# Analysis of Gambling Behavior

Volume 8 | Article 1

2014

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Tadhg E. Daly
*Victoria University of Wellington*

Gordon Tan
*Victoria University of Wellington*

Lincoln S. Hely
*Victoria University of Wellington*

Anne C. Macaskill
*Victoria University of Wellington*, anne.macaskill@vuw.ac.nz

David N. Harper
*Victoria University of Wellington*

*See next page for additional authors*

*Analysis of Gambling Behavior* 2014, **8**, 55-70 Number 2 (Winter, 2014)

# Slot Machine Near Wins: Effects on Pause and Sensitivity to Win Ratios

Tadhg E. Daly, Gordon Tan, Lincoln S. Hely, Anne C. Macaskill, David N. Harper, & Maree J. Hunt
Victoria University of Wellington

When a near-win outcome occurs on a slot machine, stimuli presented resemble those presented when money is won, but no money is won. Research has shown that gamblers prefer and play for longer on slot machines that present near wins. One explanation for this is that near wins are conditioned reinforcers. If so, near wins would produce longer latencies to the next response than clear losses. Another explanation is that near wins produce frustration; if so, then near wins would produce shorter response latencies. The two current experiments manipulated win ratio across two concurrently available slot machines and also manipulated near win frequency. Latencies were longer following near wins, consistent with near wins functioning as conditioned reinforcers. We also explored the effects of near wins on sensitivity to relative win rate and found that higher rates of near wins were associated with greater sensitivity to relative win frequency, an effect also consistent with near wins as conditioned reinforcers.
*Keywords*: gambling, near win, near miss, response latency, generalized matching law

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People who predominantly gamble with slot machines develop a pathological profile faster than gamblers favoring other gambling activities (Breen & Zimmerman, 2002). This suggests that features of the gambling medium contribute to the likelihood that an individual's gambling will become problematic. Slot machines are controlled by payout algorithms with features likely to lead to persistent and frequent play. For example, all slot machines use random ratio schedules arranging intermittent reinforcement schedules that typically yield high rates of responding and high resistance to extinction (Ferster & Skinner, 1957; Jenkins & Stanley, 1950). Payout frequency (Dixon, Maclin & Daugherty, 2006), overall payback rate (Haw, 2008) and the delay between obtaining a win and receiving a payout (Chóliz, 2010) are other features of the slot machine medium that influence gamblers' preference for and persistence on a given slot machine.

The presence of near wins may also influence preference for (Ladouceur & Giroux, 2006; Dymond & Roche, 2010) and persistence on (e.g. Côte, Caron, Aubert, Desrochers & Ladouceur, 2003; Kassinove & Schare, 2001) a given slot machine. A near win (also called a near miss) is a loss that resembles a win; for example, four matching symbols constitute a near win when the machine's only winning combination is five matching symbols. Slot machines are programmed to produce a higher-than-chance proportion of near-win outcomes (Harrigan, 2007, 2008).

The processes through which near wins affect gambling behavior have yet to be identified. Kahneman and Tversky (1982) proposed that situations like near-win outcomes on slot machines produce more frustration than other losing outcomes because near wins

Address all correspondence to:
Anne C. Macaskill
Victoria University of Wellington
PO Box 600
Wellington, New Zealand, 6012
E-mail: anne.macaskill@vuw.ac.nz



 

make it easier to imagine having received a win. Loftus and Loftus (1983) suggested that this particular type of frustration, labeled "*cognitive regret"* by the authors, might be eliminated by continuing play. Amsel (1958) proposed that situation, such as near wins, that resemble those where rewards have previously been presented produce a frustration effect that increases the speed and strength of ongoing operant behavior, in this case, causing faster responses to escape frustrating near-win outcome stimuli. This idea was revisited by Dixon and colleagues (Dixon, et al., 2011; Dixon, MacLaren, Jarick, Fugelsang & Harrigan, 2013). Dixon et al. (2011) found that arousal as evidenced by variations in skin conductance responses and heart rate deceleration measures, was greater following near wins than other types of losses or actual wins. They argued that these findings, when considered in the light of prior research on the psychophysiological effects of frustration, were consistent with the idea that near wins elicit frustration. They further proposed that, although near wins lead to frustration and thus have no hedonic value, they negatively reinforce further play as gamblers seek to escape the negative arousing effect of these outcomes. Both Amsel and Dixon suggested that if near wins create a frustration effect, then response latencies (time from the outcome until the next response is made) following them would be *shorter* than those following other losses.

An often-proposed alternative mechanism (e.g. Griffiths, 1999; Ladouceur & Sevigny, 2002; Peters, Hunt & Harper, 2010; Reid, 1986; Skinner, 1953) through which near wins might affect gambling is conditioned reinforcement. Kassinove and Schare (2001) suggested that, if winning spins are occasionally preceded by near-win spins, the joy and elation experienced from the win stimuli would eventually spread to the near win. In fact, the random schedules arranged by real-world slot machines do not create the conditions needed to establish near wins as conditioned reinforcers in this way. Although the pairings described by Kassinove and Schare likely occur, they would be insufficient to establish near wins as conditioned reinforcers because contingency rather than mere contiguity is required for Pavlovian conditioning. This means that in order for pairings of consecutive spin outcomes to establish near wins as conditioned reinforcers it would be necessary for wins to be more likely to occur following near wins than following other losses. Slot machine outcomes are independent, that is, the probability of a win is identical following every spin and near wins do not signal any increased probability of a win occurring. Although there is a lack of contingency between near win spin outcomes and win spin outcomes, there is another portion of the sequence of events arranged by real-world slot machines that does arrange a contingency between near win outcomes and win outcomes. This occurs within a winning spin: between when the gambler presses the spin button and when the final outcome is presented. That is, because slot machine reels stop one-by-one from left-to-right, during every win sequence near win stimuli are displayed before the final reel stops spinning, displaying the win stimuli. This rapid pairing of near win with win stimuli during every win sequence is an ideal sequence of events for establishing near wins as conditioned reinforcers.

