

Examining the Influence of Scratch Card Structural Characteristics on Psychophysiology,
Motivation, and Gambling Behaviour

by

Madison Stange

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Examining Committee Membership

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

External Examiner

Dr. David Hodgins
Professor
Department of Psychology
University of Calgary

Supervisor

Dr. Mike J. Dixon
Professor
Department of Psychology
University of Waterloo

Internal Members

Dr. Jonathan Fugelsang
Professor
Department of Psychology
University of Waterloo

Dr. James Danckert
Professor
Department of Psychology
University of Waterloo

Internal-External Member

Dr. Steven E. Mock
Associate Professor
Department of Recreation and Leisure Studies
University of Waterloo

Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Statement of Contributions

Excerpts of the material presented in Chapter 1 has been published in the following articles: *Journal of Gambling Issues*, 45, DOI: <http://dx.doi.org/10.4309/jgi.2020.45.7>; *Journal of Gambling Studies*, 33(3), 867-879; *Journal of Gambling Studies*, 36, 887-902.

Excerpts of the material presented in Chapter 2 has been published in *Journal of Gambling Issues*, 45, DOI: <http://dx.doi.org/10.4309/jgi.2020.45.7>. Additionally, a subset of the data presented in this chapter was used for the completion of Michael Pinnau's Honours thesis (completed 2018). The full dataset was re-analyzed by Madison Stange for the aforementioned publication, and further supplementary analyses were conducted by Madison Stange for the purposes of this thesis. Madison Stange was the sole author of Chapter 2.

The Experiments presented in Chapter 4 have been published as part of the following articles: *Journal of Gambling Studies*, 33(3), 867-879 (Experiment 3); *Journal of Gambling Studies*, 36, 887-902 (Experiment 4).

Abstract

Scratch cards are a popular and accessible form of gambling. Although scratch cards, like other lottery products, are typically cast in an innocuous light, this gambling form contains structural features that resemble slot machines – one of the most harmful forms of gambling available. One of the most striking structural similarities between these gambling forms is the near-miss – a special type of losing outcome which appears to come close to a jackpot win, but falls just short. In a prototypical scratch card game, a near-miss consists of uncovering two of the three required matching top prize symbols needed to win, missing the top prize by only one symbol. Near-miss outcomes are prevalent in scratch cards, and have been associated with increases in physiological arousal and subjective ratings of arousal, disappointment, frustration, and urge to continue gambling relative to regular losing outcomes, despite the fact that these two outcome types are objectively equivalent (like their slot machine counterparts – near-misses are monetary losses). Although the literature on slot machine near-misses suggests that these outcomes may prolong gambling behaviour and encourage continued expenditure, it remains unknown how near-misses impact further scratch card gambling. Overall, scratch cards remain relatively understudied in the gambling literature particularly with regard to their psychophysiological, subjective, and behavioural impacts on gamblers despite concerning similarities to slot machines and their widespread appeal. Currently, only one type of scratch card game has been experimentally investigated, despite a wide and ever-changing selection of game types available in the lottery marketplace. Additionally, some evidence has suggested the importance of anticipatory arousal in scratch card near-miss effects, however the time course of these effects as the various symbols in an outcome are revealed remains unknown. Finally, the influence of near-miss outcomes on further scratch card purchases, and consideration of individual differences related to erroneous

cognitions and impulsivity have not been addressed in the extant scratch card literature. To address these and other key limitations, the current thesis presents five experiments. In Chapter 2, we compare the influence of two scratch card game types on participants' psychophysiological responses and find that scratch cards with a protracted anticipatory window lead to heightened psychophysiological responses leading up to the outcome reveal, whereas games without this feature tend to result in heightened responses following the outcome reveal. Chapter 3 extends these findings by further investigating the effects of the anticipatory window on participants' psychophysiology on a symbol-by-symbol basis, which varied how early within the card the two top prize symbols (the near-miss) appeared, and hence the length of the anticipatory window. The results of this experiment suggest that near-misses uncovered just before the final symbol is revealed (e.g., the shortest anticipatory window) result in the largest increase in physiological arousal of all near-miss outcomes presented. Finally, Chapter 4 presents three experiments focused on whether near-misses lead to further purchases of scratch cards. Although we find no evidence to suggest that experiencing a near-miss is associated with an increase in purchasing behaviour, we did find that purchasers reported higher levels of impulsivity than non-purchasers. Additionally, preliminary evidence suggests that participants' beliefs about the meaning of near-misses may impact their experience of these outcomes. Finally, across all of the experiments, near-misses reliably resulted in an increased urge to continue gambling relative to regular losses. In conclusion, the present thesis adds to our existing knowledge of scratch card gambling and emphasizes the impact that structural features have on gamblers' experiences.

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Dedication

For Mom, Dad, and Jake

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Chapter 1: Introduction

1.1 Scratch Card Gambling

Scratch cards (also referred to as “instant games”) are a form of gambling characterized by scratching off an opaque layer from the surface of a physical card, in the hopes of uncovering game symbols that align with a winning pattern (Reid, 1986). This form of gambling has existed for nearly forty years (Clotfelter & Cook, 1991) and has been acknowledged in the gambling literature since this time. Early writers expressed concern about the availability of scratch cards at accessible, everyday shopping locations (e.g., grocery stores), which might potentially lead to excessive gambling behaviour (Moran, 1979). This was thought to be compounded by certain games called “heart stoppers” which “give the illusion of coming close to winning a big prize” (p. 7, Moran, 1979).

These concerns are still relevant today. In our home jurisdiction of Ontario, Canada, the Ontario Lottery and Gaming Corporation (OLG) offers scratch card games at nearly 10,000 retailers across the province (OLG, 2019a), in various locations including gas stations, grocery stores, and shopping malls. At these locations, approximately 80 different types of scratch cards are available each fiscal year (OLG, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019a). The overall revenue derived from scratch card games in Ontario has increased steadily over the last 12 fiscal years (see Figure 1), as has the average price per scratch card game (Figure 2). In comparing the overall proportion of lottery revenue derived from scratch card games, traditional lottery draws (i.e., “lotto”), and sports-related lottery games available for sale in Ontario over the last 12 fiscal years, scratch card games have shown increases in their share of revenue, whereas traditional and sports lottery draws have seen

decreases in their share of lottery revenue (Figure 3). Overall, it is clear that scratch cards represent a large and profitable segment of today’s lottery gambling landscape.

