Experiment 2 – Participants' mean heart rate in Beats Per Minute (BPM), skin conductance levels (SCLs), subjective arousal, subjective excitement, and subjective enjoyment while playing the few LDW (3-line) game and moderate LDW (6-line) game.

.	**3-Line Game (4 LDWs)**		**6-Line Game (26 LDWs)**		**Paired Samples t-tests**		
	M	**SD**	**M**	**SD**	**direction**	**T**	**p**
BPM	75.62	9.98	76.78	10.01	6 > 3	1.01	.33
SCL	-.31	3.20	-1.61	4.68	3 > 6	-1.62	.13
Subjective Arousal	2.75	1.29	2.81	1.42	6 > 3	.37	.72
Subjective excitement	2.75	1.29	2.81	1.42	6 > 3	1.87	.082
Subjective enjoyment	3.13	1.13	3.53	1.46	6 > 3	1.31	.21

Verbal Categorization of LDWs

Following the playing sessions, participants categorized 10 spins as either a win or a loss. In Experiment 2, **100%** of participants verbally miscategorized the single LDW as a win rather than correctly categorizing the LDW as a loss. Moreover, even after defining a win as one where you win more than you wagered, two participants still miscategorized the LDW as a win rather than a loss.

3.2.3 Discussion

In Experiment 2, we replicated the LDW overestimation effect observed in Experiment 1, showing that participants once again recall winning more often in games with more rather than fewer LDWs, despite experiencing identical numbers of actual wins and identical payback percentages in both games. What is truly remarkable about the results of Experiment 2 is that by reducing the number of LDWs in "many LDW" game from 46 (Experiment 1) to 26, while keeping the same baseline "fewer" LDW game with 4 LDWs, we found a significant **reduction** in the size of the LDW overestimation effect.

Thus, given the level of experimental control in our simulator games, the majority of participants in this study were in fact miscategorizing LDWs as wins, leading them to conflate LDWs and wins in memory. Our claim is further supported by the fact that every participant in this experiment verbally mislabeled the LDW as win rather than a loss, with two participants still mislabeling the LDW as a win even after the experimenter defined a win as one on which you won more than you wagered.

As previously discussed, participants in Experiment 1 did not show a preference for the many LDW (9-line) game despite reporting that this game had “more wins” than the few LDW (3-line game). We argued that this may have been due to some participants finding the few salient “large” wins in the 3-line game very rewarding. Reducing the number of LDWs in the “moderate” LDW (6-line) game (compared to the many LDW 9-line game) enabled us to replace these large wins with a few moderately sized wins. As such, we speculated that if participants in Experiment 1 were in fact reporting that they preferred playing the “fewer” LDW game due to the few “big” wins, then we could eliminate this artifact by reducing the number of these “big” wins. We evaluated this hypothesis by comparing participants’ game preferences in Experiments 1 to participants’ game preferences in Experiment 2 using Pearson’s Chi Square. The analysis indeed revealed that significantly more participants in Experiment 2 reported that they preferred playing the game with more rather than fewer LDWs compared to participants in Experiment 1, χ^2 (1) = 4.05, p = .044.

Despite the fact that the majority of participants in Experiment 2 reported that they preferred playing the game with more rather than fewer LDWs, we failed to find any differences between participants’ physiological arousal and subjective experience while playing these games. It is important to note, however, that participants were asked to play two rather long games (approximately 20 minutes each) on a slot machine simulator, which may not be nearly as arousing or exciting as a real slot machine game. Moreover, our procedure may have had an effect on participants’ playing experience. Specifically, all practice trials and games in this study were started by selecting the appropriate files from a drop down menu on the simulator's **display** monitor. As a result, we contend that the participants in this study were likely quite aware from the outset that there was no element of chance involved in these games – the element that makes gambling exciting in the first place. Future experiments could use a separate host computer (i.e., one that is not visible to the participant) to ensure that the simulator's display remains unchanged (i.e., similar to a real slot machine) during the playing session.

Chapter 4: GENERAL DISCUSSION

In two studies we investigated whether the positive reinforcement in multiline slot machine games would be effective at hiding monetary loss. We predicted that the marked audio-visual similarity between LDWs and actual wins and the marked dissimilarity between LDWs and regular losses would lead participants to miscategorize LDWs as wins rather than correctly categorizing LDWs as losses. We tested our predictions using two measures. In Study 1 we showed that participants who played a 6-line game on Lobstermania with more LDWs estimated that they won significantly more often than participants who played a 3-line game with fewer LDWs. We replicated and extended this overestimation effect in Study 2 using a repeated measures design and a slot machine simulator that enabled us to better equate the actual number of wins. In two experiments, we showed that participants estimated that they won more significantly more often in games with more LDWs (i.e., more lines played) than in a game with fewer LDWs (i.e., 3-lines played), despite identical numbers of wins and payback percentages in all games. Moreover, we showed that the more LDWs experienced in the many LDW game, the larger the size of this *LDW overestimation effect*. Given that we replicated this LDW overestimation in three experiments, we assert that participants were conflating LDWs and wins in memory due to the perceptual similarity between these outcomes.