Alternatively, Delfabbro and Winefield (1999b) and later Peters et al. (2010) suggested Pavlovian generalization as a more straightforward process through which near wins might develop conditioned reinforcement effects. That is, if wins are (conditioned) reinforcers then stimuli that resemble them – near wins – may also become conditioned reinforcers through generalization.

If near wins are conditioned reinforcers as a result of either or both of these processes, they would be expected to produce *longer* response latencies than other losses. Delfabbro and Winefield (1999a) recorded participants playing on real slot machines and found that response latencies were longer following wins than losses. Peters et al. (2010) found the same in a rat model of gambling. This is consistent with findings that reinforcers in general produce response latencies or "post-reinforcement pauses" that are longer than latencies following other responses (Ferster & Skinner, 1957).

Previous studies have found inconsistent effects of near wins on response latencies, meaning that it is not yet possible to determine whether near wins primarily increase persistence of play through conditioned reinforcement or through frustration. Dixon and Schreiber (2004) examined response latencies following near wins, wins, and losses on a real slot machine and found much between-individual variability in the effect of outcome type on latency length. Dixon et al. (2013) in a simulation with human participants found *shorter* response latencies following near wins than following other losses. Whereas Peters et al. (2010) found that rats responding on a slot machine analog task produced *longer* latencies following near wins than other losses.

The differences in results across these studies may partially reflect the species studied, however, there were several other differences in these studies that may be relevant and which point to features of the slot machine program as determinants of the effects of near wins on response latencies. One possible contributor to this variability is the patterns of symbols classified as near wins. Both frustration and conditioned reinforcement as explanations for the near win effect suggest that near wins with outcome sequences that resemble those presented on win trials for the longest portion of the sequence would produce a stronger near win effect.  Differences in the length of reels across studies (Dixon et al., 2013 used three while Peters, et al., 2010 used five) might therefore account for some of the observed variability. This is also consistent with Dixon et al.'s finding that only "classic near wins" (two winning symbols followed by a different symbol) produced differential (shorter) response latencies (although Ghezzi, Wilson, & Porter, 2006 found inconsistent effects of the pattern of symbols comprising a win on persistence). This may also explain the variability in Dixon and Schreiber's (2004) results as they used several types of near win but did not control the rates of each pattern and collapsed across them when calculating latencies. The current study used only near wins in which the first four symbols matched while the fifth differed.

Whether wins are presented during the session may also affect subjects' responses to near-wins resembling them (Ghezzi, et al., 2006). Dixon et. al. (2013) assessed latencies following near misses where the first two of three symbols were the jackpot symbol. Participants never experienced Jackpots. If – as previously suggested – near wins obtain reinforcing effects during presentation of the win sequence, the near wins in Dixon et al. would not have become conditioned reinforcers because win sequences were never experienced. Furthermore in some procedures, for example, Kasinove and Schare, (2001) near wins are initially presented with wins and then presented without. In such procedures each near win presented in the absence of wins would act as an extinction trial, gradually eliminating any existing conditioned reinforcement effects. In the current study, participants experienced wins as well as related near wins and clear losses.

In addition, we inserted a behavioral choice paradigm into each game. A procedure developed by Davison and Baum (2000) was used to assess sensitivity to relative win frequency. This involved varying the proportion of wins allocated to each of two reels across a series of frequently-changing conditions. Lie, Harper, and Hunt (2009) successfully used this procedure to assess sensitivity to win ratios in humans responding for hypothetical money. In this context, sensitivity refers to the extent to which individuals allocate their responses across two alternatives in proportion to the distribution of reinforcers received from those two alternatives. The generalized matching law was used to assess this sensitivity because it separates sensitivity to the rate of wins from bias toward one of the two slot machines for some other reason such as the symbol set used. Such biases are likely given that people have different histories with gambling contexts prior to taking part in the research. It is of interest to investigate the extent to which people are sensitive to the distribution of wins because gambling is a context in which people demonstrate an apparent insensitivity to reinforcement rate in that they continue to gamble although the mean result is a loss.

## EXPERIMENT 1

In Experiment 1, participants played on computer-simulated slot machines that produced no near wins in one session and near wins on 50% of non-winning trials in another session. Within each session, relative win frequency was also manipulated across four conditions in order to assess sensitivity to win ratios. If near wins affect gambling behavior via conditioned reinforcement, we expected response latencies following near wins to be longer than those following other losses. Conversely if near wins affect gambling behavior via frustration, we expected response latencies following near wins to be shorter than those following other losses.

## METHOD

### Participants

Twenty-nine first year psychology students from Victoria University of Wellington participated voluntarily in partial fulfillment of a course requirement. Three participants did not complete the required conditions in the time allotted for either of the two sessions, one elected to leave before a session ended, and another was excluded because of their high Problem Gambling Severity Index (PGSI) score (see below). Therefore, we included 24 participants in the final experiment.

### Apparatus and Materials

Participants completed the PGSI, a nine-item subscale of the Ferris and Wynne (2001) Canadian Problem Gambling Index (CPGI). For each item on the PGSI people respond on a four point scale ranging from 'never' (0) to 'almost always' (3). The total PGSI score ranges from 0 to 27, with a score of 3 or higher signifying a potential gambling problem. None of the 24 participants included scored above 3. One additional student signed up to participate and received a score above this threshold. Therefore they were given an alternative non-gambling-related task to complete and were not included in the study. An absence of gambling problems was an inclusion criterion for the current experiment because of ethical concerns with exposing problem gamblers to gambling-related stimuli.