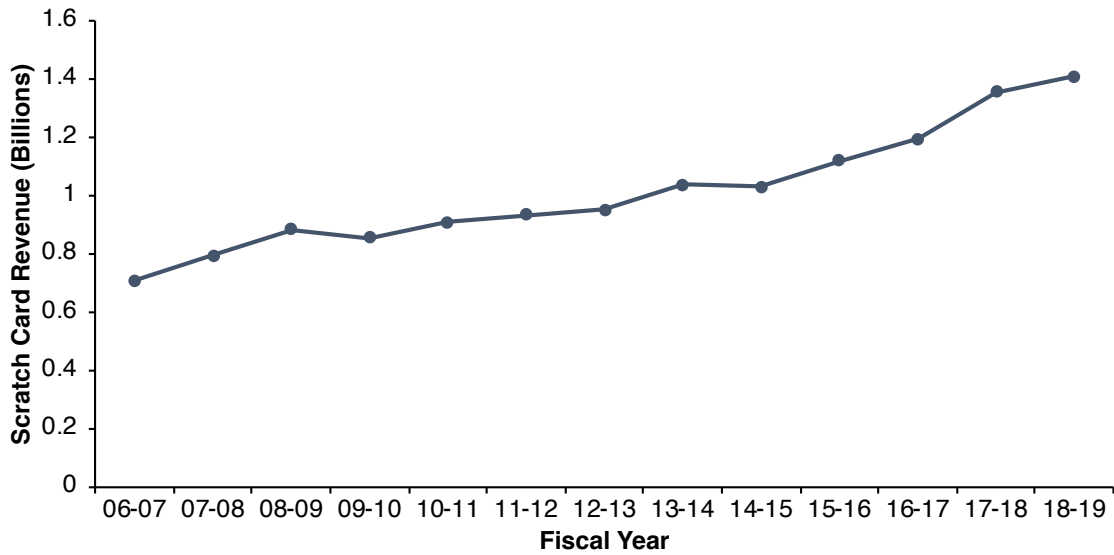


Figure 1. Scratch card revenue in Ontario, from fiscal year 2006-2007 to 2018-2019, in billions of dollars (CAD). The data displayed in this figure is reported in each respective year’s annual report (OLG, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019a).

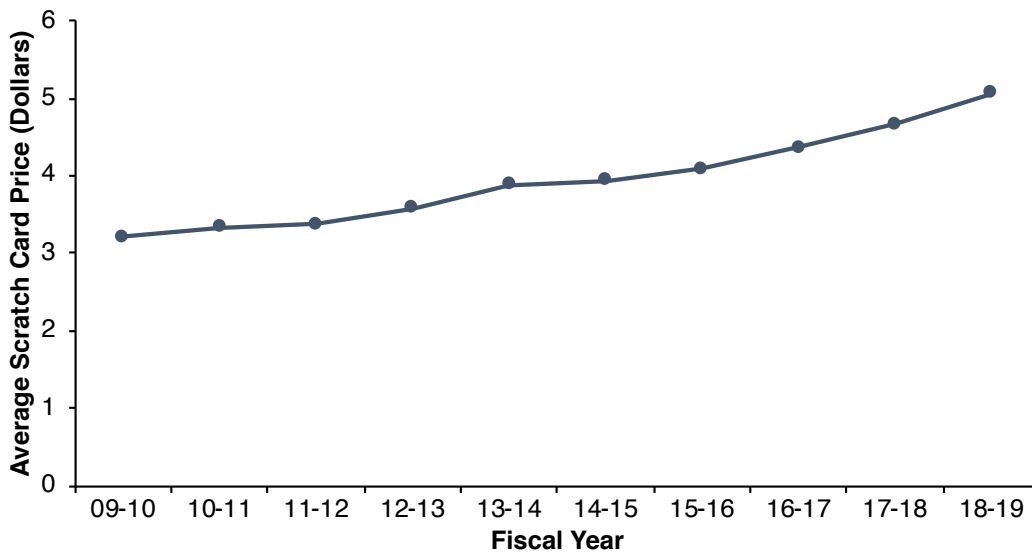


Figure 2. Average scratch card price in dollars in Ontario, from 2009-2010 to 2018-2019 (CAD). The data displayed in this figure is reported in each respective year’s annual report (OLG, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019a).

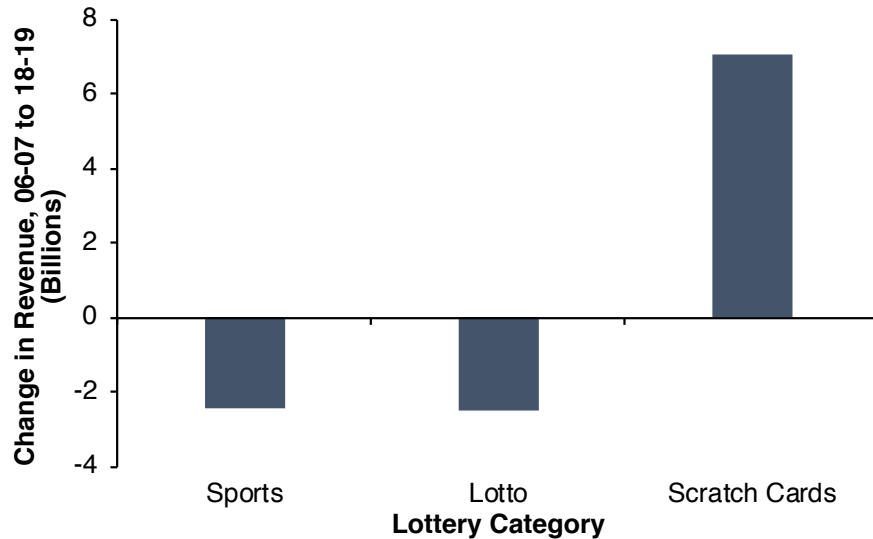


Figure 3. Change in Ontario lottery revenue based on lottery market segment. The data displayed in this figure was calculated from the annual revenue reported in the 2006-2007 and 2018-2019 OLG annual reports (OLG, 2007, 2019).

Despite their ubiquity and long-standing presence in the gambling marketplace, existing research examining scratch card games has typically focused on population-level engagement, individual characteristics of scratch card gamblers, and experiences of gambling-related harm related to these games. In contrast, little empirical research has examined the psychological *experience* of scratch card gambling, its psychophysiological impacts, or how these games influence gambling behaviour. A comprehensive understanding of gambling behaviour necessitates an understanding of these underexplored aspects of scratch card gambling. Furthermore, given their widespread availability, the limited research in these areas represent substantial gaps in the gambling literature.

