THE NEAR-MISS EFFECT IN ONLINE SLOT-MACHINE GAMBLING: A SERIES OF
CONCEPTUAL REPLICATIONS

by

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The following individuals certify that they have read, and recommend to the Faculty of Graduate and Postdoctoral Studies for acceptance, the thesis entitled:

The near-miss effect in online slot-machine gambling: a series of conceptual replications

submitted by Lucas Palmer in partial fulfilment of the requirements for the degree of Master of Arts in Psychology

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Abstract:

The field of gambling studies is beginning to recognize the need to conduct targeted replications of influential effects throughout the field. Given the limited resources afforded to researchers, we must be systematic in our approach to selecting which effects are most in need of replication. Following a systematic approach to replication selection, a series of conceptual replications of the ‘near-miss effect’ in slot machine gambling was conducted, on online community samples. Near-miss outcomes on a slot machine are those that appear proximal to a win, though they are functionally identical to other losing outcomes (herein termed ‘full misses’). Near-misses have been shown to elicit a range of differential psychological effects compared to full-misses. Experiment 1a and 1b attempted to replicate a previous study by Clark et al. 2009 that 1) near-misses are experienced as more negative, 2) near-misses are rated as more motivating to continue playing a slot machine. Experiment 2 tested the effects on speed of gambling (a replication of Dixon et al. 2013) that near-miss outcomes speed up participant speed of play compared to full miss outcomes. Experiment 3 tested whether near-miss outcomes influence subsequent bet size. I replicated the motivation hypothesis of Clark et al., (2009), but found a significant effect in the opposite direction for the valence hypothesis. Across both study 1a and 1b, near-miss outcomes were more positive relative to full-misses. Experiment 2 replicated the hypothesis that near-miss outcomes increase speed of play (Dixon et al., 2013). Experiment 3 observed near-miss outcomes led to a significant increase in bet size on the subsequent spin relative to full-miss outcomes. I consider how this pattern of results across 3 different dependent variables speak to the different theoretical accounts of how near-misses operate.
Lay Summary:

In the field of gambling studies, researchers are beginning to recognize the need to establish the reliability of important observations. One classic finding in gambling research claims that ‘near-miss’ events on a slot machine game (i.e. losing outcomes that appear close to a win) cause a range of psychological and behavioural effects, relative to clear losses (also known as ‘full-misses’). Note that near misses and full misses are strictly identical: neither returns any reward nor provides any information about future success. In this thesis, I replicated a series of results from past research on the near-miss effect, in the context of online slot machine gambling. These findings establish the reliability of near-miss effects, which has important implications for the regulation of slot-machine design.
Preface

I completed the experimental designs and data analysis for this thesis under the supervision of Dr. Luke Clark. The slot-machine task was adapted from a simulation designed by Mario Ferrari.

The Behavioural Research Ethics Board at the University of British Columbia approved each of the experiments in this study (H21-01342).
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Thank you to my committee members Dr. Ara Norenzayan and Dr. Rebecca Todd for their helpful comments and discussions in preparing the final draft of this thesis.

This thesis would also not have been possible without the coding skills of my lab mate Mario Ferrari who graciously helped guide me through developing my slot machine task.
Introduction:

The field of gambling research is beginning to recognize the challenge faced by the broader field of psychological science over the past decade. I refer of course to the so called “replication crisis”, where several classic effects and phenomena across numerous areas of psychological research are failing to replicate under close scrutiny (Nosek et al., 2022; Open Science Collaboration, 2015). There are increasing calls from researchers within the gambling field to begin conducting targeted and systematic replications of influential gambling-related effects (Heirene, 2020; LaPlante, 2019; Wohl et al., 2019). The rising interest in replication in a field where there has been little concern for replication studies historically (Wohl et al., 2019) raises a few important questions: how exactly should studies be prioritized for replication; how exactly should a replication be conducted (e.g. if superior methods are now available), and what should be done when the results of a replication attempt are unexpected? In the next chapter I will consider these broader issues before focusing in on a particular set of effects within the field of gambling research.
Chapter 1: What and how do we replicate?

The replicability of experimental results is fundamental to scientific inquiry (Jeffreys, 1973; Popper, 2005; Radder, 1992). The importance of replication has recently begun to gain wider appreciation within psychological science. Indeed, the 2010s could be characterized as a decade of active confrontation with respect to replicating popular effects (Nosek et al., 2021). Nevertheless, the understanding of replication as integral to science runs deep within the history of psychology. For decades, researchers and methodologists have been speaking on the dangers of overemphasizing statistical significance (Meehl, 1990; Rosenthal, 1979), and underemphasizing the importance of repeated replications of published experimental results (Meehl, 1978). The overreliance on statistical significance has further led to an array of analytic practices that researchers can employ to turn out significant results, often termed “p-hacking” (Simmons et al., 2011; Wicherts et al., 2016). These practices, when allowed to continue unchallenged, could bring about a body of scientific literature in which null findings are consistently presented as true (Button, 2016; Ioannidis, 2005). The practice of replication is the essential error monitoring process for identifying theories built on erroneous empirical data.

Though error monitoring may be the chief purpose of replication studies, they serve a variety of specific functions within a field of inquiry. One relatively common framework for outlining the possible functions of a given replication comes from Schmidt (2009). A replication study can: 1) control for sampling error, 2) control for issues with internal validity, 3) control for fraud, 4) enable generalizability to different populations, 5) enable verification of underlying hypotheses. A replication study need not fulfill all these functions at once, and indeed doing so is not really possible. For instance, if one has concerns surrounding sampling error and the internal validity of an original study, it would not be sensible to run a replication to extend the
generalizability of the original hypothesis. A replication study should be tailored to the precision or maturity of a given theory from which the hypothesis of the original study was derived (Nosek et al., 2022). If there is interest in confirming the original results of an experiment, either for fear of something like fraudulent data or simply because the theoretical background that explains the original effect is underdeveloped, it would make the most sense to tailor a replication study so that functions 1-3 are pursued. If instead the underlying theory is precise and there is little reason to doubt the findings of the original research, researchers may be more interested in enabling generalizability to different populations or verifying the hypothesis of the original experiment with a different material realization (Schmidt, 2009).

A common way to distinguish replications that attempt to confirm the validity of an original study’s results, versus those that seek to extend generalizability, is the notion of “direct” versus “conceptual” replications (Crandall & Sherman, 2016; Derksen & Morawski, 2022; Nosek & Errington, 2017; Simons, 2014). Traditionally, “direct” replications refer to studies in which all practical aspects of the original study were maintained (Derksen & Morawski, 2022; Simons, 2014), while “conceptual” replications test the underlying hypothesis of the original study, while varying one or more elements of the experimental design (Crandall & Sherman, 2016; Derksen & Morawski, 2022; Nosek & Errington, 2017). However, to some degree, this classic distinction of “conceptual” versus “direct” can be misleading. For example, an original study conducted in a lab or particular setting could be moved to an online experiment in order to enable a larger sample size to be collected. It is impossible to conduct a perfectly “direct” replication of any given experiment. Samples will differ, experimental locations will differ, and even something like changing the time of day the experiment is conducted at means one has altered some parameters of the original study (Shadish et al., 2002). Every study, no matter it’s
similarity to an original, is unique. Not only that, but the distinction between “direct” versus “conceptual” places the emphasis of replication on procedural rather than theoretical expectations (Nosek & Errington, 2020; Zwaan et al., 2018b). For instance, there may be a strong theoretical basis for why one would alter certain parameters of an original study (thereby not meeting the criteria for a “direct” replication), while maintaining a high level of commitment that the outcome of the proposed study will replicate the results of the original.

Before determining exactly how to go about designing a replication study, the replication researcher must determine which study or studies within a field of research are most valuable for replication. This task raises an important and challenging question: how exactly do researchers with limited resources go about determining which effects are most in need of replication attempts (Coles et al., 2018). While there has been a lot of work done on how we should design and interpret the results of replications (Machery, 2020; Schmidt, 2009; Zwaan et al., 2018a), the question of which studies we choose to replicate has only recently become an active topic of focus (Heirene, 2020; Isager et al., 2021; Kuehberger & Schulte-Mecklenbeck, 2018; LaPlante, 2019). Because empirical literature grows at an accelerating rate, and because the technological landscape through which certain psychological effects are observed is constantly evolving, the question of how we choose which studies to replicate given limited resources becomes increasingly important (Isager et al., 2021). Additionally, in a field of research like gambling where the results of studies often have a direct impact on public policy and regulation, the importance of prioritising the replication of certain studies over other becomes even more salient (LaPlante et al., 2021; Louderback et al., 2021; Wohl et al., 2019).

Methodologists working in this area have claimed that researchers should focus replication efforts where they have methodological expertise (Zwaan et al., 2018b), but also that
researchers should be transparent about how they are considering the relative value of conducting a particular replication study over another (Giner-Sorolla et al., 2018; Isager et al., 2021), especially given the fact that replication studies are rewarded less when it comes to publication (Koole & Lakens, 2012). Considering on methodological expertise is helpful for reducing the scope of possible effects worth replicating (Zwaan et al., 2018b). For conveying the relative value of conducting a particular replication within a body of effects, the vast majority of methodologists argue that effects with the greatest level of theoretical impact should be considered priority for replication (Isager, 2019; Makel et al., 2012). Considering the degree of corroboration that exists for the effect is also deemed necessary to effectively compare which effects are most in need of replication within the body of effects underlying a theory (Heirene, 2020; Isager, 2019). The emphasis on these two constructs dovetails nicely with the argument that replication functions as an error monitoring process for theories built on erroneous data. Thus, effects which have the greatest theoretical impact with the lowest level of corroboration should take priority for an error monitoring process meant to shine a light on theories with erroneous evidence.

In considering both these parameters, Isager (2019) provides a simple but versatile formula to derive a ratio of some measure of a claim's impact to some measure of the corroboration existing for a claim:

\[
RV = \frac{\text{impact}}{\text{corroboration}}
\]

These two constructs could be operationalized in several different ways to suit the needs of researchers depending on their reason for being interested in replication. Impact, for example, could be operationalized to consider the number of times an effect has been cited in academic
textbooks, while corroboration could be operationalized as the degree of statistical power of the experiment which found the effect (Heirene, 2020). A more liberal and versatile approach would be using the number of times a given effect has been cited across academic literature (e.g. by looking at google scholar citation counts), and considering sample size as an index of the degree of corroboration existing for an effect. The upside of using citation count and sample size is that these operationalizations do not rely on the quality of reporting of past studies. Calculating something like statistical power as a measure of corroboration for previous studies may not be possible when certain information is not presented by the original authors, which is a historical problem with reporting of psychological research (Bakker et al., 2012; Bakker & Wicherts, 2011; Cohen, 1992; Sedlmeier & Gigerenzer, 1992).