Four desktop Dell PC dual-core Pentium® computers were arranged in the corner of a room (two along each wall). Each had a mouse attached that participants used to make responses. The slot machine simulations were programmed in Visual Basic 6®. The sounds of the slot machines were presented via the computer speakers.

### Procedure

Up to two participants completed the experimental tasks simultaneously in the testing room. Participants first completed an informed consent form, and the PGSI. The experimenter then introduced the slot machine task, and instructed participants to try to win as much money as possible, to switch freely between the two available reels while playing on each computer, and to move to the next computer when a message on the screen instructed them to do so. The experimenter also told participants to read the instructions on the screen, these read:

> *"This is a slot machine task. You start with $5. On each spin you can bet between 10c and 30c and you can choose whether to play 'SLOT 1' or 'SLOT 2' (you can freely switch back and forth between the two slot lines). When all five pictures in a row match each other you win 50c for every 10c you bet (e.g. 10c bet = 50c win, 20c bet = $1 win etc.). The task will automatically stop after 10 mins of play or 12 wins (whatever happens first). When the task stops please wait until told what to do next. Any questions?"*

Participants clicked a button labeled "Start Task" to advance to the playing screen. There were two five-symbol slot machines presented vertically aligned on the playing screen each with radio buttons displayed to their right that could be used to select a bet amount of 10c, 20c or 30c (see Figure 1). The symbols on each reel were from a visually distinctive set.

At the start of each trial, participants selected a reel to play, chose an amount to bet, and then clicked the associated play button in order to initiate a "spin" on the selected reel. When this button was clicked, slot machine spinning sounds played while a slot-machine animation occurred. During this animation, all slot stimuli were removed for 150ms and were then displayed for 150ms creating a flashing effect. For the first 600ms, different symbols were presented in every position during each flash. After 600ms, the left-most symbol became fixed, and one additional symbol became fixed every 300ms until the five symbols associated with the trial outcome were presented.

The number of matching symbols from the left was associated with the outcome of the spin. Three types of outcome were possible: win, near win, and clear loss. If a win occurred, five matching symbols were presented, a ringing bell sounded, and participants saw a message stating that they had won five times the bet amount (e.g. bet 30c and win $1.50). Note that money bet and won was hypothetical. On near-win trials the four left-most symbols matched, and on clear loss trials either two or no matching symbols were presented (no spin ever resulted in three matching symbols). On near-win and clear loss trials no money was won, and participants saw a message stating that they had won $0. After each outcome the participant's current "total balance" was updated on screen. Additionally, after the computer displayed an outcome, all the screen elements reappeared and the computer de-selected the bet selection radio buttons.

The current experiment manipulated two independent variables in a within subjects, 2 x 4 factorial design producing 8 conditions. Each condition lasted for 12 wins (obtained from both slot reels) or 10 minutes, whichever came first. Of the 192 conditions completed in Experiment 1 (8 conditions for each of the 24 participants), 154 finished after all 12 wins were obtained and 38 finished after reaching the 10-minute time limit.

The first independent variable was the probability of a near win occurring on a trial on which a win was not programmed. Whether a near win was presented was determined randomly with replacement for each non-win trial for each participant. During one session this probability of a near win occurring on a non-win trial was 0, and in the other 0.5. For the session including near wins, this arrangement of outcomes meant that there was no contingency between near wins and wins. That is, near wins signaled nothing about the likelihood of a win on the following trial. Analyses of outcomes actually experienced by

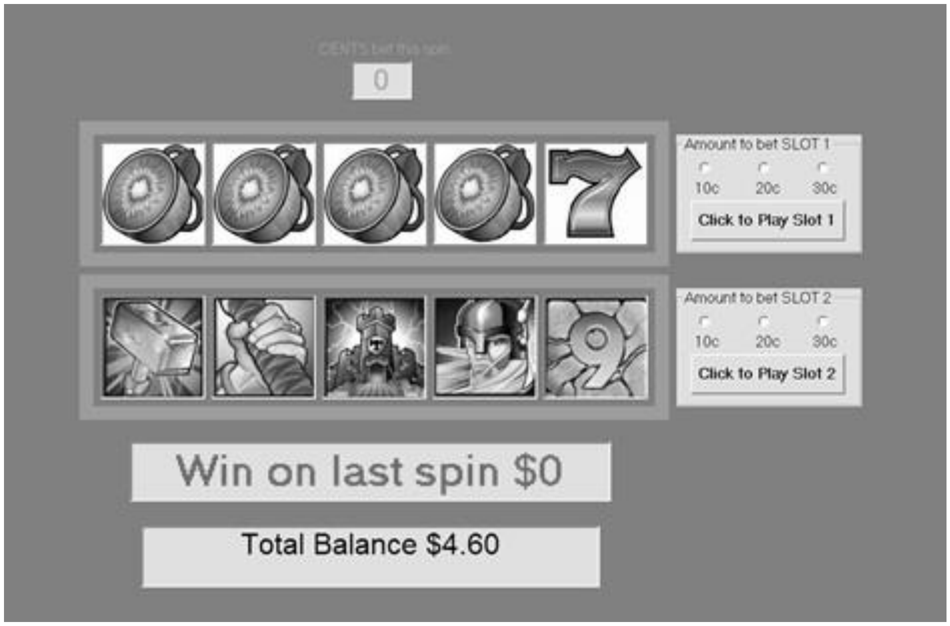


**Figure 1.** Screenshot showing the play screen. During the play animation, only the chosen row was visible. The top row depicts a near win. The bottom row depicts a clear loss.

the current participants confirmed that they were independent in this way. Sessions were no more than one week apart.