1.1.2 Participation and Gambler Characteristics

Researchers have long focused on the use of scratch cards by youth, with lottery products representing a highly sought-after type of gambling for this demographic (Adebayo, 1998; Boldero et al., 2010; Donati et al., 2013; Felsher et al., 2004a, 2004b; Griffiths, 2000; Wood &

Griffiths 1998, 2004; Pisarska & Ostaszewski, 2020). A recently published study of Canadian youth aged 13–19 found that scratch cards were the most common type of regulated gambling behaviour engaged in, with 13.8% of the sample endorsing participation (Elton-Marshall et al., 2016). It is important to remember that in most jurisdictions, youth are unable to legally purchase scratch cards themselves. In line with this, 40% of Canadian parents had engaged in joint scratch card gambling with their children (Campbell et al., 2011), and it is a common practice to provide youth with scratch cards as gifts (Devernsky & Gupta, 2001), despite evidence of higher rates of problem gambling among youth who have received scratch cards as presents (Kundu et al., 2013).

Specific participant characteristics associated with scratch card gambling have been reported in the literature. In a large Canadian survey study (Short et al., 2015), the amount of scratch card gambling that participants engaged in was negatively correlated with level of education; no other demographic variables (e.g., age, sex, marital status) were meaningfully correlated with the frequency of scratch card play. Research examining the introduction of the National Lottery in the UK observed that participants with lower levels of household income and education purchased more scratch cards (Shepherd et al., 1998). In line with these findings, a recent analysis examining lottery sales in Toronto, Ontario, reported that neighbourhoods with lower socio-economic status had higher rates of lottery gambling (including scratch cards) than higher status neighbourhoods (Fu et al., 2021). Given their widespread availability, popularity, and uptake among potentially vulnerable segments of the population (e.g., youth and low-income/socio-economic status households), it is important to consider the potential harm that may be associated with these products.

1.1.3 Gambling-Related Harm

Until recently, scratch cards have typically been thought of as innocuous, or not a “real” form of gambling (Lange, 2001; Wood & Griffiths, 1998). Although estimates of the number of individuals uniquely addicted to scratch cards are low (DeFuentes-Merillas et al., 2003; Hendriks et al., 1997), some authors have described cases of problematic adolescent scratch card gambling (Wood & Griffiths, 1998), and case studies of pathological scratch card gambling have been reported (Raposo-Lima et al., 2015). Furthermore, in a study of individuals seeking problem gambling treatment in Ontario, scratch cards were one of the most commonly cited forms of gambling related to harm, with 29.5% of clients entering treatment identifying these games as one of their top three problematic activities (Rush et al., 2002). In addition, a study of Ontario baby boomers revealed that those who played scratch cards reported participating in more forms of gambling and had higher rates of at-risk/problem gambling prevalence, than those in the baby boomer cohort who did not report playing these games (Papoff & Norris, 2009). Moreover, self-reported frequency of scratch card gambling has been shown to longitudinally predict gambling harm (Williams et al., 2015), and to account for additional predictive value in models of gambling harm (Williams et al., 2021). Finally, associations between the frequency of scratch card gambling and problem gambling severity have been demonstrated in large online survey samples (Stange et al., 2018).

Gambling-related harm from scratch cards appears to be related to other mental health concerns and addictions. In a study of treatment-seeking pathological gamblers, those who identified scratch cards and lottery games as their preferred form of gambling reported higher rates of psychiatric problems and substance use (Petry, 2003). Interestingly, this group spent the least amount of money gambling, but gambled more frequently than individuals with a different

preferred form of gambling (Petry, 2003). In an examination of the prevalence of lottery-related harm among specific populations, a number of individual characteristics were associated with reporting harm: being young, male, a smoker, e-cigarette user, and purchasing scratch cards more frequently (Booth et al., 2020). In this study, overall expenditure on scratch cards was not related to gambling harm, but frequency was (Booth et al., 2020). Additionally, scratch card gamblers have been reported to experience higher rates of eating disorders and panic attacks compared to gamblers with different preferred forms of gambling (Challet-Boujou et al., 2015).

Finally, comparisons have been made between categories of lottery products and their associations with gambling harm. For example, traditional lottery draws and scratch card games contain substantial differences in terms of their structure. In traditional lottery draws, a gambler chooses numbers (or has them randomly generated for them) and may wait for days for the next draw to occur; in scratch cards, the gambler purchases the card and determines their outcome as quickly as the symbols can be uncovered. In a study that compared traditional draw-based lottery to instant lottery (including scratch cards), frequency of instant gambling was found to be predictive of problem gambling severity over and above the influence of draw-based lotteries, with no evidence for the reverse association (Short et al., 2015). This suggests that scratch card games may be differentially associated with gambling harm compared to other classes of lottery products. Collectively, these findings highlight the importance of considering both the individual differences of gamblers, and the structural characteristics of the gambling forms with which they interact (see Wardle et al., 2019).

1.2 Near-Miss Outcomes

When considering the structure of scratch card games, some authors have noted that these games bear many similarities to slot machines – so much so that they have referred to scratch

cards as “paper fruit machines” (Griffiths, 1995, 1997) or “paper slot machines” (Ariyabuddhiphongs, 2011). Given that slot machines are generally considered to be the most harmful form of gambling available (Williams et al., 2021), these similarities have prompted concerns from gambling researchers, especially when considering the aforementioned availability of these games and their attractiveness to young people (Elton-Marshall et al., 2016; Felsher et al., 2004; Wood & Griffiths, 1998, 2002).

One of the most striking similarities between scratch cards and slot machines is a particular type of losing outcome commonly referred to as a near-miss (Reid, 1986). Near-miss outcomes, although resulting in an objective monetary loss, *appear* to fall just short of a jackpot win (Reid, 1986) and seem to be treated differently than regular losses (i.e., the “heartstoppers” referred to by Moran [1979]). Although these outcomes are incredibly common in scratch card games (Stange et al., 2016; Stange, Brown, et al., 2017), they have been most extensively researched in slot machine games, where they also occur more frequently than chance alone would dictate (Harrigan, 2008; Harrigan & Dixon, 2009).

The most prototypical example of a slot machine near-miss occurs on a three-reel slot machine game, in which the gambler is attempting to line up three 7's on the payline – the first two 7's land directly on the payline, but the third is *just* missed, resulting in a monetary loss. Despite their objective status as a loss, slot machine near-miss outcomes have been shown to increase the physiological arousal of gamblers as measured by skin conductance and heart rate deceleration (Dixon et al., 2011, 2013), and lead to activity in brain areas related to reward processing (Clark et al., 2009). Pathological gamblers experience enhanced reward-related neural activity to near-miss outcomes relative to controls (Sescousse et al., 2016). Additionally, following near-miss outcomes, slot machine gamblers are faster to move on to their next spin

compared to other losing outcomes, an effect thought to be driven by the frustration associated with near-miss outcomes (Dixon et al., 2013).