The versatility of this formula means there will always be a degree of vagueness with how the formula can be implemented. The formula makes no claim about whether RV should be calculated only for an original study, or whether subsequent replication attempts should be considered in calculation. For example, if I want to calculate the RV for the original rat park study (Alexander et al., 1978), do I calculate RV based only on the citation count and sample size of the original study, or do we include studies which sought to replicate this effect (e.g. Petrie, 1996)? If we do consider replications of the original study in the formula, do we only include those studies that operationalized variables in the exact same way as the original study (Petrie, 1996), or do we include studies which sought to extend the generalizability of the original effect by altering the operationalization of the independent and dependent variables (El Rawas et al., 2009)? For instance, do we only consider those studies which tried to match the now defunct methods of the original rat park study, or should we consider more modern variations of this study using up to date methodology or studies which have varied their methods
Further, should this RV apply only to specific claims and effects or to broader features of a theory? For instance, should RV be calculated for the claim “social isolation increases morphine consumption in a rat model”, “social isolation increases morphine consumption”, or at more broad theoretical level “social isolation influences drug consumption”? These questions highlight the need for researchers to place exogenous constraints on what exactly they will be calculating RV for (i.e., a specific effect or collection of effects outlining a feature of a theory), and how exactly they will calculate RV (i.e. include only original studies or all replication attempts). I would argue that RV need not be exclusively calculated for specific hypotheses. Rather, its versatility lends itself to being applied in contexts where the theoretical interest lay less with specifically operationalized hypotheses and more with collections of effects based around a shared feature of an underlying theory. In the following chapter I will demonstrate the process of applying this formula to a body of work within the broad field of gambling studies.
Chapter 2: Establishing the replication values for selected slot machine structural
characteristics

While gambling has often been portrayed as a generally harmless leisure activity, with only certain individuals ever developing gambling problems, there is increasing recognition that it constitutes a public health concern (Goyder et al., 2020; Price et al., 2021; Schalkwyk et al., 2021). Researchers have begun to look beyond the individual as the source of gambling related harm, instead placing the emphasis on the interplay between personal risk factors and the effects of gambling product design and its environmental accessibility (e.g. Korn & Shaffer, 1999). Since the legalization of gambling in Canada in the 1970’s, there has been a marked increase in the accessibility of gambling products (Korn, 2000). This expansion of gambling products has occurred in parallel with rapid advancements in the underlying technology. Beginning with the computerization of traditional “one-armed bandits” (Dow Schull, 2014), today slot-machines can be accessed from one’s home through online casino websites (Håkansson & Widinghoff, 2020), or even through various smart-phone apps (James et al., 2017, 2019). The covid-19 pandemic has potentially further facilitated a migration to online forms of gambling (Emond et al., 2022; Price, 2022), with online slot-machine play as one of the highest forms of engagement for online gambling (British Columbia Lottery Corporation, 2020; Lesch & Clark, 2017). Thus, given the increased accessibility to slot-machine gambling, and due to the relatively higher risk for gambling related financial harm associated with this gambling product (Mravčík et al., 2020), it is paramount for a public health approach that we have a truly accurate evidence base for how exactly slot-machines can bring about gambling related harms.

An accurate evidence base is one which incorporates the process of replication, as outlined in the previous chapter. The current state of the gambling research is sorely lacking any targeted
replication attempts of popular effects (LaPlante, 2019; Wohl et al., 2019). It is possible then, given the high degree of erroneous effects uncovered in other domains of psychological research (Open Science Collaboration, 2015), that the current evidence base of the gambling field could be rife with false positive findings. Researchers need to begin conducting targeted, systematic replications of popular effects in the gambling literature, in order to provide the most up to date evidence-base for policy makers, regulators, and treatment providers. Given the increased risk for problem gambling associated with slot-machines (Murch & Clark, 2016), here, I outline the process of a systematic replication to determine which effects in the slot-machine literature are most in need of replication. In pursuing the open science recommendations outlined in the previous chapter, here I will:

1. Outline/restrict the initial scope of interest.

2. Choose a series of effects or theoretical features which may be worth replicating within the determined scope.

3. Outline replication value (RV) constraints and calculate RV for the chosen effects/theoretical features.

4. Determine the study design based on level of commitment to theoretical expectations.

One of the prevailing frameworks in psychology for harmful or problematic gambling is often referred to as the cognitive model of gambling (Brooks et al., 2020; Clark & Wohl, 2022). This model purports to answer the question of why exactly people continue to gamble in the face of mounting losses, especially given the negative expected value (the “house edge”) associated with casino gambling (Brooks et al., 2020; Ladouceur & Walker, 1996). Put simply, the cognitive model argues that gamblers continue to place bets because they inaccurately perceive the negative expectancy of gambling (Clark & Wohl, 2022), and that this inaccurate perception is
the result of some interaction between individual vulnerabilities (e.g. impulsive decision making styles) and the specific structural features of gambling games (Korn & Shaffer, 1999; Murch & Clark, 2016).

Key research in this area can be traced back to a series of classic experiments conducted by Ellen Langer throughout the 1970’s. In the most famous of these studies, she provided office workers with the option to buy a lottery ticket for $1. Half the participants chose their ticket from a selection of options, while the other half were assigned a ticket. Prior to the lottery draw, participants were allowed to sell back their lottery ticket to the experimenter. Langer found that participants who chose their own ticket listed the resale price of their ticket as significantly higher than participants in the assigned ticket group (Langer, 1975). Langer’s interpretation of these results was that participants valued their lottery ticket more in the choice condition, because choice increased their subjective likelihood of success, i.e. holding the winning ticket. Across a series of experiment, Langer identified 4 key features of chance situations that she argued could induce this feeling of illusory control: choice, involvement, competition, and familiarity (Langer, 1975).

In one of the first explorations of the illusion of control in slot-machine play, Robert Ladouceur pioneered a new technique to understand gamblers cognitions during gambling sessions, referred to as the “think-aloud” technique. This technique simply involved gamblers verbalizing their thoughts during a gambling session (Gadboury & Ladouceur, 1989; Ladouceur et al., 1988; Ladouceur & Mayrand, 1984a). These verbalized cognitions revealed that many gamblers engaged with games of chance such as slot-machine as if they involved some element of skill (e.g. “I won on three rows, I’m going to bet on those rows again.”; Ladouceur et al., 1988). Several years of work in this area following Ladouceur’s landmark studies has revealed
a robust association between the endorsement of gambling related cognitions (usually measured by the Gambling Related Cognitions Scale; Raylu & Oei, 2004) and problem gambling behaviour (often measured using the South Oaks Gambling Questionnaire, or Problem Gambling Severity Index; (Ferris & Wynne, 2001; Lesieur & Blume, 1987). Importantly however, these associations provide no information about directionality or causality; it could very well be that the development of problem gambling behaviours leads one to endorse erroneous gambling cognitions, or that the initial presence of erroneous cognitions makes one vulnerable to developing problem gambling behaviours. Additionally, the modern reliance on these self-report questionnaires has led to a neglect of an essential temporal component of these cognitions: gamblers expressed accurate beliefs about the chance element of gambling games while they were not gambling, but once they began gambling, they started to express erroneous gambling beliefs (Clark & Wohl, 2022; Gaboury & Ladouceur, 1989). Sevigny and Ladouceur (2003) have proposed the concept of “double switching” to explain this observation. They argue that gamblers may “switch off” their rational thoughts about the chance element of gambling during gambling, and that certain elements of gambling games encourages this “switching off” (Sévigny & Ladouceur, 2003)

A key claim within the cognitive model then, is that features which increase feelings of inferred control in games of chance can cause some people who gamble to overestimate the expectancy of gambling, thereby increasing their gambling behaviours (e.g. increased bet sizes, faster speed of play, increased persistence in gambling; Clark & Wohl, 2022). This notion has been investigated across a swathe of studies assessing the role of various “structural characteristics” of slot-machines in increasing gambling behaviour and leading to potential gambling harm (Griffiths, 1993). Slot-machines, as briefly mentioned earlier, hold a unique
place in the landscape of gambling products due to their increased potential for financial harm (Murch & Clark, 2016), and due to the fact that structural features that increase gambling behaviours can be engineered into these games (Cornish, 1978; Griffiths, 1993; Parke & Griffiths, 2006). For example, while horse races may contain events that affect people’s gambling behaviour (e.g., when the horse one has wagered on comes just short of winning), these events cannot be created in the way they can with computerized products. Classic structural characteristics of slot machines include the payout interval (i.e., the interval of time between the wager and the outcome), and the win probability/payout ratio (i.e. the average amount of money players will win back on a slot machine, usually 70% to 90%; Griffiths, 1993). Shorter payout intervals for instance, are associated with increased gambling harms because players can place many more bets in shorter periods of time (Griffiths, 1993; Newall et al., 2021), with slot machines being one of the forms of gambling with the shortest payout interval.

With the increasing accessibility of slot machines, gambling researchers must ensure an accurate evidence base on the effects that engineered slot machine structural features can have on players behaviour. My initial plan for my Masters project was to run a series of systematic replications of behavioural effects attributed to a specific structural feature of slot-machines that could be accurately measured in an online environment (i.e. excluding studies measuring neurophysiological variables associated with slot-machine gambling). At the outset of this project, I needed to ascertain which features were most in need of replications. To guide my replication efforts, I employed the replication value (RV) formula presented in Chapter 1 to four distinct slot machine structural characteristics that have been purported to have various effects on individuals’ behaviour during gambling sessions. Prior to RV calculation, I consulted several modern review papers in this area to arrive at this selection of slot-machine features (Balodis,
2020; Barton et al., 2017; Brooks et al., 2020; Clark & Wohl, 2022; Ejova & Ohtsuka, 2020; Newall et al., 2021), ultimately identifying four features that were cited consistently across these review:

1. Near-misses
2. Losses disguised as wins
3. Stopping devices
4. Jackpots

The feature known as the near-miss was the most commonly described feature across these reviews (Balodis, 2020; Barton et al., 2017; Brooks et al., 2020; Ejova & Ohtsuka, 2020). Near-misses are situations in which a losing outcome is proximal to a winning outcome; for example, when two out of three reels have matching symbols on the “payline” of a slot-machine, and the third matching symbol falls either directly before or after the payline. These events have been explored across a variety of dependent measures ranging from self-report (Clark et al., 2009), to behavioural (Dixon et al., 2013), to neurophysiological (Clark et al., 2014a; Sescousse et al., 2016). Many of these studies provide evidence showing near-misses can increase a person’s motivation to gamble, though there is some contention about the psychological processes underlying this effect (Clark, 2010; Wu et al., 2021).

With regard to the other three features: Losses disguised as wins emerged as the second most popular feature here (Dixon et al., 2010). These events are common in multiline slot machines, involving a scenario in which a participant wins back some amount of their wager while still experiencing a net loss (Barton et al., 2017). The outcome is also accompanied by audiovisual feedback similar to a win, unlike other loss outcomes. One popular hypothesis surrounding LDW’s is that they may cause people to underestimate the amount of money they
have lost in a session of gambling (Graydon et al., 2021). Stopping devices are features of slot machines that allow participants to choose when to stop the spinning reels without having any real impact on the symbols output by the machine (Clark & Wohl, 2022; Brooks et al., 2020). This feature could increase illusory control as it adds a superficial choice element to a game of chance (Ladouceur & Mayrand, 1984b; Langer, 1975). The presence of very large jackpots (or skewed gambles) in slot-machines has also been cited as a feature which can have the effect of increasing motivation to gamble (Ejova & Ohtsuka, 2020; Rockloff & Hing, 2013).

While each of these features is important for understanding slot-machine gambling related harms, the limited resources afforded to individual researchers necessitates the prioritization of confirming the role of certain features over others.