The second independent variable was the distribution of the 12 wins across the two reels. Wins were presented according to a dependently-scheduled variable-interval (VI) 10 schedule and the proportion of wins allocated to each reel was manipulated within each of the two sessions. A one-spin changeover delay was in effect meaning that, even if a win had been allocated to a given reel, it was not presented until the second spin made on that reel following a switch. The four win distributions were 2:10, 10:2, 4:8, and 8:4, where the first number indicates the number of wins allocated to the top reel and the second the number allocated to the bottom reel.

Each of the eight conditions was associated with a different background screen color and presented on a different computer. When participants completed a condition, the computer displayed an end screen prompting them to move to the next computer to complete the next condition. Twelve participants completed the conditions in the order: 2:10, 10:2, 4:8, and 8:4; the remaining 12 completed the conditions in the order: 4:8, 8:4, 2:10, and 10:2. Which near win frequency participants experienced during their first session was also counter-balanced. Neither changes in win distribution within each session nor changes in the probability of near wins between sessions were accompanied by any additional stimulus changes. Dependent variables were the proportion of spins, amount bet, and response latencies for each reel. The response latency was defined as the duration between a trial outcome on trial ‘n’ and the response to initiate the spin on the subsequent trial ‘n+1’.

## RESULTS AND DISCUSSION

We calculated the median response latencies following wins, near wins and clear losses for each participant for each of the eight conditions. We averaged the means of these median response latencies to produce mean response latencies for each participant

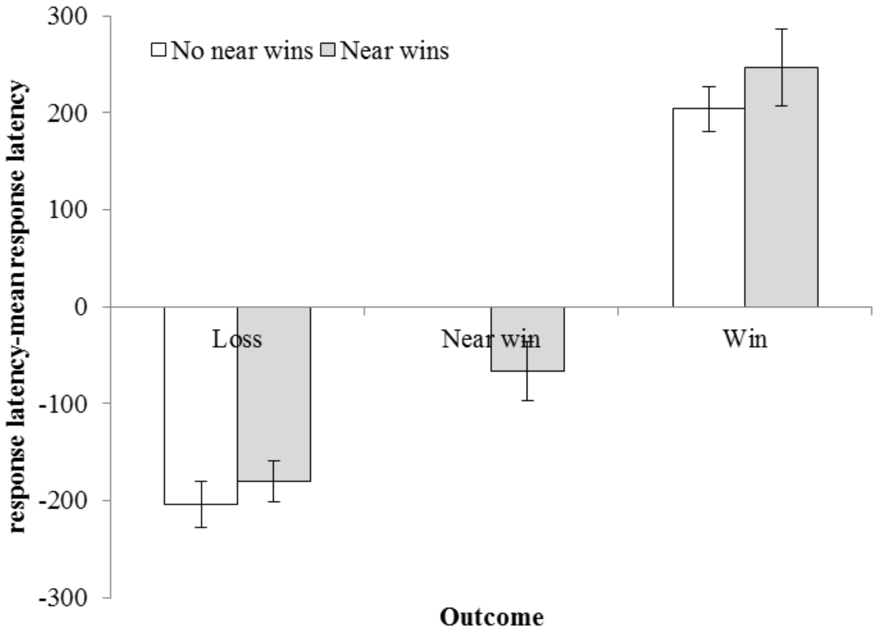


**Figure 2.** Response latency for each outcome type. Latencies for each outcome type have been partially normalized by subtracting the mean response latency. Open bars indicate the condition with no near wins, and gray bars the condition with near wins. Error bars are standard errors.

for each outcome type for each near-win condition. In order to assess the effect of outcome type on response latency, each participant's mean response latency for a given outcome type was partially normalized by subtracting their mean response latency for that condition from it. The means of these difference scores are presented in Figure 2.

As can be seen in Figure 2, in both conditions, the mean response latency following wins was longer than that following losses and in the near-win present condition mean response latency following near wins was longer than that following losses but not as long as that following wins. The direction of the difference in response latencies between near-win and clear loss outcomes was very consistent at the individual level with 91 % of the participants showing this effect.

Inferential statistics also confirmed this pattern of results. A paired samples *t*-test revealed a significant difference between mean win and clear loss response latencies in the near-win-absent condition ($t(23) = 8.71$, $p < 0.05$, $d = 1.91$). A repeated measures ANOVA also revealed a significant effect of outcome type on response latencies in the near-win-present condition ($F(2, 46) = 33.36$, $p < 0.05$, $\eta_p^2 = .59$). In addition, three post-hoc paired samples *t*-tests revealed significant differences between win and clear loss response latencies ($t(23) = 7.57$, $p < 0.05$, $d = 1.92$), win and near win response latencies ($t(23) = 4.67$, $p < 0.05$, $d = 1.46$) as well as near win and clear loss response latencies ($t(23) = 3.41$, $p < 0.05$, $d = 0.81$) in the near-win-present condition.

These results are consistent with near wins as conditioned reinforcers and not consistent with near wins as producing frustration in the current procedure. This result was consistent with that of Peters et al. (2010) who found rats produced longer latencies following near wins than following losses on a slot machine analog task. In contrast, this result differs from Dixon and Schreiber (2004) who found no consistent effect of near wins on response latencies, and from

Dixon et al. (2013) who found *shorter* response latencies following near wins. These differences suggest that features of how outcomes are arranged on slot machines influence the behavioral effects of near wins. These features will be discussed further in the general discussion. Consistent with previous research Experiment 1 also found that participants paused longer after experiencing wins than after experiencing clear losses (Delfabbro & Winefield, 1999a; Peters et al., 2010).