In our second measure of miscategorization, we asked participants to verbally categorize LDWs as wins or losses. In Study 1, we found that the vast majority of participants verbally mislabeled LDWs as wins, rather than correctly labeling these outcomes as losses. Using a “think out loud” protocol, we also evaluated whether any of the participants who verbally mislabeled LDWs as wins ever seemed uncertain about their miscategorizations. Using this more conservative measure, we still found that over 50% of our sample not only verbally miscategorized LDWs as wins, but also showed no awareness that they were losing money on these outcomes. In Study 2, we found in both experiments that not only did the vast majority of participants miscategorize LDWs as wins, some participants still miscategorized LDWs as wins even after the experimenter specifically defined a win as one in which the gambler won more than they wagered. Thus, we contend that the vast majority of participants are taken in by the “winning” disguise accompanying LDWs, leading them to miscategorize monetary losses as wins. These results of these studies, taken together with Dixon et al.’s (2010) finding suggest that novice gamblers miscategorize LDWs as wins both psychologically and somatically. As a result, we contend that LDWs may contribute significantly to the allure of multiline slot machine games by effectively increasing the number of times a gambler thinks and feels that they are winning during a playing session.

In this series of experiments, we have assumed that the large amount of feature overlap between actual wins and LDWs caused participants to conflate these two events in memory, which in turn lead gamblers to overestimate the number of times on which they won during a gambling session. A much simpler alternative, however, is that participants simply encoded LDWs as wins. This alternative is supported by the large number of participants who failed to realize that LDWs were actually losses. Future studies could explore whether gamblers who are aware that LDWs are in fact losses still conflate LDWs with wins in memory. Concerning the relationship between LDWs and problem gambling - whether LDWs are mistakenly coded as wins, or correctly coded as losses but conflated with wins in memory, the key point remains that LDWs lead gamblers to remember winning more often than they actually did. As such, the memory of a gambling session may be unduly rewarding, and contribute to the allure of multi-line slot machines.

In both studies, we also evaluated whether participants would find games with more LDWs more subjectively arousing, exciting and enjoyable than games with fewer LDWs. While we did not find differences in participants’ subjective arousal, excitement, or enjoyment, nor in their physiological arousal in the large game epochs in Study 2, we did find that participants in our final experiment reported that they preferred playing games with more rather than fewer LDWs. This latter result is consistent with previous research showing that participants prefer games with higher reinforcement rates. For instance, Dixon, MacLin, and Daugherty (2006) previously found that the vast majority of participants preferred playing games with smaller but more frequent payouts than games with larger but less frequent payouts. In a more recent investigation, Young, Wohl, Matheson, Baumann, and Anisman (2008) showed that participants who were exposed to a “priming” session with a series of small wins persisted to gamble (voluntarily) for significantly longer during a losing streak than participants who experienced a single large win that was equivalent in magnitude. They argued that this persistence is consistent with learning theory – namely, that intermittent reinforcement leads to behaviours that are more resistant to extinction.

Harrigan and Dixon (2009), Haw (2009), and Harrigan et al. (in press) have shown that one way that gamblers can increase the reinforcement rate on multiline slot machine games is to increase the number of lines played. Harrigan et al. analyzed a multi-line slot machine called “Money Storm” that enables players to wager on up to 20 lines. After playing 5000 spins on a one-line game and 5000 spins on a 20-line game, they found that the payback percentages of both games were identical (90.5%). Thus, (consistent with their analysis of the PAR sheets for this game) playing multiple lines does not increase how much money the gambler wins (or loses). The reinforcement rate (i.e., number of wins and LDWs) on the 20-line game, however, far exceeded the reinforcement rate on the single-line game (wins). While they found that the percentage of actual wins was slightly greater in the 20-line (18.2% of spins) compared to the one-line game (15.4% of spins), what is absolutely remarkable is the number of LDWs that occurred in the 20-line game. Specifically, LDWs occurred on 29.7% of spins in the 20-line game, which combined with the number of actual wins, leads to a combined reinforcement rate of 47.8% (compared to only 15.4% in the one-line game). Thus, playing the maximum number of playable lines on Money Storm effectively increase the reinforcement rate of the game, without increasing the amount paid to the gambler.

Haw (2009) remarks that gamblers' abilities to change the reinforcement rate, by changing the number of lines played, may be the "operant link between the gambler and the reinforcer". Harrigan et al. (in press) further remark that using the mini-max strategy in multiline games may foster an illusion of control for some gamblers. Langer (1975) defined the illusion of control as being a perception of success that is higher than that mandated by objective probability, and argues that any games that can foster choice (e.g., being able to choose your own lottery ticket) can lead to the propensity to misperceive games of pure chance as games of skill. Harrigan et al. argue that enabling gamblers to adjust the reinforcement rate by increasing the number of playable lines may lead gamblers to believe that they have uncovered a successful "strategy" because they can maximize the number of "wins" by adopting a mini-max strategy.

As a final remark, we claim that LDWs may not only lead gamblers to believe that they are winning more often than they actually are, but may also influence gamblers in surrounding vicinities to believe that they are winning more often as well. According the cognitive *availability heuristic* (Tversky & Kahneman, 1973), individuals may judge the probability of chance events occurring by the ease with which they come to mind. As Griffiths (1994) remarks, slot machines are often placed in large groups beside each other such that the sounds of the machine (e.g., coins falling in a tray or rolling sound) can be heard constantly by all players, suggesting to players that wins are a common occurrence. Given that LDWs, like actual wins, are also accompanied by "winning sounds", and that LDWs can be an even more common occurrence than actual wins, multiline play in today's casinos may lead to an overall distorted perception that everyone in the casino is winning (!), regardless of the fact that the majority of players in a casino at any given time are most certainly losing money. This exciting "casino effect" may also contribute to the development and maintenance of problem gambling.

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