I next applied Isager’s (2019) RV formula to sets of studies testing various behavioural effects of each feature of interest. The RV calculation involves indexing the degree of theoretical impact that the given structural feature has in the cognitive model of gambling, while also considering the degree of corroboration underlying claims about the particular feature. I operationalised impact as the total Google Scholar citation count across studies investigating the feature, while corroboration was operationalised as the total sample size across studies investigating the feature. An informal literature search was conducted to collect a set of studies for RV calculations\(^1\). The highest RV for a specific feature indicates that conducting a replication of a study which tested that feature would have the greatest relative value. I searched the databases PsycInfo and Pubmed using the following search terms:

\(^1\) The literature search is labeled as informal, as I did not directly follow the PRISMA guidelines for systematic reviews, though in my past work I have had experience conducting these styles of review (Palmer et al., 2022).
- Near miss AND slot machine OR video lottery terminal OR electronic gambling machine OR EGM
- Losses disguised as win OR slot machine OR video lottery terminal OR electronic gambling machine OR EGM
- Stop button OR stopping device OR stopper device AND slot machine OR video lottery terminal OR electronic gambling machine OR EGM
- Jackpot AND slot machine OR video lottery terminal OR electronic gambling machine OR EGM

Studies were then screened to meet a specified set of inclusion criteria to determine which studies would be entered into the RV calculation for each feature. RV calculations based on the results of this database search are reported in Table 1. To be included in the RV calculation a study must have:

1. Been an experimental study
2. Involved a slot-machine task (whether simulated or real)
3. Included the feature of interest as the manipulated variable/predictor variable.
4. Included a dependent / outcome variable which can be easily captured online*
According to these RV calculations, the near-miss effect would have the highest replication value for the field. Although this feature had the highest level of existing corroboration (clearly due to its higher number of overall studies), its significant degree of theoretical impact meant the ratio of impact to corroboration was still higher than the other three features. For example, the total sample size for near misses is only around 150 participants larger than that for losses disguised as wins, despite near-misses having 8 more corroborating experiments than losses-disguised as wins. This may reflect a problem of low statistical power in the near-miss literature.

Given the wealth of literature on gambling near-misses, to determine which of exact study was appropriate for replication, it was necessary to both explore the historical literature on near-misses, and dive deeper into the studies that were eligible for the RV calculation. The near-miss has a rich history in psychology dating back to the behaviourist era (e.g. Strickland & Grote, 1967) and pre-dating much of the research on other structural characteristics of gambling games. For example, the very first paper describing the Losses Disguised as Wins phenomenon was Dixon et al., (2010). A pure behaviourist perspective of the near-miss, arising directly from Skinner’s (1953) discussion of conditional reinforcement, argues

<table>
<thead>
<tr>
<th>Structural Characteristic</th>
<th>Citations (Impact)</th>
<th>Sample Size (Corroboration)</th>
<th>RV</th>
<th>Number of Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Losses disguised as wins</td>
<td>690</td>
<td>1012</td>
<td>0.682</td>
<td>13</td>
</tr>
<tr>
<td>Near Miss</td>
<td>1748</td>
<td>1276</td>
<td>1.37</td>
<td>21</td>
</tr>
<tr>
<td>Stop Button</td>
<td>179</td>
<td>278</td>
<td>0.644</td>
<td>3</td>
</tr>
<tr>
<td>Jackpot</td>
<td>195</td>
<td>831</td>
<td>0.235</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1
Replication value calculations for selected structural characteristics
that near-miss outcomes increase gambling persistence by working as a secondary reinforcer to gambling wins. Through pairing the near-miss outcome to the winning outcome, the near-miss stimulus could lead to “joy and elation” similar to a win, thereby increasing persistence on the machine (Kassinove & Schare, 2001). Besides a behaviourist perspective, there are a number of other accounts of near-misses that appeal to different psychological processes. One of these draws on low-level goal generalization (Clark et al., 2009); gamblers may process near-misses as similar to a winning outcome, simply due to its perceptual similarity to the win as the outcome is unveiled. This can otherwise be described as a primarily appetitive, “miniature-win” account of the effect. Other perspectives of the near-miss have attributed its effects to induced feelings of frustration (Amsel, 1958, 1968; Reid, 1986) closely related to a modern cognitive account that emphasizes regret (Kahneman & Tversky, 1982; Loftus & Loftus, 1983; Wu et al., 2021). A third set of explanations note that near-misses contribute to a state of skill-chance confusion (Reid, 1986), enabling the illusion of control (e.g. in archery a near-miss is indicative of mastery as one gets closer to the target; Clark et al., 2009; Langer, 1975).

A recent replication attempt grounded in the behaviourist perspective shows some trouble for the hypothesis that near-misses increase gambling persistence. Across two experiments, Pisklak et al., (2020) failed to support this hypothesis. They used a resistance-to-extinction paradigm in a highly simplified slot-machine simulation to compare the reinforcing ability of near-miss outcomes to full-miss outcomes, in a sample of pigeons (experiment 1) and humans (experiment 2). Both experiments found no significant difference in the reinforcing capabilities of near-misses compared to full-miss outcomes. An important note on the Pisklak et al., (2019) human study is the slot-machine task had low ecological validity. While the task presented the three symbols successively as opposed to all at once, it neglected other boundary conditions
associated with the near-miss effect more broadly (Wu et al., 2017). In showing a single line to the participants as opposed to a 3x3 symbolic grid common for 3-reel slot machines, the task lacks the adjacent visual cues that may be necessary for observing near-miss effects (Dixon et al., 2015). Specifically, there is an important visual effect if the final winning symbol on the third reel of the slot machine stops immediately either side of the payline. This subtle boundary condition has been found to have varying effects on outcome measures of the near-miss (e.g. (Sharman & Clark, 2016; Wu, van Dijk, et al., 2017) and could be one reason for the null results reported in Pisklak et al., (2019).

Persistence designs are helpful for testing the long-term reinforcing effects of near-misses (Côté et al., 2003; Kassinove & Schare, 2001), but they are not the only dependent variable that might be considered. Capturing persistence in the lab is challenging and can lead to designs that lack ecological validity. Most persistence measures rely on resistance to extinction designs, where participants are required to play a given number of trials on the slot machine, in order to establish the association between the conditioned reinforcer of the near-miss and the winning outcomes. After an initial exposure to the game, winning outcomes are then withdrawn during the extinction test, such that the participant only receives losing outcomes. Some measure is then taken of how long the participant continues to play, in the face of mounting losses (Côté et al., 2003; Kassinove & Schare, 2001; Pisklak et al., 2020). This design can be unreliable as an ecological measure of gambling behaviour, because often when people are given an endowment in a lab setting and are told they can keep any money the win, they will leave the first chance they are allowed. For example, in Pisklak’s study, participants had to play at least 300 trials to reach the extinction phase, and only 60% of their sample made it to the extinction phase. With this many trials, it is possible that only those participants who really enjoyed gambling, or even
may have had gambling problems (Pisklak took no measure of this), continued to the extinction phase. Such a design misses out on the possible harms near-misses can have in those first 300 trials prior to extinction.

Approaching near-misses from a public health perspective elucidates other potential harmful outcomes of slot machine near-misses (Goyder et al., 2020; D. Korn & Shaffer, 1999; Schalkwyk et al., 2021). Gambling harms do not exclusively arise necessarily in populations of disordered gamblers (Murch & Clark, 2016), where “uncontrollable” persistence in gambling is a primary factor of gambling induced financial harms. With no prior gambling issues, people can lose significant amounts of money on a single wager; for example, on a bad sports gambling decision (Toce-Gerstein et al., 2003). The possible design of slot-machines’s to enable a state of skill-chance confusion or induce feelings of frustration means people can lose a lot of money in one session of slot-machine gambling in the absence of past gambling problems (Markham et al., 2016). This is because, as stated, there are other outcomes to consider with respect to the near-miss which increase the potential for gambling related financial risk. For instance, do near-misses increase self-reported motivation to continue gambling on a slot-machine; do they contribute differently to the valence associated with slot-machine gambling compared to other outcomes; do they increase speed of play; do they increase the amount people wager on subsequent trials? These questions do not rest on whether near misses are conditionally reinforcing and/or bring about persistence in gambling. If the underlying mechanism of near-miss effects is cognitive, then near-misses could have a number of potential effects on player behaviour (Murch & Clark, 2016).

Moving away from the behaviourist account of near-misses then, one account which starts to incorporate cognitive aspects of the near-miss is one based around low-level goal
generalization processes (Clark et al., 2009). This account argues participants may begin to process near-misses as an unexpected winning outcome due to the sequential presentation of outcomes (e.g. seeing two matching symbols is argued to begin engaging reward processes). This account draws on evidence showing differential activation of the ventral striatum and the anterior insula, brain regions central to decision making and reward processing (Clark et al., 2014b; van Holst et al., 2014). Specifically, following near-misses these areas showed patterns of activation more similar to wins than full-misses (Clark et al., 2009; Sescousse et al., 2016). Importantly, one issue with this account is that – without further extensions -- it does not readily account for findings that near-misses are rated more negatively than full-misses in many experiments (Clark et al., 2009; Sharman & Clark, 2016; Wu et al., 2021). If these outcomes where processed similar to a win, we would likely see participants rating these outcomes as more positive relative to full misses. Goal generalization is a fundamentally ‘appetitive’ theory, and negative valence ratings to near misses would be more characteristic of ‘aversive’ explanations such as the frustration and regret accounts.

A different cognitive account of near-misses rests on Langer’s (1975) notion of a skill-chance confusion leading to a state of illusory control while playing the game. Classic gambling studies show some gamblers treat slot machines as if they involve a skill element (Gadboury & Ladouceur, 1989). In many games of skill, a near-miss outcome is indicative of skill-acquisition or improving performance and is truly indicative of future successful outcomes. In slot-machine gambling however, goal achievement (i.e. achieving a winning outcome) is based purely on chance, and near-misses are not indicative of a coming win. However, because humans are notoriously deficient at processing chance events (Kahneman & Tversky, 1996), it could be that near-misses on slot-machines exploit a deficiency in the human understanding of probability,
leading some people to believe they indicate a coming win (Clark 2009). People may overgeneralize the notion of a near-miss as an accurate predictor of a coming success to activities where it only *appears* that skill has a contingent role to play in determining outcomes (Billieux et al., 2012). However, this account runs into a similar problem as the goal-generalization account, namely that near-misses are often rated as a more-negative experience compared to full-miss outcomes (Wu et al., 2021). If near-misses were perceived as indicators of impending success, a near-miss would likely be experienced as more positive relative to full-misses.

An alternative account takes the experience of negative valence associated with near-misses to argue that frustration induced regret is the mechanism underlying near-miss effects (Dixon et al., 2013, 2018; Wu et al., 2021). The argument here is that the visual cue of the near-miss either just approaching the payline (i.e. a near-miss before; NMB) or just passing the payline (i.e., near-miss after; NMA) induces a feeling of frustration at the apparently lost reward. Participant behaviour is assumed to change based on this frustrative state of negative affect. After a winning outcome, participant’s display consummatory behaviour by pausing their play prior to initiating a new trial (an effect referred to as the post reinforcement pause; Dixon et al., 2013). After near-miss outcomes, past research finds that participant’s speed of play increases following near-misses relative to full-misses and wins (Dixon et al., 2013), possible to escape the negative affect state brought on by the near-miss. This experience of frustration following near-misses is also evidenced by participant’s increase heart rate and skin conductance level following near-misses relative to full-misses (Clark et al., 2012; Dixon et al., 2013). This account can also better accommodate the nuanced differences between NMB and NMA effects. Specifically, Wu et al., (2015) argue that the visual cue of the third matching symbol passing through the winning payline combination engages ‘upward’ counterfactual processes where players mentally simulate
the positive outcome of the missed win. Because the NMA relative to NMB represent different styles of a missed win (i.e., for NMA the win was achieved and seemingly taken away as the symbol passes through the payline), these outcomes could have different effects on counterfactual thinking, such that NMA could be consistently reported as more negative relative to NMB (Clark et al., 2013; Wu et al., 2015).