**The effect of the presence of near wins on sensitivity to win ratio**

The matching law (Baum, 1974) was used to characterise each subject's sensitivity to the relative frequency of wins on each reel. The matching law refers to the following relationship between the distribution of responses across two alternatives and the distribution of reinforcers across those two alternatives:

$$\log\left(\frac{B_1}{B_2}\right) = a\log\left(\frac{R_1}{R_2}\right) + \log k \qquad (1)$$

In the current experiment, $B_1$ was the number of spins of the last 30 in a given condition made on the top reel, and $B_2$ the number of spins of the last 30 in a given condition made on the bottom reel. $R_1$ was the total number of wins delivered on the top reel during a condition and $R_2$ the total number delivered on the bottom reel. The mean number of spins made in a condition was 76, and therefore the last 30 spins represented 39% of each condition on average (range: 29% -52%). If plotted, Equation 1 is the formula for a straight line, and $a$ is the slope of that line which also describes how sensitive the distribution of a subject's behavior was to the distribution of wins. Occasionally, participants either made no responses on one of the two reels during a condition or received no wins from one of the two reels during a condition. When this occurred, we added 0.25 to each of $R_1$, $R_2$, $B_1$ and $B_2$ in order to allow Equation 1 to be used.

We calculated two sensitivity values for each participant using linear regression: one for conditions during which near wins were present, and another for conditions during which no near wins were present. The mean sensitivity value was 0.20 (range:-0.93 to 0.73) when near wins were absent and 0.39 when near wins were present (range: -0.15 to 1.27). The average r-squared value was 0.47 (range: 0.01 to 0.99) when near wins were absent and 0.57 (range: 0.08 to 0.99) when near wins were present. Figure 3 presents differences in the individual participants' sensitivity values when near wins were present and their sensitivity values when near wins were absent. Bars above the *x* axis indicate that sensitivity was greater when near wins were present. As Figure 3 indicates, approximately two thirds of participants were more sensitive to the relative distribution of wins when near wins were also present in the condition than when they were absent. A paired samples *t*-test ($t(23) = 2.19$, $p < 0.05$, $d = 0.45$) confirmed that sensitivity values were significantly greater during the condition in which near wins were present.

The majority of sensitivity values greater than zero demonstrate the sensitivity of participants to the ratio of wins presented on a slot machine analog task. This is consistent with the findings of Lie et al. (2009) who found that humans were sensitive to the rate of reinforcers in a similar rapidly-changing choice paradigm in a non-gambling context. The current experiment and the results of Lie et al. confirm the utility of this procedure for efficiently assessing humans' sensitivity to changing reinforcement rate in a given context, extending the use of this procedure, originated by Davison and Baum (2000), to a context of applied relevance.

As displayed in Figure 1 the top slot on each version of the slot machine was

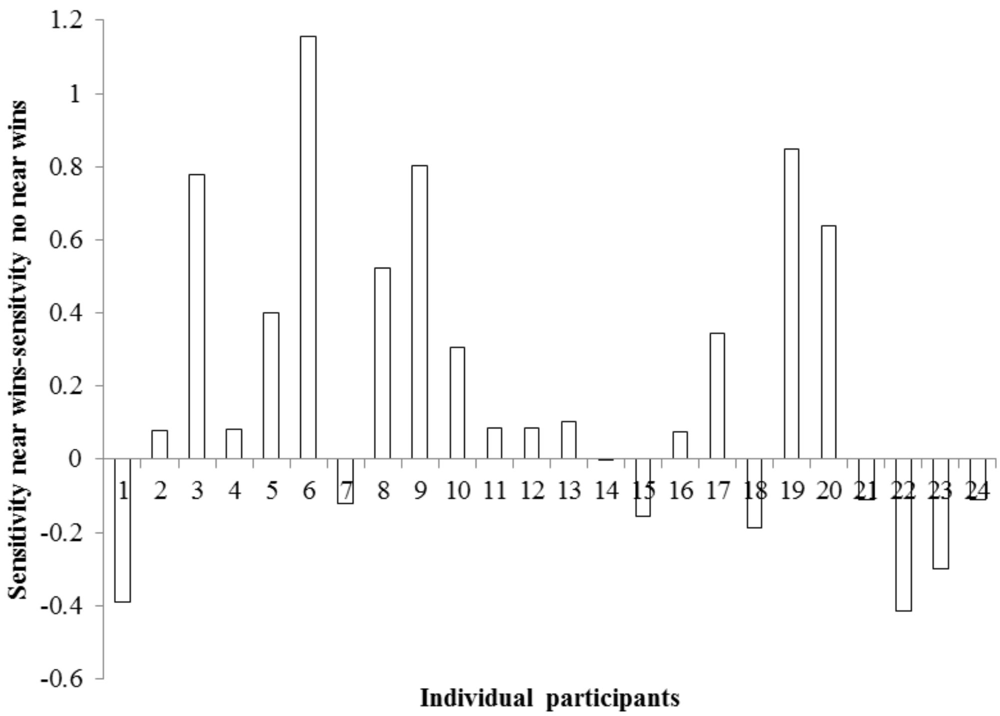


**Figure 3.** Differences between sensitivity to relative win frequency when near wins were present and sensitivity to relative win frequency when near wins were absent for each participant. Bars above the x axis indicate participants exhibited higher sensitivity to win rate ratios when near-wins were also present in the condition, those below the axis indicate participants were more sensitive to relative win frequency when near wins were absent.

always fruit symbols and the bottom slot was always Viking symbols. The matching law analysis allowed an assessment of whether participants showed a bias towards one or other of these reels. A bias is a preference for one of the response alternatives (here, responding on one of the two reels) that is unrelated to the rate of reinforcement (wins) presented by those two alternatives (Baum, 1974). There was no consistent across-participant pattern of biases to one or other of the reels, suggesting that neither the position (top or bottom) of a reel nor the symbol set presented on that reel consistently affected participants' preference for that reel.