A number of studies have also reported enhanced motivation to continue gambling following slot machine near-miss outcomes, relative to regular losing outcomes, despite their objective equivalence as monetary losses (see Barton et al., 2017 for a review; Billieux et al., 2012; Sharman & Clark, 2016). Furthermore, early studies examining the behavioural consequences of slot machine near-misses discovered that the presence of these outcomes in slot machine games led to increased behavioural persistence when delivered at optimal rates (Kassinove & Schare, 2001), and when compared to games without near-misses (Côté et al., 2003).

Limited experimental research on scratch card games has focused on the psychophysiological and cognitive experience of various scratch card outcomes, including near-misses (Stange et al., 2016; Stange, Grau et al., 2017). In these experiments, which utilized custom-made scratch card games, participants aimed to uncover three matching symbols within a game matrix of six symbols (see Stange et al., 2016). In this type of game, a win consists of uncovering three matching prize symbols, a regular loss consists of six unique, non-matching symbols and a near-miss consists of uncovering two of the three required symbols to win the top prize. Gamblers tended to experience greater physiological arousal (as measured by skin conductance and heart rate) leading up to the reveal of winning and near-miss scratch card outcomes, relative to regular losses (Stange et al., 2016; Stange, Grau et al., 2017).

Additionally, scratch card near-miss outcomes are consistently rated as significantly more frustrating, subjectively arousing, disappointing, and urge-inducing than regular losses (Stange et al., 2017a; Stange, Grau et al., 2017). These results suggest that scratch card near-miss outcomes,

despite being monetary losses, are experienced in a similar manner to slot machine near-miss outcomes, such that they paradoxically increase frustration-induced arousal, while simultaneously increasing motivation to continue gambling. Therefore, it is possible that scratch card near-miss outcomes, like their slot machine counterparts, may also encourage continued gambling behaviour. However, to date, there have been no empirical studies concerning whether scratch card near-miss outcomes may impact a gambler's decision to continue gambling.

One framework for conceptualizing near-misses is skill learning. In skilled tasks, near-misses indicate improvement and that future attempts may be successful (Clark, 2014). This belief that near-misses indicate the acquisition of skill and therefore proximity to wins is erroneous when applied to pure chance scenarios, since near-miss outcomes only *appear* to signal relevant information. Regardless, these outcomes prove extremely compelling to gamblers. A study of slot machine gamblers found that participants who reported a high likelihood of winning following a near-miss in chance-based gambling (i.e., those who spuriously “learned” from the near-miss) were more likely to persist at gambling than were those who did not (Clark et al., 2013). Therefore, how participants conceptualize near-miss outcomes may have an impact on future gambling behaviour and responses to various outcomes.

Collectively, these near-miss findings highlight the importance of information encountered *prior* to the outcome in the anticipatory period when a win appears imminent, before the gambler's hopes are dashed. Experiments investigating scratch card near-misses in which participants must collect three matching top prize symbols to win have shown increases in psychophysiological reactivity during this anticipatory phase, as sequential top prize symbols are uncovered (Stange et al., 2016; Stange, Grau, et al., 2017). This increase is in contrast to physiological responses in slot machine games, where increases in arousal tend to occur *after* the

outcome reveal (Dixon et al., 2011). This suggests that in scratch cards, cues of impending success encountered during the unfolding of near-miss outcomes may be erroneously misconstrued as useful, causing an increase in psychophysiological reactivity before the outcome reveal and comparably heightened subjective responses following it.

1.3 Overview of Present Experiments

As the previous sections illustrate, experimental research examining the impact of scratch card structural characteristics on gambler experiences is limited, despite their widespread availability and appeal. Therefore, this thesis presents a collection of experiments that are designed to further investigate the physiological, subjective, and behavioural effects of scratch card outcomes on individuals, with a specific focus on near-miss outcomes and their role in gambler behaviour, motivation, and psychophysiology. Overall, the present studies continue to place emphasis on near-miss outcomes in scratch card games, in order to supplement the rather limited experimental research investigating these outcomes in this form of lottery gambling. Such research is especially important given that near-misses have been shown to be related to erroneous cognitions (Clark et al., 2013), increased behavioural persistence (Côté et al., 2003; Kassinove & Schare, 2001), and that scratch cards in general are related to gambling harms (Raposo-Lima et al., 2015; Short et al., 2015; Stange et al., 2018; Williams et al., 2015; Wood & Griffiths, 1998).

In Chapter 2, Experiment 1 builds on previously published research suggesting the importance of the anticipatory period in scratch card outcome reactivity (Stange, Graydon et al., 2017; Stange, Grau et al., 2017), and investigates a previously unexplored game type. The extant scratch card literature has only experimentally investigated the influence of one game type on participants' responses and reactions. We presented participants with two types of scratch card

games, each modelled after available games in our jurisdiction of Ontario, Canada. These games contained either a brief or protracted window of anticipation leading up to the outcome reveal. Here we predicted that the timing of participants' physiological responses to wins, losses, and near-misses would differ depending on the structure of the game that they were engaged in, providing evidence of the impact of game structure on the temporal specificity of physiological responses.

In Chapter 3, we present an experiment designed to address key limitations in Experiment 1 and the extant scratch card near-miss literature. In Experiment 2, we presented participants with multiple instances of near-miss outcomes, consisting of different arrangements of top prize and non-matching symbols. This allowed for a more nuanced look at the structure of the anticipatory period of near-miss outcomes and its influence on participant experiences and responses. Specifically, we presented participants with near-misses that varied in terms of the position in which the second top prize symbol was uncovered, allowing us to manipulate the length of the anticipatory window that participants experienced. Here we predicted a relation between the anticipatory period length and arousal responses, such that early near-misses should lead to increased arousal over the course of the remaining symbols, compared to near-misses which occur later in the outcome. Furthermore, Experiment 2 utilized a more internally valid design which constrained the scratching epochs for each participant, as opposed to allowing participants to engage in naturalistic game play. Additionally, we extended the extant literature on the psychophysiological correlates of scratch card gambling to pupillometry, a previously unstudied variable in the scratch card gambling literature.

Finally, in Chapter 4 we present three experiments that examine the behavioural impact of experienced near-miss outcomes. Here we explored the complex relations between the

propensity of near-misses to trigger increases in the urge to gamble, and actual purchasing behaviour. We presented participants with a decision between retaining certain winnings or purchasing an additional scratch card for another chance at the top prize. Drawing from the slot machine near-miss literature, we predicted that experiencing a near-miss (compared to a regular loss) would result in an increased urge to gamble accompanied by increased purchasing behaviour. In Experiment 3, we empirically examined these influences of near-miss outcomes on urge to gamble and purchasing behaviour. Experiment 4 aimed to replicate these findings and further explore the influence of bet size and endorsement of the illusion of control on participants' purchasing decisions. Experiment 5 was designed to provide a further replication of these previous two experiments and extend these findings by investigating the role of individual differences in delay and probability discounting on purchasing behaviour. Finally, in Chapter 4 we conducted an exploratory analysis examining the interaction between experienced outcomes (near-miss or regular loss) and endorsement of near-miss-related erroneous cognitions on experienced urge to gamble.