In scoping this literature for effects that could help distinguish between the various accounts of near-misses, I identified a key paper assessing how near-misses influenced self-reported motivation and valence (Clark et al., 2009), and a second key paper that examined how near-misses affect speed of play on a slot machine (Dixon et al., 2013). Clark et al (2009) employed a slot machine simulation involving just two reels, and 40 undergraduate volunteers were asked to play 60 spins on the machine (Clark et al., 2009). In a notable feature, each trial began with a selection phase where either the participant (30 trials) or the computer (30 trials) selected the matching symbol (on the left-hand reel) for that spin. After the selection phase, participants were asked “How do you rate your chances of winning”. After submitting this rating, the right-hand reel spun for a few seconds. The simulation could deliver either a winning outcome where the symbols matched (on 1/6 of trials), a ‘full-miss’ outcome where the matching symbol on the second reel was nowhere near the payline (on 3/6 trials), or a near-miss outcome where the matching symbol fell either directly above or directly below the payline (on 2/6 trials). In this design, the near misses and full misses were objectively equivalent as losing outcomes. Following delivery of the outcome, participants provided two further ratings, successively: 1) how happy they were with the outcome, and 2) how motivated they were to continue playing the simulation.
The study by Clark et al., (2009) went on to use the same procedure in fMRI, but focussing on their behavioural task validation, on trials where the participant chose the symbol on reel 1, they rated their chances of winning significantly higher than on computer chosen trials. On the valence rating, participants rated near-miss outcomes as more aversive than full-misses, but increased the motivation to continue with the game more than full-misses. The winning outcomes were associated with the highest ratings of both valence and motivation. Notably, the motivational effect of near-misses has been observed across a number of other experiments using both similar slot machine tasks and some other games (Clark et al., 2012, 2013; Qi et al., 2011). However, the findings regarding the valence ratings are more mixed, with a few studies replicating the effect observed in Clark et al. (2009; Sharman et al., 2015), and others finding no differences between near-misses and full-misses in terms of the experienced valence (Clark et al., 2013). There are some notable limitations with this design which impact the ecological validity of the task. Specifically, two reel slot machines do not exist either in land-based or online casinos. Additionally, slot-machines where the machine itself initiates the spin, or where the player chooses their matching symbol do not really exist in land-based or online casinos (an exception is the “free-play”/”bonus-spins” feature on certain slot-machines). As such, it in the interest of ecological validity I was interested in attempting to replicate these effects on a more realistic slot-machine, removing the computer initiated trials (see Study 1 in Chapter 2).

Subsequent studies following Clark et al 2009 further distinguished near misses either side of the payline, termed NMA vs NMB. Clark et al., (2013) noted that the motivational effect was mainly driven by NMB and the aversive effect was mainly driven by NMA. This difference can be explained by the regret and frustration accounts that on an NMA the goal configuration is presented (briefly) and then actually withdrawn (Amsel, 1958; Loftus & Loftus, 1983; Reid,

The study by Dixon et al., (2013) assessed the effect of different slot-machine outcomes on speed of play. This study employed a realistic 3-reel slot machine played on a computer created by Game Planit Interactive Corp. that delivered winning outcomes which differed in magnitude, as well as full-miss outcomes and near-miss outcomes. To gauge speed of play, they measured the amount of time between the offset of a spin (i.e. the delivery of the outcome) and the initiation of the following spin. I refer to this interval as the spin initiation latency. They found the spin initiation latency increased as the magnitude of wins was larger. This win effect is known as the post reinforcement pause, and is also seen in experimental studies on animals on operant tasks (Weatherly & Derenne, 2007). Additionally, they found that 66.4% of their sample showed shorter spin initiation latencies for near-miss relative to full-miss outcomes. A related-samples Wilcoxon signed rank test indicated the difference in spin initiation latencies between near-misses and full-misses was significant a striking effect due to the functional equivalence of these outcomes (Dixon et al., 2013). Dixon et al (2015) have subsequently replicated this effect in a 5-reel slot machine design.

Aside from latency, and persistence, a third behavioural study that is widely studied in gambling research (and decision-making research more broadly) is bet size. Surprisingly, few studies investigated bet size changes in a slot-machine paradigm. The one study I found analyzed changes in bet size as a function of Outcome Type on the previous trial (Alicart et al., 2015). They found that following near-misses, a community sample were more likely to bet the highest possible wager on a two-reel slot machine (similar to the task in Clark et al., 2009) compared to full-miss outcomes, although this study had a very small sample size (n = 23). Considering other
forms of gambling, a field study assessed the effects of near miss outcomes on bet size, using a roulette style gambling task. This study observed that near-misses were associated with a reduced bet size on the following spin compared to near-miss outcomes (Sundali et al., 2013).

In the following chapter I report results of 4 empirical studies assessing the effect that near-misses can have on three distinct measures of gambling. In Study 1a and Study 1b, I describe a replication study looking at self-reported motivation and valence ratings observed in Clark et al., (2009). In Study 2 I will attempt to replicate the results of Dixon et al., 2013, where near-misses increased spin initiation latencies. Finally, in Study 3 I will analyze the effect that near-miss outcomes can have on the bet size of the following trial, testing two competing hypotheses that near-misses will either decrease bet size (Sundali et al., 2013) or increase bet size (Alicart et al., 2015) on the following spin.
Chapter 3: Self Report Ratings

Study 1a and 1b

The main question for Study 1 was how near-miss outcomes on a slot machine affect self-reported ratings of experienced valence and motivation to continue playing the slot machine. Study 1b was a direct replication of Study 1a, and these studies will be discussed together as their methods were identical; the only differing factor between these studies was the separate sample. We preregistered two hypotheses based on the prior study by Clark et al., (2009):

H1: ratings of motivation to continue playing the slot machine increase after near-misses compared to full-miss outcomes.

H2: ratings of valence will decrease after near-misses compared to full-miss outcomes.

These two hypotheses were also pre-registered for Study 1b. In Study 1b, I reversed the directional prediction for hypothesis 2 based on findings from Study 1a, to hypothesize that the valence ratings will increase after near-misses relative to full-misses.

Methods

Participants

The online crowdsourcing platform Prolific was used to recruit participants. Study 1a was run from October 19, 2021 to October 21, 2021. Study 1b was run from February 7, 2022 to February 8, 2022. A pre-screen questionnaire was employed to ensure participants met the following criteria for the study:

1. Be resident of Canada, Great Britain, USA, Ireland, Australia, or New Zealand.
2. Be at least 21 years of age.
3. Have a Prolific approval rate of 95.0% and at least 50 previous submissions (to increase data quality).
4. Have proficiency with English (reading and writing), to ensure acceptable comprehension of survey contents.

5. Not be at risk for problem gambling. For this criterion, the Problem Gambling Severity Index (PGSI) was administered at the start of the pre-screen survey (Ferris & Wynn, 2001). Participants who scored greater than 7 on this measure (indicating high risk) were not able to progress to the main study. Similarly, participants were not able to progress to the main study if in the pre-screen they endorsed having gambling problems and/or receiving treatment/counselling for gambling problems, including gambling 'self-exclusion' programs.

There were an additional set of pre-registered data exclusion criteria for participants who completed the main study:

1. Participants who complete fewer than the required 30 spins on the slot machine were excluded from the primary analysis.

2. Based on initial debugging, participants who have trial lengths that exceed 10 seconds will be excluded from the primary analysis. This is because trial lengths longer than 10 seconds indicate that the participant has switched browser tabs and thus is not paying attention to the task.

3. Participants who show no variability (i.e. SD of zero) in their valence or motivation ratings will be excluded from the primary analysis.

For each of the two studies I aimed to recruit a sample of n = 200. This sample size was based on a power analysis for an effect size of $d = 0.42$, calculated from the mean difference on motivation ratings between near-misses and full-misses in Clark et al., (2009) using the formula for Cohen’s $d_z$ (Lakens, 2013). Power analysis using G*Power (Faul et al., 2009), indicated a
required sample of \( n = 150 \) to achieve a power of 0.95. We opted to over-recruit by 25% to account for the possibility of participants failing to meet the data inclusion criteria listed above. To achieve the sample of \( n = 200 \) for the main studies, I capped our pre-screen recruitment at 400 places with the assumption that many participants who completed the pre-screen would not be eligible for the main study due to the pre-screen exclusion criteria.

For Study 1a, 366 participants who completed the pre-screen study were eligible, and invited to complete the main study. Of the 196 participants who completed the main study, \( n = 14 \) were removed for having at least one slot machine trial length that exceeded 10 seconds, \( n = 8 \) were removed for having incomplete motivation or valence ratings, and \( n = 6 \) were removed for having motivation or valence ratings with no variability across the 30 trials. The final sample for Study 1a was \( n = 169 \).

For Study 1b, 370 participants who completed the pre-screen study were eligible and invited to complete the main study. Of the 196 participants who completed the main study, \( n = 19 \) were removed for having at least one slot machine trial length that exceeded 10 seconds, \( n = 12 \) were removed for having incomplete motivation or valence ratings, and \( n = 17 \) were removed for having motivation or valence ratings with no variability across the 30 trials. The final sample size for Study 1b was \( n = 148 \).

As remuneration, participants received £0.75 for the pre-screen, and £4.50 for the main study. To increase the ecological validity of the gambling task, participants were informed they could win a bonus payment for any credits they earned above their initial endowment. Because the slot machine outcomes and bet size were fixed, each participant earned an additional bonus payment of £1, from finishing the slot machine task with 100 credits above their endowment (see slot machine task section for further details).
Procedure/Slot-Machine Task:

After recruitment from Prolific, participants were provided with a link to the pre-screen study hosted on Qualtrics. If participants were eligible for the main study, once they completed the pre-screen they received a link to the main study which was also hosted on Qualtrics. Prior to the slot machine task, participants completed a set of questionnaires assessing demographic information (i.e. age, gender, occupation, relationship status, education and location of residence), and PGSI score (Ferris & Wynn, 2001).

Following the questionnaires, participants played a realistic 3-reel online slot machine simulation that I developed using the Unity development platform (Unity Technologies, 2018) which returned four possible outcome types: wins (1/6 of trials), full-misses (3/6 of trials), near-misses before the payline (1/6 of trials), and near-misses after the payline (1/6 of trials). A winning outcome is indicated by any 3 matching symbols, and a full-miss is when none of the symbols on the payline match. A Near-Miss Before (NMB) occurs when the 2 first reels display matching symbols on the payline, but the third matching symbol falls directly before (i.e. above) the payline. A Near-Miss After (NMA) occurs when the 2 first reels have matching symbols on the payline and the third matching symbol falls directly after the payline.