## EXPERIMENT 2

Experiment 2 investigated whether response latency and sensitivity to wins were affected by changes in the frequency of near-win outcomes. Kassinove and Schare (2001) found that increases in the proportion of near wins initially increased but later decreased persistence of play. Decreases may therefore also occur in sensitivity to the relative frequency of wins or in response latency length when the proportion of near wins experienced is above a particular value. To investigate this possibility we conducted a second experiment identical to Experiment 1, except that players experienced one session where near wins were present on 25% of non-win trials and another where they were present on 50% of non-win trials. These values were selected because previous research indicates that persistent play effects are greatest when the near win frequency lies somewhere between 25 and 50% (Chantal, Vallerland, Ladouceur & Ferland, 1996; Côte et al., 2003; Kassinove & Schare, 2001).

## METHOD

### Participants

Twenty-four first year psychology students from Victoria University of Wellington completed Experiment 2 in partial fulfillment of a course requirement.

### Apparatus

The materials used were as for Experiment 1.

### Procedure

The procedure was as for Experiment 1, except participants completed one session during which near wins occurred on 25% of non-win trials and another where near wins occurred on 50% of non-win trials. The order in which participants experienced these two conditions was counterbalanced. Of the 192 conditions played in Experiment 2, 159 ended due to the acquisition of 12 wins and 32 conditions ended after reaching the 10-minute time limit for the condition. Data from one of the 192 conditions were lost due to a recording error.

## RESULTS AND DISCUSSION

Mean response latencies were calculated as for Experiment 1. The within-condition pattern of mean response latencies found in Experiment 1 was replicated in Experiment 2 with response latencies for near wins falling between those for wins and losses in both conditions (see Figure 4). A clear majority of participants showed this difference in response latency in each condition, and there was no difference in the distribution of response latencies between conditions. A 2 (25% near wins, 50% near wins) x3 (clear loss, near win, win) repeated measures ANOVA confirmed that there was no significant interaction of near win proportion by outcome type ($F$ (2, 46) =1.69, $p$ = 0.20, $\eta_p^2 = 0.068$) and no significant main effect of near win proportion on response latencies ($F$ (1, 23) = 0.58, $p$ = 0.46, $\eta_p^2$ = 0.025). The 2x3 ANOVA did however reveal a significant main effect of outcome type on response latencies ($F$ (2, 46) = 27.70, $p < 0.05$, $\eta_p^2 = 0.46$). Following this, post-hoc $t$-tests revealed significant differences between mean response latencies of wins and clear losses ($t(23) = 8.28$, $p < 0.05$, $d = 1.31$), wins and near wins ($t(23) = 5.00$, $p < 0.05$, $d = 0.94$), as well as near wins and clear losses ($t(23) = 3.15$, $p < 0.05$, $d = 0.52$).

The pauses following win, near win and clear loss outcomes in Experiment 2 replicate the pattern of results found in Experiment 1, extending this finding to an additional near win frequency (25%). Pause length was not affected by the relative proportion of near wins experienced. The inconsistent effects of near wins on pause length in Dixon and Schreiber (2004) is therefore unlikely to be due to differences in the proportions of near wins experienced by each participant.

As in Experiment 1, sensitivity values were calculated for each participant in each near win frequency condition. In Experiment 2, the mean number of spins made in a condition was 71, and therefore the final 30 spins that were included in calculations of sensitivity represented 42% (range: 29% to 66%) of the condition on average. The mean sensitivity value was 0.09 (range:-0.34 to 0.64) when near wins were presented on 25% of trials and 0.20 when near wins were presented on 50% of trials (range: -0.17 to 0.71). For two participants, r-squared could not be calculated. For the remaining participants, the average r-squared value was 0.41