Overall, the experiments included in this thesis suggest that the structural characteristics of scratch card games and the discrete outcomes that they contain have an appreciable impact on gamblers' physiological and subjective experiences. Specifically, these experiments deepen our understanding of the pre-outcome anticipatory period and outcome-specific responses. Furthermore, this work highlights the importance of considering the role of individual differences between gamblers when examining observable gambling behaviour, and how the structural aspects of scratch cards may interact with such individual differences to impact subjective experience and cognitive evaluations.

Chapter 2: Scratch Card Structure and Outcome Reactivity

2.1 Experiment 1¹

The impact of game structure on scratch card near-miss effects remains unknown in terms of the pre-outcome anticipatory period. For example, do scratch card games with no pre-outcome anticipatory phase still result in increased physiological arousal after the near-miss outcome has been revealed? In the current experiment, we examined the effects of regular losses, small wins and near-misses in two types of scratch cards: games in which participants uncover symbols hoping to find three matching symbols (“Match Three”) and games in which participants aim to match a “lucky” number with a given number (“Number Matching”).

Previous studies (Stange, Graydon, et al., 2017; Stange, Grau, et al., 2017) have examined only Match Three games, despite many other card types being available for purchase. Examination of these two game types allows for the comparison of games with (Match Three) and without (Number Matching) an anticipatory pre-outcome phase. Although Number Matching games may provide reduced opportunity for anticipatory processing, they still contain near-misses and may create an opportunity for increased physiological arousal following the completion of an outcome. For example, the goal of a Number Matching game may be to find a match to the “lucky” number 27. When uncovering the other numbers in the game, finding a 26 may be viewed as narrowly missing a win.

Since both game types contain near-miss outcomes, but differ structurally in terms of their outcome processing phases, we can assess how structural differences in scratch card games affect a gambler’s experience in terms of the timing of psychophysiological arousal and subsequent subjective evaluations. We also sought to replicate previous findings of near-miss

¹ A version of this Experiment is published in *Journal of Gambling Issues* (Stange, Pinnau, & Dixon, 2021).

effects in Match Three scratch card games in terms of psychophysiological and subjective reactivity.

We hypothesized that for both game types, participants would show elevated psychophysiological arousal and heightened subjective reactions to small wins and near-miss outcomes relative to regular losses. Crucially, we hypothesized that Match Three games would result in psychophysiological reactivity before the outcome reveal (replicating previously observed results; Stange et al., 2016; Stange, Grau, et al., 2017), whereas Number Matching games would result in reactivity only after the outcome reveal. For Match Three games, we also sought to replicate past findings concerning regular losses, small wins, and near-misses (Stange et al., 2016; Stange, Graydon, et al., 2017) – namely that both small wins and near-misses would result in significantly greater ratings of subjective arousal and urge to gamble than regular losses, and that near-misses would result in greater disappointment and frustration compared to regular losses.

2.1.1 Method

Participants

A sample of 66 participants was recruited from the University of Waterloo's Research Experiences Group. All participants were at least 18 years of age (the legal age to purchase scratch cards in Ontario), had experience playing scratch cards, were not in treatment for problem gambling, were not in treatment or taking medication for an anxiety disorder, and did not have any allergies or sensitivities to adhesives or sanitizing agents used in psychophysiological data recording (the latter two criteria included to optimize psychophysiological recordings). Participants' self-reported age, gender, problem gambling severity level, and frequency of scratch card play are reported in Table 1.

Participants were undergraduate students enrolled in a psychology course and received a 0.5% course credit for participating. All participants received \$10.00 in remuneration corresponding to the scratch card outcomes that they encountered during the experiment (see Materials section; all amounts expressed in CAD). All procedures were reviewed and received ethics clearance from a University of Waterloo Research Ethics Committee.

Table 1. Experiment 1 participant characteristics.

Measure	Value
Age, mean (<i>SD</i>)	19.26 (1.71)
Gender, <i>n</i> female, <i>n</i> male	50, 12
Frequency of scratch card gambling, <i>n</i> (%)	
1–5 times	51 (82%)
6–10 times	7 (11%)
11–15 times	4 (6%)
16–24 times	0 (0%)
24 or more times	0 (0%)
Problem Gambling Severity Index, <i>n</i> (%)	
Non-problem gambling	33 (53%)
Low-risk gambling	28 (45%)
Moderate-risk gambling	1 (2%)
Problem gambling	0 (0%)

Note. Frequency of scratch card gambling categories represent participants' self-reported gambling over the last 12 months. *SD* = standard deviation.

Materials

Sample Characteristics. The Problem Gambling Severity Index (PGSI) is a nine-item subscale of the Canadian Problem Gambling Index (CPGI) that assesses gambling-related harms (Ferris & Wynne, 2001). To assess frequency of scratch card gambling, we included the instant lottery frequency question from the CPGI. These items were administered to characterize our sample; no predictions were made on the basis of PGSI scores or gambling frequency. PGSI categories were established by using the criteria of Currie and colleagues (2013).

Scratch Cards. Participants played two types of custom-made scratch cards (Match Three and Number Matching), modelled after commercially available games in Ontario, Canada.

Match Three Game (“Cash for a Month”). In this game type, participants are presented with a matrix of six symbols under an opaque scratch-off layer (see Figure 4a). The participant sequentially uncovers each symbol within the matrix, with three matching symbols indicating a win of that prize. The top prize is “Cash for a Month” (\$25.00 a week for 4 weeks, totalling a one-time payout of \$100).

Number Matching Game (“Diamond Payout”). In this game type, participants scratch an opaque layer to reveal two “lucky” numbers. They then sequentially scratch off a six-number matrix hoping to uncover a match to a lucky number (see Figure 4b). If a match is found, the participant wins the corresponding prize amount (printed underneath the matrix numbers). The top prize of this game is \$100.



Figure 4. Scratch card game types utilized in Experiment 1. a) Match Three ("Cash for a Month") game type; b) Number Matching ("Diamond Payout") game type (note that both cards pictured here are regular losses).