The bet size in Study 1 was fixed at 5 credits, where one credit is equal to £0.01. A win on the slot machine returned 10x the initial bet size (i.e. 5 credit bet = 50 credit win). Participants were provided with a 500 credit endowment to play the slot machine. Participants were instructed to play 30 spins on the slot machine simulation. To vary the order of outcome presentation, participants were counterbalanced to one of two sequences of slot-machine outcomes, where the second sequence was simply the reverse order of the initial sequence. Each sequence returned the same ratio of outcomes as outlined above. Because the outcome sequences
and bet sizes are fixed, each participant ended with the same amount of credits (600), receiving a bonus of £1. After each slot machine spin, participants were presented with 2 Likert-style ratings: 1) “How happy are you with the result” (1 “Very Unhappy” to 7 “Very Happy”) for the valence rating, and 2) “How much do you want to continue playing the slot-machine?” (1: “Not at All” to 7 “Very Much”) for the motivation rating.

Data Analytic Approach:

The data analysis plans for these two studies were pre-registered. The two dependent variables for these studies are the valence and motivation ratings. For the primary analysis, two models tested for differences on the two dependent variables across three outcome types: wins, full-misses, and near-misses. For the primary analysis, the two types of near-misses (NMA, NMB) were collapsed as a single outcome category. In preparing the two dependent variables for analysis, each participant's self-report ratings were z-transformed based on their own mean and standard deviation. The reason for z-transforming the dependent variable scores was to remain consistent with the analysis plan in Clark et al., 2009. Repeated-measures analysis of variance was used to analyze the subjective ratings, with outcome type as the factor (wins, full-misses, near-misses). The Greenhouse-Geisser correction was used where sphericity was not met. Paired-samples t-tests were used to test the effects of near-misses on i) valence (near-misses versus full-misses) and ii) motivation (near-misses versus full-misses), with the alpha level set at 0.05.

A secondary analysis (also pre-registered) tested differences between the NMA and NMB near-misses. Similar to the primary analysis, the two dependent variables were compared using a repeated measures ANOVA across three outcome conditions: NMB, NMA, and full-misses. Wins were dropped from this analysis as their effects were already established in the primary
model. The Greenhouse-Geisser correction was used where sphericity was not met. Paired-samples t-tests were used to test the difference between near-misses before and near-misses after on i) valence and ii) motivation.

**Results**

The mean PGSI score in Study 1a was 0.76 (SD=1.28), the mean age was 34, and the gender breakdown of the sample was n = 82 men, n = 87 women. For Study 1b, the mean PGSI score was 1.01 (SD=1.56), the mean age was 37, and the gender breakdown was n = 77 mean, n = 68 women, n = 2 non-binary, and n = 1 did not provide their gender.

**Table 2.**

*Summary statistics for the motivation and valence ratings by outcome.*

<table>
<thead>
<tr>
<th>Study</th>
<th>Rating</th>
<th>Trial Outcome</th>
<th>Mean Raw Score (SD)</th>
<th>Mean Z-Score (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Motivation</td>
<td>Win</td>
<td>4.50 (1.64)</td>
<td>0.759 (0.679)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full-Miss</td>
<td>3.42 (1.53)</td>
<td>-0.23 (0.209)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Near-Miss (Combined)</td>
<td>3.66 (1.55)</td>
<td>-0.035 (0.237)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Near Miss (after)</td>
<td>3.61 (1.87)</td>
<td>-0.078 (0.896)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Near-Miss (before)</td>
<td>3.72 (1.89)</td>
<td>0.008 (0.86)</td>
</tr>
<tr>
<td></td>
<td>Valence</td>
<td>Win</td>
<td>6.14 (1.14)</td>
<td>1.87 (0.339)</td>
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<tr>
<td></td>
<td></td>
<td>Full-Miss</td>
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<td>-0.471 (0.154)</td>
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<td>Near-Miss (Combined)</td>
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<td>Near Miss (after)</td>
<td>2.44 (1.38)</td>
<td>-0.253 (0.521)</td>
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<td>Near-Miss (before)</td>
<td>2.52 (1.42)</td>
<td>-0.211 (0.529)</td>
</tr>
<tr>
<td>1b</td>
<td>Motivation</td>
<td>Win</td>
<td>4.46 (1.68)</td>
<td>0.629 (0.739)</td>
</tr>
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<td></td>
<td>Full-Miss</td>
<td>3.59 (1.58)</td>
<td>-0.194 (0.229)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Near-Miss (Combined)</td>
<td>3.801 (1.54)</td>
<td>-0.024 (0.218)</td>
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<tr>
<td></td>
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<td>Near Miss (after)</td>
<td>3.79 (1.91)</td>
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<tr>
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<td>Near-Miss (before)</td>
<td>3.82 (1.89)</td>
<td>-0.014 (0.895)</td>
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<td>Valence</td>
<td>Win</td>
<td>5.88 (1.07)</td>
<td>1.84 (0.34)</td>
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<td>Full-Miss</td>
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<td>Near-Miss (Combined)</td>
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<td></td>
<td>Near-Miss (before)</td>
<td>2.58 (1.28)</td>
<td>-0.229 (0.510)</td>
</tr>
</tbody>
</table>
**Primary Analysis**

For the motivation ratings in Study 1a, the omnibus test revealed a significant main effect of Outcome Type ($F_{2, 214.85} = 185, p < 0.001$). For the pairwise comparisons, wins were experienced as significantly more motivating than full-misses ($t(169) = 15.2, p < 0.001, d = 1.18$), and near-misses ($t(169) = 12.7, p < 0.001, d = 0.98$). Near-misses were experienced as significantly more motivating than full-misses ($t(169) = 7.14, p < 0.001, d = 0.50$), in line with the pre-registered hypothesis 1. In Study 1b, I found a significant omnibus test for the main effect of Outcome Type on motivation rating ($F_{2, 178.08} = 97.4, p < 0.001$). The pairwise comparisons revealed a qualitatively identical pattern of results in Study 1b to that of 1a: participants rated wins as significantly more motivating than full-misses ($t(148) = 10.7, p < 0.001, d = 0.80$), and near-misses ($t(148) = 9.32, p < 0.001, d = 0.77$). Near-misses were significantly more motivating than full-misses ($t(148) = 5.99, p < 0.001, d = 0.49$).

On the valence ratings for Study 1a, the omnibus test revealed a significant main effect of Outcome Type, $F_{2, 296.05} = 2991, p < 0.001$. Pairwise comparisons for the valence ratings confirmed that wins were experienced as significantly more positive both compared to full-misses ($t(168) = 75.6, p < 0.001, d = 5.82$), and near-misses ($t(168) = 54.0, p < 0.001, d = 4.16$). Additionally, near-misses were experienced as significantly more *positive* than full-misses ($t(168) = 8.15, p < 0.001, d = 0.627$). In the direct replication experiment (Study 1b), the omnibus test yielded a significant main effect of Outcome Type on valence ($F_{2, 251.22} = 2563, p < 0.001$). Pairwise comparisons revealed wins were experienced as significantly more positive than full-misses ($t(148) = 70.0, p < 0.001, d = 5.76$), and near-misses ($t(148) = 49.5, p < 0.001, d = 4.1$). We corroborated the finding from Study 1a that near-misses were rated as significantly more positive than full-misses ($t(148) = 7.05, p < 0.001, d = 0.579$).
Figure 1.

Standardized motivation ratings by trial outcome.

Note. Across Study 1a and 1b, wins were experienced as the most motivating outcome, near-miss outcomes were significantly more motivating than full-miss outcomes.
Figure 2.

*Standardized valence ratings by outcome.*

Note. Across Study 1a and 1b, wins were experienced as the most positive outcome, near-miss outcomes were significantly more positive than full-miss outcomes.

**Secondary Analyses**

A secondary analysis compared the effect of Outcome Type on the motivation and valence ratings across the two types of near misses (NMA vs NMB), and full-misses. In Study 1a, the motivation to continue play ratings differed significantly by Outcome Type ($F_{2,33.31} = 26.1$, $p < 0.001$). Pairwise comparisons suggested that full-misses were less motivating than NMB ($t(168) = -7.63$, $p < 0.001$, $d = 0.59$), as well as NMA ($t(168) = -4.52$, $p < 0.001$, $d = 0.35$). Additionally, NMB were reported as significantly more motivating than NMA ($t(168) = 2.46$, $p$
In study 1b, the omnibus test revealed a similar significant main effect of Outcome Type on ratings of motivation to continue playing ($F_{2, 292.7} = 17.0, p < 0.001$). Pairwise comparisons revealed a similar pattern of results in Study 1b: full-misses were less motivating compared to NMB ($t(147) = 5.56, p < 0.001, d = 0.46$), and compared to NMA ($t(147) = 4.75, p < 0.001, d = 0.39$). The difference between NMB and NMA on motivation ratings did not reach significance in Study 1b ($t(147) = 0.59, p = 0.5$).

For the valence ratings in Study 1a, a significant main effect of Outcome Type was observed on the omnibus test ($F_{2, 270.28} = 50.11, p < 0.001$). Pairwise comparisons demonstrated that full-misses were experienced more negatively compared to NMB ($t(168) = 8.05, p < 0.001, d = 0.61$), and compared to NMA ($t(168) = 7.34, p < 0.001, d = 0.56$). There was a significant difference in ratings between NMB and NMA of small effect, where NMB were rated as slightly more positive ($t(168) = 2.10, p = 0.038, d = 0.16$). In the direct replication Study 1b, I found a significant omnibus test for the main effect of Outcome Type on valence ratings ($F_{2, 221} = 39.3, p < 0.001$). Follow-up pairwise comparisons again showed that NMB were experienced as more positive than full-misses ($t(147) = 7.05, p < 0.001, d = 0.58$) and that NMA were experienced as more positive than full-misses ($t(147) = 6.43, p < 0.001, d = 0.53$). However, in Study 1b the difference between NMB and NMA failed to reach significance ($t(147) = 1.24, p = 0.22$).

**Discussion**

Across two studies, I sought to replicate the results of Clark et al., (2009) that slot machine near-misses were experienced as more motivating (i.e. increased desire to continue gambling) relative to full-misses, and were also experienced as more negative (i.e. aversive) relative to full-misses. The study design was a *conceptual* replication rather than a direct replication due to a couple of design changes; past work on the near-miss using other game
configurations led us to assume I would observe the same results as in Clark et al., 2009 in our 3-reel simulation. The data observed here strongly support the hypothesis that near-misses were more motivating relative to full misses, at least using self-report ratings. The second hypothesis that near-misses are experienced more negatively than full-misses was not supported. In fact, across both studies, I observed a significant effect in the opposite direction, that near-misses were rated more positively than full-misses. In the secondary analysis, NMB were experienced as significantly more motivating and significantly more positive than NMA, but only in Study 1a and with a small effect size.

The replication of the motivation ratings has relevance for regulatory considerations, such that engineering near-misses into slot-machines in electronic or online gambling might increase actual gambling behaviour. This finding has been observed across several studies (Clark et al., 2012; Sharman et al., 2015; Sharman & Clark, 2016). The motivational effect is the basic tenet of the near-miss ‘effect’, it is in line with each of the accounts of near-misses mentioned throughout the intro. A skill-acquisition account would argue near-misses are more motivating because they indicate impending success. A goal-generalization account makes them more motivating because they’re experienced similar to a win. A regret/frustration account would argue that the negative feelings elicited by just missing the reward spurs on further gambling. Each of these accounts agrees that near-misses increase motivation to gamble to some extent, although they posit distinct mechanisms which may underlie this increase in motivation.