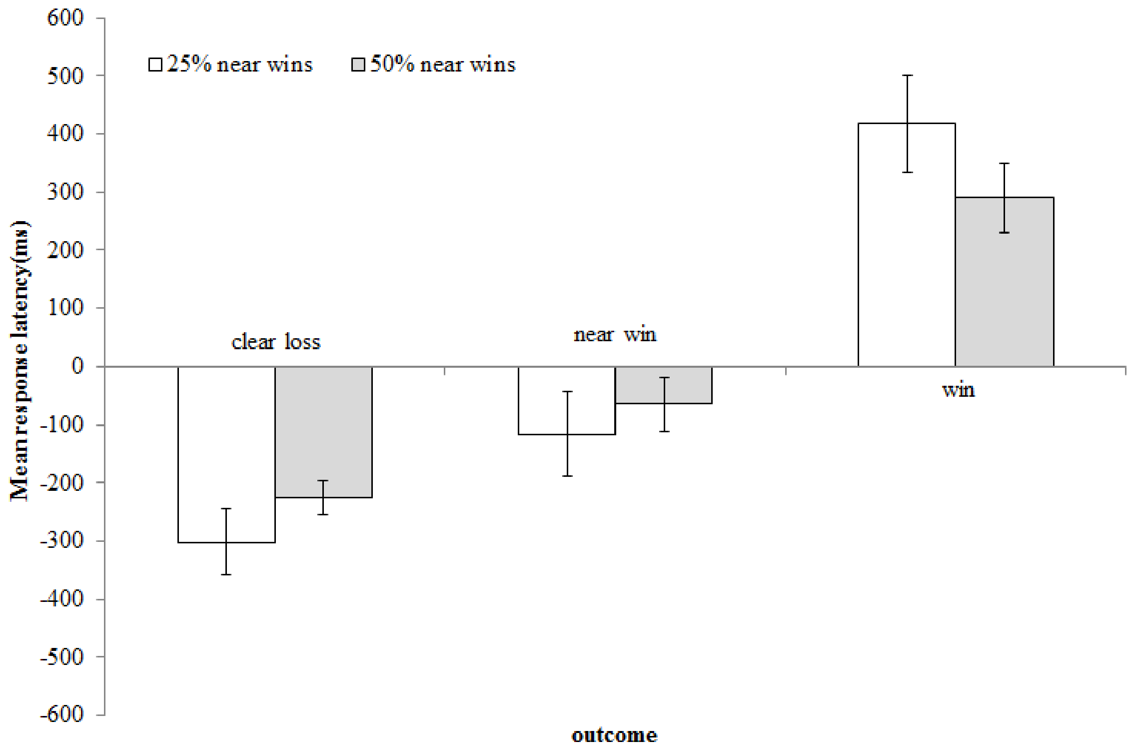


**Figure 4.** Response latency for each outcome type. Latencies for each outcome type have been partially normalized by subtracting the mean response latency. Open bars indicate the condition with 25% near wins, and gray bars the condition with 50% near wins. Error bars are standard errors.

(range: 0 to 0.95) when near wins were absent and 0.44 (range: 0 to 0.9) when near wins were present. Figure 5 displays the differences in the individual participants' sensitivity values when near wins were present on 50% of trials and their sensitivity values when near wins were present on 25% of trials. Bars above the *x* axis indicate that sensitivity was greater when near wins were present on 50% of trials. The majority of bars on Figure 5 are above zero indicating that most participants were more sensitive to the relative distribution of wins when near wins were presented on 50% rather than 25% of non-winning trials. A paired samples *t*-test ($t$ (23) = 2.484, $p < .05$, $d = 0.51$) confirmed that sensitivity values were significantly greater in the 50% near win condition. This finding extends the results of Experiment 1 by indicating that incremental increases in near win frequency produce incremental increases in sensitivity to win frequency. As in Experiment 1, there was no consistent bias for either symbol set.

## GENERAL DISCUSSION

The current study found that participants produced longer response latencies following near wins than following clear losses, an effect previously observed by Peters et. al. (2010) with rats but not previously observed with humans. The current study

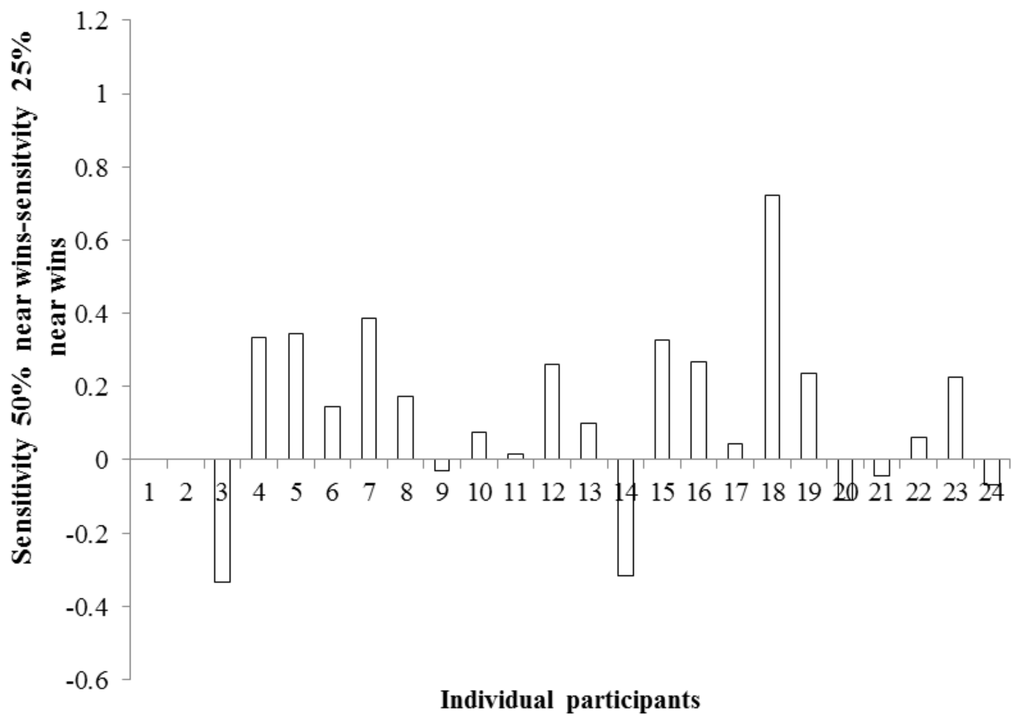


**Figure 5.** Differences between sensitivity to relative win frequency when near wins were present on 50% of trials and sensitivity to relative win frequency when near wins were present on 25% of trials for each participant. Bars above the x axis indicate higher sensitivity to win rate ratios when near-wins were present on 50% of trials, those below indicate participants were more sensitive to relative win frequency when near wins were present on 25% of trials.

also found that near wins increased sensitivity to rate of wins. These results are consistent with near wins acting as conditioned reinforcers rather than producing frustration in the current arrangement. If the near wins had produced frustration (Amsel, 1958) then pauses following them would have been shorter than those following clear losses, and no systematic effect on sensitivity to reinforcement ratios would have been expected.