Subjective Evaluations. To assess the subjective experience of the participants following each outcome type, we asked them to respond to an item for each of the following subjective dimensions: arousal, frustration, positive emotion, negative emotion, disappointment, and urge to gamble. For each item, participants placed a marker along a sliding scale (ranging from 0 to 100) at the location that best reflected their experience. All items were presented by using the same structure: “How would you rate your level of [subjective dimension] on a scale from 0 (no presence of the dimension) to 100 (extreme amounts of the dimension)?” All six items were presented in randomized order following each scratch card outcome.

Apparatus

Display Case. To simulate real scratch card gambling, we had participants choose their scratch cards from two display cases, each containing 96 scratch cards of one game type. Each scratch card display case contained two trays, each containing 48 scratch cards. Each tray contained two sections, resulting in four sections overall, one per outcome type (i.e., a near-miss section, a win section, and two loss sections).

Video Recording. To time-lock the psychophysiological responses of the participants to specific outcomes, we recorded their scratch card play with LabChart software (ADInstruments, version 7.0), using the built-in camera on the MacBook Pro laptop used for psychophysiological recording.

Skin Conductance Recording. Skin conductance was recorded with non-gelled passive electrodes attached to the index and ring fingers of participants’ non-dominant hand. These electrodes were connected to an ADInstruments PowerLab (model 8/30) equipped with a galvanic skin response amplifier. LabChart 7.0 software was used to analyse skin conductance data on the basis of temporal windows specified from video recordings.

Heart Rate Recording. Heart rate was recorded with three electrodes in a modified Mason-Likar arrangement (Mason & Likar, 1966), with two electrodes placed in the infraclavicular fossae 2 cm medial to the deltoid border and a third electrode placed on the left anterior abdomen in the axillary line, 3-4 cm inferior to the costal margin (acting as an earth ground). Electrodes were connected to the PowerLab and sampled at 1000 Hz. LabChart 7.0 software was used to analyse heart rate data from event markers derived from the video recording.

Scratching Platform. As each participant's non-dominant hand was used for skin conductance recording, scratch cards were inserted into a scratching platform during gameplay to hold each card in an upright position while the participant scratched with their dominant hand (see Stange et al., 2016).

Design

We used a within-subjects design, with each participant experiencing all outcomes (loss, near-miss, win) for each game type (Match Three, Number Matching). Participants were randomly assigned to an outcome order that ensured adequate counterbalancing. Half of the sample played Match Three cards first and Number Matching cards second, and the other half experienced the reverse. Within each game type, half of the participants experienced the near-miss before the small win, and the other half experienced the reverse. For both card types, the near-miss and small win were preceded by a regular loss. Therefore, each participant played eight scratch cards, four of each game type. Within both game types, participants experienced two regular losses (no matching symbols), a small win of \$5.00 (three matching \$5.00 symbols in the Match Three game; a match between a lucky number and a matrix number corresponding to \$5.00 in the Number Matching game), and a near-miss (two MONTH symbols in the Match

Three game; a matrix number one digit away from a lucky number corresponding to \$100.00 in the Number Matching game).

Procedure

All participants confirmed their eligibility and provided written informed consent. They completed the PGSI and CPGI item by using Qualtrics survey software on a laptop computer (Lenovo model #4446). The researcher then explained that participants would be playing eight scratch cards in the study (four cards for each game type) and explained each game's rules. For the Match Three game, participants were told that the goal was to find three matching symbols within one game matrix, indicating a win. The researcher explained that the top prize was denoted by the MONTH symbol and that three MONTH symbols indicated a top prize win. Participants were given approximate odds of winning this top prize (1 in 192). For the Number Matching game, participants were told that the goal was to find a match between a lucky number and a matrix number, indicating a win of the prize printed below the matrix number. The researcher demonstrated how to "correctly" scratch the cards to ensure consistent outcome delivery between participants: for the Match Three game, uncovering symbols in three rows (top to bottom, left to right), and for the Number Matching game, uncovering the lucky numbers (from left to right), followed by the matrix numbers in three rows (top to bottom, left to right). Participants were given instructions for completing the subjective evaluations on the tablet (10-in. [25.4 cm] Lenovo model #TB-X103F).

Participants chose scratch cards to play by selecting cards from four different sections of two trays contained in two display cases (see the Apparatus subsection) and were instructed by the researcher to choose one card from each section, which ensured that each participant received the correct number of cards for each outcome. Participants washed their hands in an adjacent

room prior to attaching their heart rate electrodes. The researcher then connected the PowerLab leads to the heart rate electrodes and attached the skin conductance electrodes to the participant's non-dominant hand. LabChart settings were configured to ensure optimal recording, and the recording laptop was arranged to video-record participants' game play.

The researcher placed the first scratch card in the scratching platform and provided a metal washer for the participant to scratch with. After scratching, the participant completed subjective measures on the tablet for the outcome they had just experienced. The researcher removed the completed scratch card and inserted the next card into the scratching platform. The participant scratched the next card and again completed subjective measures. This process was repeated for all eight scratch cards, with outcomes presented in the randomly assigned counterbalanced order (see Design subsection).

When all eight scratch card games were completed, the researcher stopped the psychophysiological and video recordings, detached the skin conductance electrodes, and instructed the participant to disconnect the heart rate leads. Participants were remunerated with two sets of \$5.00 in scratch card winnings (\$10.00 total; \$105.00 if participants won a top prize) and given a feedback letter and responsible gambling resources.

Data Reduction

Skin conductance data were separated into epochs so that we could examine changes in the pre- and post-outcome periods of scratch card play. The pre-outcome epoch started when participants began scratching the first game symbol and ended once the final symbol was uncovered (revealing the outcome). The variable length of the pre-outcome period (dependent on rate of scratching) precluded the use of traditional analysis techniques. Therefore, anticipatory skin conductance changes were assessed by using the slope of the skin conductance level over

the entire epoch. Slope values were calculated with all data points in the pre-outcome epoch and represent the average change in skin conductance level over the duration of this window. For example, a participant may show a decreasing skin conductance level over time during the pre-outcome phase for regular losses (as observed in previous studies; Stange, Grau et al., 2017) but during a near-miss, experience transient increases in skin conductance when uncovering the two top prize symbols. Although these top prize symbols may occur at different times for different participants, this phasic skin conductance activity will still reliably perturb the downward slope of skin conductance over time. Therefore, this analysis helped to circumvent variability in pre-outcome epoch lengths and allowed us to examine skin conductance changes during this period. This same pre-outcome epoch was used to examine changes in heart rate leading up to the outcome reveal, as measured by the average number of beats per minute (BPM).

The post-outcome recording epoch began following the final symbol reveal and was used to examine post-outcome skin conductance responses (SCRs). This analysis moved forward 1 s from the end of the outcome reveal and examined the peak of the SCR within a 3-s window following this 1-s advance. Square-root-transformed SCR values were then used for statistical analysis.