Our finding that the valence associated with near-miss outcomes was more positive relative to full-misses was rather surprising, and thus led to the direct replication in Study 1b. Although the valence effect of the near-miss outcome has been less consistent than the motivation ratings, in that some studies found no differences (Clark et al., 2013), the most
common finding using this style of rating was that near-misses were experienced more negatively than full-misses (Sharman et al., 2015; Sharman & Clark, 2016; Wu et al., 2015). There are a couple of possibilities for this directional change. One possibility is that because past studies used relatively small sample sizes (e.g. Clark et al., 2009), the previous findings may have been chance events which do not reflect a true effect. The current replication attempts represent the two largest sample sizes to test this effect to date, having 95% power to detect a true effect. Thus, it’s possible these are the first studies to observe the true effect. However, the fact that there are multiple previous papers with effects in the opposite direction does suggest that other forces may be at work, perhaps in terms of boundary conditions.

Thus, one possibility is that shifting to the online environment may have made an important difference to the effect of near-misses. Are there features of playing a slot machine online that renders near-misses to be experienced more positively than full-misses? One possibility was that switching to an online study may have increased the ‘collinearity’ of the two successive ratings, i.e. by taking the valence and motivation ratings back-to-back, participants may have treated them as the same question. I ruled this out in a supplementary analysis that showed that participants’ motivational and valence ratings exhibited only a medium correlation. A second possibility is that the level of control that participants had in Clark et al., 2009 was inflated due to their ability to select the matching symbol (a feature that does not occur in naturalistic slot machines). In removing this option from our study to make the task more ecologically valid, it could have had an effect on the subsequent ratings.

A third possibility relates to how participants might perceive online slot machines. A study by Wu et al., found that in social competition scenarios (a two player Tetris game), near-misses where Player A finished just behind their opponent, were also rated more positively than
full-misses where the player lost by a greater margin (Wu, Eisenegger, et al., 2017). Such an effect online is also consistent with past research showing that gamblers often ‘anthropomorphize’ slot-machines (Kim & McGill, 2011; Ladouceur & Walker, 1996; Riva et al., 2015), believing them to be a game of skill where they are in competition with the slot machine itself, as if the slot-machine is a kind of sentient being (e.g. “This machine is making me mad on purpose”; Ladouceur et al., 1988) Because people have a tendency to respond socially to computing systems (Nass & Moon, 2000; Reeves & Nass, 2003; Zhong et al., 2003), it is possible that people are more likely to perceive an online slot machine as a type of competition with an agent, thereby leading to increased positive ratings for near-miss outcomes.

The results of the secondary analysis do not quite fit the frustration induced regret account as described in chapter 2. For this account to be true, the more aversive outcome (i.e. NMA) should be the more motivating outcome as well. What I observed here contradicts such an argument: NMB were more positive than NMA which was consistent with past research, though I also observed NMB to be more motivating than NMAs in contrast with past research (Clark et al., 2013; Sharman et al., 2015). Although these effects were small (not reaching significance in Study 1b), what has been observed here seems the opposite of a frustration induced regret account, in that the positive experience associated with the NMB could be increasing the motivation to continue gambling following this outcome relative to NMA.

Regardless, the current observations support the fact that despite being functionally identical to full-miss outcomes, near-misses appear to elicit a range of differential psychological effects which should be considered from a public health approach to gambling harms. However, trying to understand the potential harm attributable to near-miss outcomes purely from the perspective of self-report ratings is certainly not comprehensive. Self-report measures are limited
in a number of ways (e.g. see Rosenman et al., 2011), but combined with other types of measures they can be quite informative. To further investigate the effect that near-miss outcomes can have, and to help determine which account of near-misses is most accurate, measures testing for behavioural effects of near-misses are necessary. Studies 2 and 3 address this aim.
Chapter 4: Speed of play

Study 2

The main question for Study 2 was how near-miss outcomes on the same online slot machine simulator affect participants' speed of play, as a behavioural measure that was operationalized as the spin initiation latency. Two competing hypotheses were pre-registered for how near-misses (relative to full-misses) might affect the spin initiation latency: 1) in considering the positive emotional effects of near-misses on subjective ratings in Study 1, it is possible that near-misses will be associated with longer spin initiation latencies relative to full-misses? Or 2) considering past research on frustration as a mechanism for near-misses, can we confirm the results of Dixon et al., (2013) that near-misses will be associated with shorter spin initiation latencies relative to full-misses.

Methods

Participants

Study 2 was run from March 9, 2022 to March 11, 2022. Recruitment used this same approach as Study 1 with a target sample of n = 200. This sample size was based on the size of the sample from Study 1, rather than being based on a power analysis of a specific effect size. Similar to study 1, to achieve the sample of n = 200 for the main study I capped our pre-screen recruitment at 400 places with the assumption that many participants who completed the pre-screen would not be eligible for the main study.

Study 2 Data Exclusion Criteria:

1. Participants who complete fewer than the required 60 spins will be excluded from the primary analyses
2. Participants who have any trial lengths that exceed 10 seconds will be excluded from the primary analysis.

3. Participant’s with spin initiation latencies longer than 10 seconds will be removed from the primary analysis.

For Study 2, 365 participants who completed the pre-screen study were eligible to complete the main study. Of the 196 participants that completed the main study, n = 26 were removed for having at least one slot machine trial length that exceeded 10 seconds. The final sample size for the primary analysis was n = 170. For remuneration, participants received £0.75 for the pre-screen, and £3 for the main study. Participants were again informed they could win a bonus payment for any credits won above their initial endowment. With the fixed outcome sequence, each participant in Study 2 earned an additional bonus of £0.50, because they ended the slot machine task with 50 credits above their endowment.

Procedure/Slot-Machine Task:

The procedure for study 2 follows a similar structure to Study 1. After recruitment from Prolific, participants were provided with a link to the pre-screen study hosted on Qualtrics. If participants were eligible for the main study, once they completed the pre-screen they received a link to the main study which was also hosted on Qualtrics.

Prior to completing the slot machine task, participants responded to a set of questionnaires assessing demographic information (i.e. age, gender, occupation, relationship status, education and location of residence), and PGSI score (Ferris & Wynn, 2001).

Following the questionnaires, participants played the same slot machine simulation used in study 1 with the same ratio of outcomes: wins (1/6 of trials), full-misses (3/6 of trials), near-misses before the payline (1/6 of trials), and near-misses after the payline (1/6 of trials). For Study 2, the
ratings following each trial were removed, as these would interfere with the primary dependent variable (spin initiation latency) for this study.

Bet size in Study 2 was fixed at 5 credits, where one credit is equal to £0.01. A win on the slot machine returned 7x the initial bet size (i.e. 5 credit bet = 35 credit win). Participants were provided with a 500 credit endowment to play the slot machine. Participants were instructed to play 60 spins on the slot machine simulation. To counterbalance the order of outcome presentation, participants played one of two sequences of slot outcomes where one sequence was simply the reverse order of the initial sequence. Each sequence returned the same ratio of outcomes as outlined above. Because the outcome sequences and bet sizes are fixed, each participant ended with the same number of credits (550), receiving a bonus of £0.50.

**Data analytic approach**

The data analysis plan for this study was pre-registered. The dependent variable for this study is participant spin initiation latency. The spin initiation latency is the amount of time between the offset of the outcome phase of a spin (after the completion of any audio-visual feedback), and the initiation of the next spin. This dependent variable was compared across three outcome conditions for the primary analysis: wins, full-misses, and near-misses (with the two types of near-misses collapsed as a single outcome). In preparing the dependent variable for analysis, the spin initiation latencies were log transformed as the data was non-normally distributed. Repeated-measures analysis of variance was used to analyze participant spin initiation latency, with outcome type as the factor (wins, full-misses, near-misses). The Greenhouse-Geisser correction was used where sphericity was not met. Paired-samples t-tests were used to test the effects of near-misses on spin initiation latency relative to full-misses, with the alpha level set at 0.05.
For the secondary analysis, I ran a repeated measures ANOVA with 3 levels: NMB, NMA, full-misses. This was to determine if a difference existed between near-misses before the payline and near-misses after the payline for spin initiation latency. The Greenhouse-Geisser correction was used where sphericity was not met. A paired-samples t-test was used to test the difference between near-misses and full-misses for spin initiation latency, with the alpha level set at 0.05.

**Results**

The means PGSI score in Study 2 was 0.69 (SD=1.31), the mean age was 36, and the gender breakdown of our sample was n = 79 men, n = 88 women, n = 2 non-binary, and n = 1 did not report gender.

**Table 3.**

*Summary statistics for the raw and log transformed spin initiation latencies by outcome.*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Raw Spin initiation latency in seconds (SD)</th>
<th>Log₁₀ Spin initiation latency (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win</td>
<td>1.611 (2.066)</td>
<td>-0.33 (0.808)</td>
</tr>
<tr>
<td>Full-miss</td>
<td>0.877 (0.755)</td>
<td>-0.967 (0.605)</td>
</tr>
<tr>
<td>Near-miss</td>
<td>0.83 (0.932)</td>
<td>-1.032 (0.629)</td>
</tr>
<tr>
<td>Near-miss (After)</td>
<td>0.821 (0.917)</td>
<td>-1.02 (0.668)</td>
</tr>
<tr>
<td>Near-miss (Before)</td>
<td>0.839 (1.21)</td>
<td>-1.041 (0.668)</td>
</tr>
</tbody>
</table>

**Primary Analysis**

The repeated measures ANOVA revealed a significant main effect of Outcome Type on the spin initiation latencies (F₂, 223.04 = 145). Wins on the slot machine led to a significant increase in spin initiation latency compared to both near-misses (t(169) = 12.8, p < 0.001, d = 0.98), and full-misses (t(169) = 12.5, p < 0.001, d = 0.96), in line with a classical post-reinforcement pause effect. Near-misses elicited a shorter spin initiation latency compared to full-misses (t(169) = -2.63, p = 0.009, d = -0.20).
Figure 3.

*Mean spin initiation latency in seconds by outcome*

![Graph showing mean spin initiation latency by outcome](image)

*Note:* Wins were associated with a slowed speed of play, while near-miss outcome were significantly faster than full-miss outcomes.

*Secondary Analysis*

The omnibus test for the secondary analysis assessing differences in spin initiation latencies for near-misses before, near-misses after, and full-misses revealed no significant
differences between groups ($F_{2, 325.33} = 2.99, p = 0.054$). Thus, I did not run any follow up pairwise comparisons for this analysis.

**Discussion**

In Study 2 I focussed on the effect that near-misses could have on the speed of play on a slot machine. To understand the effect of near-misses on speed of play, I measured spin initiation latencies as the amount of time between the offset of the outcome (i.e. after any audiovisual feedback to wins) and the participant’s initiation of the next spin. Prior to Study 1, I had predicted that near-misses would lead to shorter spin initiation latencies, previously reported by Dixon et al., (2013), and assumed to reflect frustration, i.e. that participants quickly initiate the next round to escape the negative affective state caused by the unmet expectation of winning. Clearly, this mechanism would depend on near-misses being rated more negatively than full-misses; an effect that was refuted in Study 1. Study 1 indicated that near-misses were experienced as more positive than full-misses, leading to a directional hypothesis that spin initiation latencies might be faster following near-misses than full-misses.