The longer latencies observed in the current study differed from the results of Dixon and Schreiber (2004) who found no consistent pattern of response latencies, and from that of Dixon et al. (2013) who found *shorter* latencies following near wins than other losses. Together, these studies suggest that the behavioral effects of near wins depend on features of the slot machine program, and the outcomes and related symbols presented. In the current study, wins and near wins were both presented during play and near wins appeared to function as conditioned reinforcers. In Dixon et al.'s procedures near wins were presented without the wins they resembled and they appeared to elicit frustration. This may suggest that in the presence of wins, near wins develop conditioned reinforcement effects but in the absence of wins, near wins produce frustration. Future research systematically manipulating the frequency of wins and near wins could clarify this. Ghezzi et al. (2006) investigated the effects of multiple combinations of win size and near-win frequency on persistence of gambling. Results were inconsistent, underscoring the complexity of the issue.

Additionally, procedures in which near wins resemble wins for longer portions of outcome sequences may be more likely to establish those wins as conditioned reinforcers. In the current, five-symbol slot machine analog in which only near wins with four of five symbols matching were included, near wins resembled wins for larger portions of outcome sequences than they had in previous arrangements. The mixed results of Dixon and Schreiber (2004) may have reflected the fact that they did not separate out trial types on which the pattern of symbols presented differed in meaningful ways.

There is, however, a possible alternative explanation to conditioned reinforcement for the differential pauses we observed. The longer pauses following near wins might simply be an artefact of the sequential presentation of symbols in the outcome stimuli in combination with the fact that participants require some processing time before selecting their next bet amount and alternative. This processing time may begin when the outcome of the previous spin is known rather than when the opportunity to make the next spin is presented. If this is the case, then, following clear loss outcomes, this processing time may begin earlier, while the remaining symbols are displayed and thus produce apparently shorter pauses following these outcomes than near wins. This explanation, however, does not account for the difference in pause length between wins and near wins as both types of outcomes are revealed when the last symbol is displayed. Nevertheless this possible explanation remains and could be evaluated by replicating this study with simultaneous presentation of all symbols.

This study also found that higher rates of near wins produced increased sensitivity to the relative frequency of wins. Previous research suggests two possible explanations for this. Firstly, conditioned reinforcement may explain this effect as it does for the increased pauses. Alsop and Elliffe (1988) found that when pigeons were responding on concurrent VI VI schedules increasing the overall reinforcement rate while keeping the reinforcement rate ratios equal produced higher sensitivity values. This result suggests that increasing overall reinforcement rate in a gambling context may increase sensitivity. If near wins are conditioned reinforcers, then conditions in which they occurred more frequently had higher overall effective reinforcement rates, and, therefore perhaps, higher sensitivity. This conclusion is tentative given the difference in the procedure through which reinforcement rate was increased across the two studies (the current procedure added equal rates of near wins to both alternatives).

An alternative possibility is suggested by an experiment conducted by Madden and Perone (1999). In that study, requiring participants to attend to schedule-correlated stimuli increased sensitivity to reinforcement rate ratios. The addition of near wins may have had a similar effect because it led participants to increase their attentiveness to the gambling outcome stimuli in order to discriminate wins from physically-similar near-wins.

Although there are alternative explanations to conditioned reinforcement for the effects of near wins on both response latency and sensitivity to wins in the current study, conditioned reinforcement as an explanation has the advantage of parsimony in that it alone accounts for both response latency and reinforcement sensitivity effects. Future research could investigate the extent to which stimulus generalization or conditioning that occurs within a winning spin contribute by systematically varying the extent to which near wins are paired with, versus physically similar to, wins. The extent to which each of these processes contributes to the near win effect has implications for understanding the importance of this effect for problem gamblers. If pairing is crucial, then the effect may be stronger in problem gamblers as they have experienced many win outcomes and therefore many pairings of near wins and wins.

An important novel feature of the current procedure was the application of a rapidly- changing choice procedure in combination with the generalized matching law to assess sensitivity to wins. Sensitivity values were between zero and one (undermatching) – consistent with previous findings with humans – but closer to indifference than those found by Lie, et al. (2009). Here, the strongest mean sensitivity of any condition was 0.38 (in the 50% near wins condition in Experiment 1), while the mean sensitivity they observed was 0.52. This may reflect the fact that behavior in the gambling context is uniquely influenced by factors other than reinforcement distribution such as inaccurate, self-generated verbal rules. Conditioned reinforcement and verbal rules may interact in determining the effect of near wins on gambling. Research (e.g. Dymond & Roche, 2010; Dymond, McCann, Griffiths, Cox & Crocker, 2012) has shown that derived verbal relations can influence gambling behavior. Directly relevant to near wins, Dixon, Nastally, Jackson and Habib (2009) found that participants who acquired a derived relation between an image of a near win and the word "almost" rated nears wins as more "win like" than they had before they underwent relational training. If gamblers have acquired the (inaccurate) verbal rule that near wins indicate that additional gambling is more likely to produce a win, then near wins might spur persistent play. Future research could identify experiences that lead near wins to increase the persistence of gambling through either or both of these processes.

The current findings suggest that near wins are conditioned reinforcers because they both produced longer pauses than clear losses and increased sensitivity to win frequency. The increased reinforcement rate created by slot machine operators' addition of near wins is therefore likely the mechanism through which near wins increase the persistence of slot machine play. Future research that further investigates this process will contribute to the design of regulations and interventions to reduce the adverse social impact of slot machines by reducing persistence.

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*Action Editor:* **Jeffrey N. Weatherly**