Statistical Analysis and Analytical Strategy

Of the 66 participants who were recruited, one was excluded from participating because of ineligibility (resultant $N = 65$). Three participants who won a top prize were excluded from all analyses, as they experienced different outcomes from the rest of the sample (resultant $N = 62$). Twelve participants were excluded from all psychophysiological analyses because of incorrect scratching patterns (leading to inconsistent outcome delivery) or technical errors, resulting in the loss of certain outcome recordings (resulting in a final $n = 50$ for heart rate analysis). One

additional participant was excluded from skin conductance analyses because of a technical error (resulting in $n = 49$ for skin conductance analysis). Participants who did not submit a subjective evaluation for a specific outcome were excluded listwise for the analysis of that specific subjective dimension (resulting in a minimum of $n = 33$ for each subjective analysis).

For each participant, six values were entered for each measure (for each game type: a win, a near-miss, and the average of the two losses). If only a single loss data point was artefact free, this loss value was used. Scores outside 3 standard deviations of the mean were excluded as outliers. Factorial repeated measures analyses of variance (ANOVAs) were conducted for each dependent variable. Sphericity assumption violations are presented with corrected degrees of freedom and F values (Greenhouse-Geisser). To localize the source of significant differences between outcome types following a significant main effect, we conducted further comparisons between outcome types within a given game type and across game types by using least significant difference pairwise comparisons. Following from our hypotheses, comparisons of psychophysiological responses to outcomes within each game type constituted *a priori* comparisons (and therefore were not further corrected). For Match Three games, previous findings of significant increases in pre-outcome arousal for near-misses versus losses (Stange et al., 2016; Stange, Grau, et al., 2017) justified planned directional comparisons.

2.1.2 Results

Pre-Outcome Skin Conductance Slopes

A factorial repeated measures ANOVA with outcome and game type as the repeated measures factors revealed a main effect of outcome, $F(2, 90) = 13.58, p < .001, \eta_p^2 = .23$, and an outcome by game type interaction, $F(2, 90) = 10.00, p < .001, \eta_p^2 = .18$ (see Figure 5). A repeated measures ANOVA that examined the Match Three game with outcome as the repeated

measures factor revealed a main effect of outcome, $F(2, 92) = 15.33, p < .001, \eta_p^2 = .25$. Pairwise comparisons revealed significant differences between losing ($M = -2.82^{-5} \mu\text{S/s}, SD = 3.56^{-5} \mu\text{S/s}$) and winning outcomes ($M = 6.50^{-6} \mu\text{S/s}, SD = 2.21^{-5} \mu\text{S/s}, p < .001$); near-miss ($M = -1.82^{-5} \mu\text{S/s}, SD = 3.93^{-5} \mu\text{S/s}$) and winning outcomes ($p = .001$); and losing and near-miss outcomes ($p = .047$; one-tailed). An equivalent analysis that examined the Number Matching game revealed no significant main effect of outcome ($p = .394$).² To further test the comparison between losses and near-misses across both game types (i.e., to determine whether the difference between losses and near-misses was significantly different between games), we conducted a repeated measures ANOVA with outcome (loss, near-miss) and game type (Number Matching, Match Three) as the repeated measures factors. This analysis revealed no significant outcome by game type interaction, $F(1, 46) = 1.11, p = .30, \eta_p^2 = .02$.

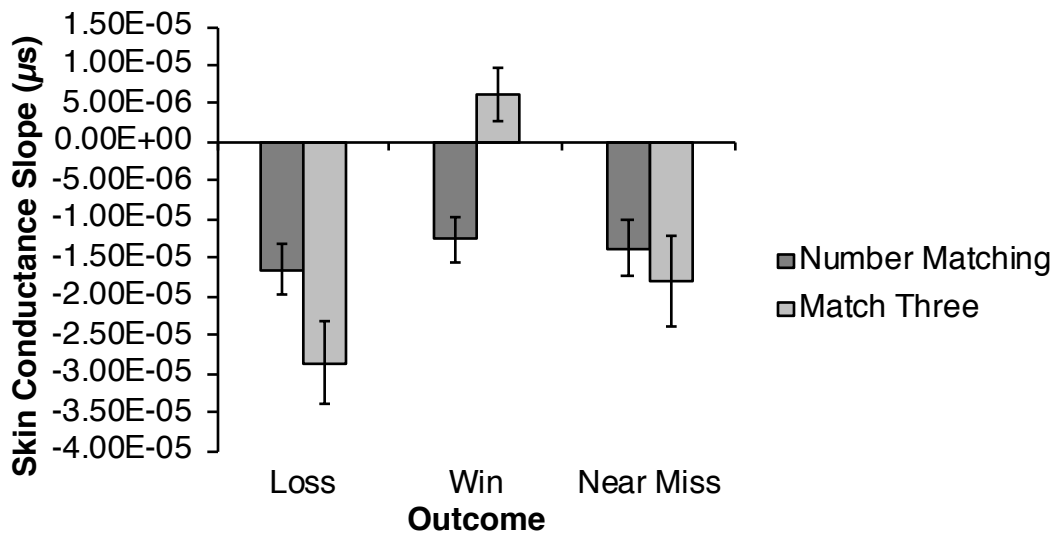


Figure 5. Pre-outcome skin conductance slopes by outcome and game type. Values presented are derived from participants with valid data on all variables in the omnibus model. All error bars $\pm 1 SEM$.

² To ensure that epoch length was not systematically related to calculated skin conductance slope values, we conducted correlations between these two variables for each outcome type (average of both losses, win, and near-miss for each game type). None of these correlations remained significant following a Bonferroni correction ($\alpha/6; p = .008$).

Post-Outcome SCRs

A factorial repeated measures ANOVA with outcome and game type as the repeated measures factors revealed a main effect of outcome on SCRs, $F(2, 96) = 5.71, p = .005, \eta_p^2 = .11$, and of game type, $F(1,48) = 13.03, p = .001, \eta_p^2 = .21$, but no outcome by game type interaction ($p = .09$; see Figure 6). A follow-up repeated measures ANOVA for the Match Three game revealed no significant effects of outcome on SCRs ($p = .246$). An analogous analysis of the Number Matching game revealed a main effect of outcome, $F(1.80, 86.15) = 7.49, p = .001, \eta_p^2 = .14$. Pairwise comparisons revealed significant differences between losing ($M = .81 \mu\text{S}, SD = .52 \mu\text{S}$) and winning outcomes ($M = 1.01 \mu\text{S}, SD = .61 \mu\text{S}, p = .006$), and winning and near-miss outcomes ($M = .76 \mu\text{S}, SD = .58 \mu\text{S}, p = .002$), but no significant difference between losing and near-miss outcomes ($p = .345$).