The observed data in Study 2 provided support for the hypothesis that near-misses were associated with shorter (i.e. faster) spin initiation latencies relative to full-misses, supporting the original findings of Dixon et al., (2013). We also found support for a classical finding in slot machine research and operant behaviour known as the post reinforcement pause, where spin initiation latencies are lengthened following winning outcomes (Dixon et al., 2013). This is attributed to the consummatory component of the reward system, with the idea being that upon achieving the rewarding outcome participants take a moment to enjoy the state of goal attainment (i.e. the subjective ‘liking’ of hedonic enjoyment; Alcaro et al., 2007; Dixon et al., 2013; Robinson & Berridge, 2000). To our knowledge, this is the first demonstration of this effect in
online slot machine gambling. In the secondary analysis, I found no significant differences for spin initiation latencies between Outcome Types (i.e. no difference between NMB, NMA, and full-misses).

These findings contribute to a growing body of literature looking at the effects of EGM Outcome Types on participants’ speed of play. We replicated results from past research showing near-misses lead to significantly shorter spin initiation latencies compared to wins and full-misses. This means that near-misses are likely not experienced in the same manner as wins, in that participants responses to near-misses lack the consummatory pause associated with the subjective ‘liking’ of hedonic enjoyment. In other words, it seems unlikely that near-misses elicit operate via low-level goal generalization in which they are experienced as “miniature wins”.

Indeed, the shorter spin initiation latencies would be predicted more so by a frustration account of near-misses, where it is argued that the participants increase their speed of play on these trials to escape a negative affect state induced by an unsatisfied expectation of winning (Dixon et al., 2013).

Although the results of Study 2 form a coherent pattern within this experiment, and corroborate the past work by Dixon, the results of Study 1 and Study 2 appear somewhat contradictory. The data observed in Study 1 do not support the frustration account of near-misses, because near-misses were rated more positively relative to full-misses. A frustration account of near-misses would require them to be experienced as more negative relative to full-misses (Dixon et al., 2013, 2018). However, the faster speed of play that I observed in Study 2 has in the past been interpreted as evidence that near-misses are experienced as primarily aversive. This is said to be because participants increase their speed of play to escape the negative affect state brought on by the near-miss (Clark et al., 2013; Dixon et al., 2013).
Importantly though, interpreting reduced spin initiation latencies following near-misses as evidence of frustration conflates two components of action with respect to decision-making: the invigorating of a response to avoid a negative affective state, versus the invigorating of a response to achieve a reward that one believes is close (Guitart-Masip et al., 2014). The frustrative non-reward account argues that the initiation of the following spin on a slot machine is faster following near-misses because people are trying to quickly escape the negative affective state brought on by the unmet expectation of winning as the near-miss outcome is revealed. However, researchers have also shown that people increase their response vigor in situations where they believe their action will obtain a reward (Griffiths & Beierholm, 2017; Guitart-Masip et al., 2014). If an element of skill-acquisition plays a roll in the processing of near-miss outcomes (Clark et al., 2009), I might be seeing faster spin initiation latencies following near-misses because people perceive these outcomes to indicate a reward is close, thereby invigorating their following spin initiation (i.e. speeding it up). Cleary then, spin initiation latency is not sufficient for distinguishing between the different accounts of near-misses. Thus, it is necessary to consider other measures to make better sense of the roll that near-misses can play in affecting gambling harms (e.g. through some measure of risk taking such as bet size).
Chapter 5: Bet Size

Study 3

The main question for Study 3 was how 'near-miss' outcomes on a slot machine affect participants' betting. Specifically, I was interested in how the different outcome types influenced participants’ subsequent bets, and this required modification to the basic online slot machine task to allow the participant to vary their bet size. Based on previous research I pre-registered and tested two competing hypotheses that 1) bet size will increase following a near-miss relative to a full-miss (Alicart et al., 2015), or 2) bet size will decrease following a near-miss relative to a full-miss (Sundali et al., 2012).

Methods

Participants

Study 3 was run from April 24, 2022 to April 30, 2022. We employed the same method of recruitment as that of Study 1 and 2. For this study, I aimed to collect a sample of n = 250. This sample size was based on the size of the sample from study 2, rather than being based on a power analysis of a specific effect size. We did not conduct a power analysis for this study as I was unsure of the likely effect size for near-misses on changes in subsequent bet size. We anticipated a greater amount of data loss compared to Study 1 and 2 due to an additional data exclusion criteria for this study (see 3. in Study 3 Data Exclusion Criteria), thus, I increased the target sample by 50. To achieve the sample of n = 250 for the main study I capped our pre-screen recruitment at 400 places with the assumption that many participants who completed the pre-screen would not be eligible for the main study.

Study 3 Data Exclusion Criteria:
1. Participants who complete fewer than the required 60 spins will be excluded from the primary analyses.

2. Based on initial debugging, participants who have trial lengths that exceed 10 seconds will be excluded from the primary analysis. This is because trial lengths longer than 10 seconds indicate that the participant has switched browser tabs, and is not paying attention to the task.

3. Participants who maintain the same bet size throughout the trial will be removed from the primary analysis.

For study 3, n = 361 participants who completed the pre-screen study were eligible to complete the main study. Of the n = 244 participants that completed the main study, n = 25 were removed for having at least one slot machine trial length that exceeded 10 seconds, and n = 46 were removed for showing no variability in their wagering throughout the whole task. The final sample size for the primary analysis was n = 172.

Procedure/Slot Machine Task

The procedure for study 3 follows a very similar structure to study 1 and 2. After recruitment from prolific, participants are provided with a link to the pre-screen study hosted on Qualtrics. If participants were eligible for the main study, once they completed the pre-screen they received a link to the main study which was also hosted on Qualtrics.

Prior to completing the slot machine task, participants responded to the same set of questionnaires from study 1 and 2. Following the questionnaires, participants played a similar slot machine simulation to that used in study 1 and 2 with an identical ratio of outcomes: wins (1/6 of trials), full-misses (3/6 of trials), near-misses before the payline (1/6 of trials), and near-misses after the payline (1/6 of trials).
The main difference in Study 3 is the introduction of a variable bet size. In this version of the task, participants selected a bet from 1-5 credits on each trial, where one credit is equal to £0.01. A win on the slot-machine returned 5x the initial bet size (e.g. 3 credit bet = 15 credit win). Participants were provided with a 500 credit endowment to play the slot machine, and were instructed that they would play 60 trials. To counterbalance the order of outcome presentation, participants played one of two sequences of slot outcomes where one sequence was the reverse order of the initial sequence. Each sequence returned the same ratio of outcomes as outlined above. Because betting was variable in this study, participants could win anywhere from £0 to £2.50 as a bonus depending on their betting decisions.

Data Analytic Approach

The main dependent variable was the average bet size following each outcome type, ranging from 1 to 5. Repeated-measures analysis of variance was used to analyze differences between average participant bet sizes following each outcome type, with outcome type entered as factors (wins, full-misses, near-misses). Specifically, I am looking to tests the effect of changes in bet size as a function of the outcome on the previous trial. Bet size on the first trial was necessarily excluded from these analyses. The Greenhouse-Geisser correction was used where sphericity was not met. A paired-samples t-test was used to test the effects of near-misses compared to full misses, with alpha levels set at 0.05.

For the secondary analysis comparing near-misses before, near-misses after, and full-misses, I used a repeated measures ANOVA with these three outcome types entered as factors. The Greenhouse-Geisser correction was used where sphericity was not met. A paired-samples t-test was used to test the difference between near-misses after the payline and near misses before the payline on subsequent bet size, with alpha levels set at 0.05.
Results

The means PGSI score of our sample was 0.67 (SD=1.18), the mean age was 36, and the gender breakdown of our sample was n = 81 men, n = 85 women, n = 6 endorsed non-binary genders.

Table 4.

Summary statistics for bet size as a function of the previous outcome

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Average Following Bet Size (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win</td>
<td>2.924 (1.40)</td>
</tr>
<tr>
<td>Full-miss</td>
<td>3.205 (1.17)</td>
</tr>
<tr>
<td>Near-miss</td>
<td>3.275 (1.18)</td>
</tr>
<tr>
<td>Near-miss (After)</td>
<td>3.312 (1.18)</td>
</tr>
<tr>
<td>Near-miss (Before)</td>
<td>3.238 (1.22)</td>
</tr>
</tbody>
</table>

Primary Analysis

The initial omnibus test showed a significant main effect of Outcome Type on the size of the bet for the following spin ($F_{2, 222.81} = 58.2$, $p < 0.001$). Winning outcomes were associated with a decrease in bet size on the following spin compared to both near-misses ($t(171) = -8.30$, $p < 0.001$, $d = -0.63$), and full-misses ($t(171) = -7.44$, $p < 0.001$, $d = -0.57$). Additionally, near-misses were associated with a significant increase in bet size on the following spin compared to full-misses ($t(171) = 3.79$, $p < 0.001$, $d = 0.29$).
Figure 4.

Bet size as a function of previous outcome

Note: Wins were associated with the greatest reduction in the following bet size, while near-miss outcome led to the significantly largest increase in bet size on the following spin.

Secondary Analysis

The ANOVA on subsequent bet size following NMB, NMA, and full-misses showed a significant main effect of Outcome Type on the following bet size ($F_{2,276.4} = 7.64$, $p = 0.001$). Pairwise comparisons showed that NMA were associated with a significant increase in bet size
compared to full-misses ($t(171) = 5.04, p <0.001, d = 0.38$), and NMB ($t(171) = 2.21, p = 0.029, d = 0.16$), while there was no difference between NMB and full-misses ($t(171) = 1.18, p = 0.24$).

**Discussion**

Study 3 tested the effects of near-miss outcomes on subsequent betting behaviour, as a relatively neglected behavioural variable in research on slot machines and the near miss effect. Based on two previously findings tested the effect of near-misses on bet-size, across slot machines (Alicart et al., 2015) and a field study of roulette (Sundali et al 2012), we tested two competing hypotheses that relative to full-misses, near-misses would either 1) increase participant’s bet size on the following trial, or 2) decrease participants’ bet on the following trial. The observed data lend support for the hypothesis that near-misses cause participants to increase their wager on the following spin relative to full-misses. Notably, I also found that participants wagered significantly less on trials following a winning outcome compared to both near-misses and full-misses. There were also notable significant differences observed in the secondary analysis: NMA led to increased bet sizes compared to full-misses and NMB, while there were no differences between NMB and full-misses.

It is worth disentangling the effect of wins on bet size prior to discussing the effect of near-misses. The well-known ‘house-money effect’ claims that when a person wins money (or is given money as a ‘windfall’) during a session of gambling, their subsequent risk taking often increases (Thaler & Johnson, 1990). However, the effect is not uniformly seen, and in recent investigations in field settings, the exact opposite of the house money effect has been reported: participants reduced their risk taking in the form of lower average wagers after receiving an inducement or after winning a jackpot (Flepp & Rüdisser, 2019; Rüdisser et al., 2017). This is similar to what I observed in the current study: following delivery of the winning outcome,
participants bet significantly less money on the following spin. This may relate to how people misunderstand the independence of slot-machine spins, in that some people perceive a contingent relationship between past and future outcomes on the slot-machine when no such relationship exists (Ejova et al., 2013; Langer & Roth, 1975). For instance, there is some evidence showing that people believe a winning outcome is less likely to occur on a slot machine if a winning outcome has just been delivered (Turner, 2000), despite the true independence of slot-machine outcomes. This shows that in playing slot machines, people may believe they can effectively reason about the probability of specific outcomes occurring by considering past sequences of events (Ejova & Ohtsuka, 2020).

Such a situation relates to the notion of the gambler’s fallacy, the belief that future chance events are contingent on past chance events which in reality have no causal relation. It is possible that some people see chance as a type of “self-correcting process,” believing that chance aims at a balanced equilibrium. Deviations from this balanced equilibrium are then assumed to correct by the revealing of opposing outcomes as a chance process unfolds (Tversky & Kahneman, 1974), say, over a session of slot-machine play. So, a reason people may reduce their bets following a win is simply because they believe a win will be less likely on the following trial, despite future outcomes on slot-machines’s having no contingent relation to past outcomes. This style of reasoning about probability relates back to the idea that slot-machines may induce a state of skill-chance confusion. People may believe that they can accurately predict the sequence of slot-machine outcomes based on previous outcomes (Ejova and Ohtsuka, 2020), and in doing so may alter their betting strategy based on the delivery of specific Outcome Types. Our finding that near-misses led to increased wagering also fits well with this notion. If gamblers perceive a near-miss as indicating a win is close (as is the case in truly skill-based activities such as
archery), it seems reasonable that people will increase their wager on the spin directly following a near-miss.

The differences between NMB, NMA, and full-misses in the secondary analysis speaks to the regret account of near-miss outcomes. If the increased bet-sizes following NM is attributed purely to a skill-chance confusion fostering the illusion of control, then we should see no differences between the two types of near-misses because they are equally close to the winning outcome. However, if near-misses induce a feeling of regret at the nearly missed win, thereby engaging upward counterfactual processing, then we would likely see different behavioural and risk taking outcomes depending on the position of the final reel, i.e. whether the matching symbol is above or below the payline. The regret account argues that NMA are particularly motivating because it can seem as if a win was achieved and then taken away as the matching symbol slowly passes through the payline. This is contrasted with NMB where the participant never actually sees the 3 matching symbols line-up, the counterfactual processing in such a case requires simulating a possible scenario in which the three reels could have lined up. The relevant difference here is that it is more intuitive to imagine a counterfactual situation in which the win was taken away as a missed opportunity (NMA; (Wu et al., 2021)), rather than simulating a potential situation that never appeared to actually occur. It is not difficult to consider how these different experiences could lead to differences in risk taking on the following spin. Studies looking at feelings of regret associated with missed opportunities show that people are more likely to choose a risky option following missed opportunity situations (e.g. see Feeney et al., 2018; Lin et al., 2021). Perhaps then, experienced regret is a relevant mechanism for explaining changes in risk taking following certain slot-machine Outcome Types.
Chapter 6: General Discussion

The field of gambling studies is beginning to recognize the potential pitfalls of a growing body of research that does not regularly incorporate the process of systematic replications. Without this crucial error monitoring process, researchers within the field may inadvertently perpetuate theoretical accounts and gambling policy built on erroneous data. While governments and gambling regulators may care little about psychology theory, it is nonetheless important for policy and regulation because development of theory is one of the main factors that motivates the research that policy makers and regulators do consider (Newall et al., 2022). To ensure such a situation does not occur, it is the responsibility of researchers to retest effects which may already be considered established, both through direct and conceptual methods depending on the specified effect of interest.

In considering the open-science and replication recommendations from addictions researchers (Heirene, 2020; Wohl et al., 2019) and methodologists (Isager, 2019; Nosek et al., 2022), I sought to conduct a systematic replication of a popular effect within the field of gambling research looking specifically at structural characteristics of slot-machines. Specifically, through employing the versatile replication value (RV) formula outlined by Isager (2019), I chose to run a series of conceptual replications around the structural characteristic of the near-miss in slot-machine gambling. Focussing on this feature in conducting the series of replications outlined two important “issues” that could be pertinent across the field of gambling studies: 1) many studies may have small sample size and are likely underpowered, which may be contributing to the second possible issue that 2) there is a lack of consensus for theory underlying commonly cited effects. Specifically, through scoping the literature to determine which near-miss related effects to replicate, it became apparent many of the most highly cited studies had
rather small sample sizes (e.g. Clark et al., 2009). Additionally, for certain claims that appeared across different articles (e.g. the claim that near-misses increase motivation to gamble on a slot-machine), there was disagreement about accounts explaining the underlying psychological or cognitive mechanisms of the effect.

Modern accounts of near-misses include the low-level goal generalization account, the frustrating non-reward account, the regret account, and the skill-acquisition account. Goal generalization is a somewhat less developed account than the others, it simply argues that due to its perceptual similarity to a win, a near-miss generates an expectation of winning as the outcome unfolds, so participants react to the near-miss almost as if it is a miniature win (Clark et al., 2009). The frustrating non-reward and regret accounts are somewhat complimentary to one another, emphasizing the negative emotional consequences of near-miss outcomes, and where regret may be considered the cognitive aspect of frustration. The idea here is that the expectation of reward generated by the sequential unveiling of the reels generates the expectation of winning, which is then thwarted upon the reveal of the final reel, where a negative affect state is induced because of the apparent closeness to the reward (if NMB) or apparent lost reward (if NMA). Finally, a skill acquisition account argues that near-misses contribute to a state of skill-chance confusion, potentially inducing an illusion of control where the participant believes they have some degree of control in predicting the sequence of slot-machine outcomes (Ejova & Ohtsuka, 2020).

Across the 4 studies, I observed consistent differences between the functionally identical near-miss and full-miss outcomes. Study 1a and 1b supported the claim that near-misses are experienced as more-motivating to continue playing a slot-machine relative to the functionally identical full-miss (Clark et al., 2009), a claim which can conceivably fit into any of the different
accounts. However, I failed to replicate the claim that near-misses were primarily aversive, as they were reported to be significantly more positive relative to full-misses across both Study 1a and 1b. This finding had consequences for our hypotheses in Study 2 examining the speed of play. We initially predicted in Chapter 2 that participant’s speed of play would increase following near-misses, based on a previous study (Dixon et al 2013) and informed by the frustration account, that the assumed negative affect state brought on by a near-miss would cause participants to initiate the next spin more quickly. Because I observed near-misses to be more positive than full-misses in the first studies, I also considered a bi-directional hypothesis and the possibility that near-misses might lengthen (i.e. slow) spin initiation latencies similar to the post-reinforcement pause after winning outcomes. In the results to Study 2, I did observe this faster speed of play following near-misses made distinguishing between the different accounts of near-misses difficult. We hoped out final study looking at the effect of near-misses on bet-size would help to “fill out the picture of near-misses”, where I found participants significantly increased their bet size following near-misses compared to full-misses; a finding which seems best explained through a skill-acquisition account (Clark, 2010).

Another key finding from scoping the literature for this thesis was the apparent lack of attention paid to boundary conditions in designing tasks meant to measure the effect of near-misses. Though I focussed mainly on studies employing a slot-machine paradigm, there were a plethora of differences in simulation design by study. Some studies used overly simplified simulations where there were no spinning reels and the only visible symbols were those on the payline (Pisklak et al., 2020). This design makes it impossible to distinguish between NMB and NMA and may exclude potentially necessary boundary condition for eliciting near-miss effects,
i.e., the skill-acquisition and regret accounts depend partly on the final symbol appearing proximal to the payline (Wu et al., 2021).

What these results really seem to highlight then, is that near-miss events on slot-machines are experienced as complex psychological events capable of eliciting both seemingly aversive effects (exhibited by shorter spin initiation latencies relative to full-misses), and seemingly appetitive effects (exhibited in the more positive ratings for near-misses compared to full-misses). It could be the case the separate accounts of near-misses are not necessarily mutually exclusive, and that some of these accounts can be paired together to better explain the effects that near-misses can have. For instance, it’s possible that the experience of frustration is responsible for the increased speed of play following near-misses, while the skill-acquisition account could help to explain why people rate these events as more positive than full-misses, and why they end up changing their betting strategy depending on the outcome of a spin. It is possible that upon being asked to reflect upon the last spin (as done so in Study 1), that certain people appraise the outcome as being skill based, leading them to view the near-miss as more positive relative to the full-miss because it indicates their closeness to the reward. In any case, the fact that certain effects appear to align with different accounts suggests that, in comparison to the functionally identical full-miss outcome, near-misses can elicit complex psychological responses which may contribute to increased gambling related financial harms (e.g., through speeding up the players betting, or increasing the amount players bet).

Two overarching limitations across each of the studies are worth mentioning. Across each of our samples, participants presented rather low levels of gambling ‘pathology’, mainly due to our exclusion criterion around problem gambling behaviour. This exclusion criterion has consequences, however. Specifically, the research herein does not really speak to the effect that
near-miss outcomes can have on people who experienced problem gambling. Indeed, the effect of near-misses may be more exaggerated in people with problem gambling, as past research has observed different patterns of brain activation to near-misses for people experiencing problem gambling (e.g. amplified striatal response to near-misses; Sescousse et al., 2016). Another limitation worth bearing in mind if the task used across studies, while more ecologically valid than many laboratory slot-machines, is still some way short of the modern multi-line games seen in casinos and online. The decision to simplify the task was taken to specifically model the near-miss outcome, but this outcome becomes more complicated in modern games, though it has been show to still elicit effects in these games (Sharman et al., 2015). Finally, while I employed standard data cleaning techniques to ensure high quality data, the nature of online data is such that it can be difficult to know whether the overall quality of the data is high (Stewart et al., 2017).

The investigation throughout this series of replications has illuminated some directions for future studies in this area to account for some of the surprising outcomes. One thing I plan to explore in future analyses with the current data are gender differences related to the near-miss affect. Additionally, the finding across Study 1a and 1b that near-misses were rated as more positive relative to full-misses warrants further specific investigations. One possibility for this change relates to the potential increased likelihood for participants to anthropomorphize a slot-machine game online, thus, viewing the slot-machine more so as a game of competition as opposed to a game of pure chance (Riva et al., 2015). This possibility aligns well with the skill-acquisition account of near-misses. One of the tenets of this account claims that people who approach games of chance like slot machine with pre-conceived notions about the nature or probability (e.g. a belief in cyclical luck, or views of luck/chance as a kind of entity one can
sway; e.g. see Ejova & Ohtsuka 2020), might be both more susceptible to the various structural characteristics of a slot-machine, and be more likely to anthropomorphize the slot-machine (Riva et al., 2015). We could investigate this effect by designing a more anthropomorphized online slot-machine (e.g. Kim & McGill, 2011), comparing participant behaviour on this anthropomorphized machine to a distinctly “non-anthropomorphized” slot-machine.

Additionally, one tenant of the frustration account is that near-misses are led to an accelerated heart rate relative to both full-miss outcomes and winning outcomes. A future study could incorporate physiological measures though webcam based technology. If we see this accelerated heart rate following near-misses (Clark et al., 2012), alongside more positive ratings for near-misses relative to full-misses, it is likely that some mechanism other than frustration is responsible for the increased heart rate acceleration, perhaps the excitement associated with the erroneous perception that one is close to achieving a win (Ejova & Ohtsuka, 2020). In sum, the results of this Thesis demonstrate the need to continue running targeted replications in the gambling field, focussing efforts on effects which have a high degree of theoretical impact with low corroboration.
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