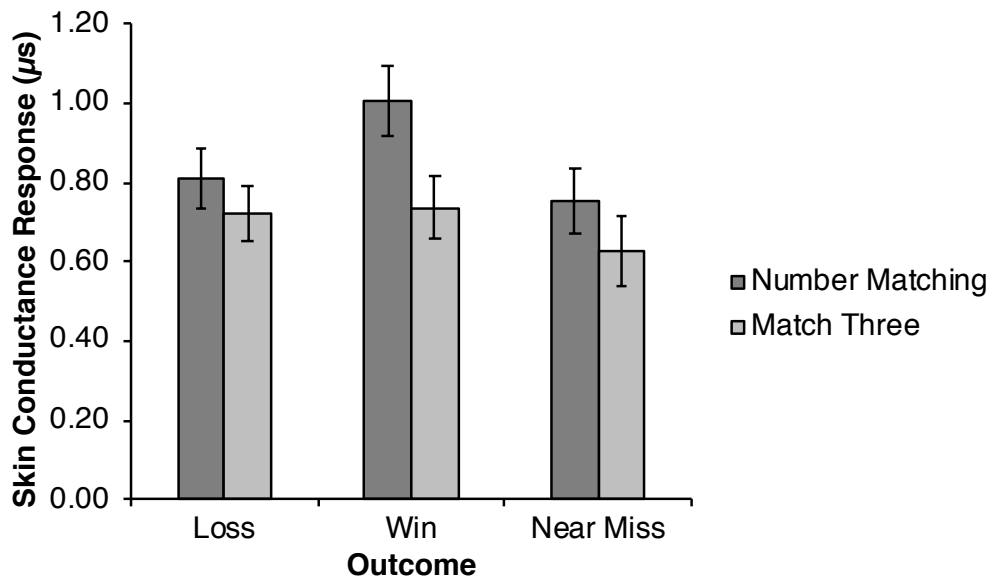


Figure 6. Post-Outcome skin conductance responses by outcome and game type. Values presented are derived from participants with valid data on all variables in the omnibus model. All error bars $\pm 1 SEM$.

Pre-Outcome Heart Rate

Data from 24 participants were not analysed, because of excessive artefacts (instances in which individual r-waves could not be distinguished from movement artefacts and therefore could not be labelled) or technical errors. A factorial repeated measures ANOVA revealed a main effect of outcome, $F(2, 50) = 3.58, p = .035, \eta_p^2 = .13$; a main effect of game type, $F(1, 25) = 6.58, p = .017, \eta_p^2 = .21$; and an outcome by game type interaction, $F(2, 50) = 5.93, p = .005, \eta_p^2 = .19$ (see Figure 7). A repeated measures ANOVA for the Match Three game revealed a main effect of outcome, $F(1.42, 35.53) = 7.15, p = .006, \eta_p^2 = .22$. Pairwise comparisons revealed significant differences between losing ($M = 85.31$ BPM, $SD = 11.21$ BPM) and winning outcomes ($M = 87.48$ BPM, $SD = 11.53$ BPM, $p = .003$), and between winning and near-miss outcomes ($M = 84.71$ BPM, $SD = 10.21$ BPM, $p = .009$), but no significant difference between losing and near-miss outcomes ($p = .33$). An analogous analysis for the Number Matching game revealed no significant effects ($p = .259$).

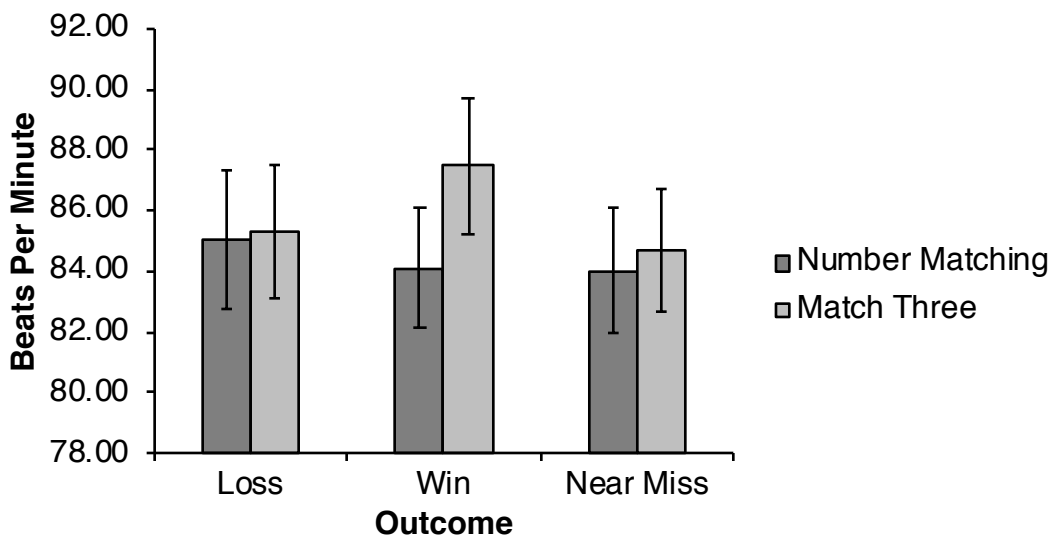


Figure 7. Pre-outcome heart rate by outcome and game type. Values presented are derived from participants with valid data on all variables in the omnibus model. All error bars ± 1 SEM.

Subjective Evaluations

Urge to Gamble. The factorial repeated measures ANOVA revealed only a main effect of outcome, $F(1.69, 87.84) = 14.68, p < .001, \eta_p^2 = .22$ (see Figure 8a). Collapsing across game type, pairwise comparisons revealed significant differences between urge to gamble ratings following losses and wins ($p < .001$), wins and near-misses ($p = .005$), and losses and near-misses ($p = .0096$).

Frustration. Our analysis of participants' frustration ratings revealed a main effect of outcome, $F(1.56, 49.88) = 32.44, p < .001, \eta_p^2 = .50$, and a significant main effect of game, $F(1, 32) = 5.18, p = .03, \eta_p^2 = .14$, indicating that the Match Three game was higher in frustration than the Number Matching game overall (see Figure 8b). Collapsed across game type, pairwise comparisons revealed significant differences between frustration ratings for losses and wins ($p < .001$), wins and near-misses ($p < .001$), and losses and near-misses ($p = .002$).

Arousal. The analysis of subjective arousal revealed a main effect of outcome, $F(1.57, 75.50) = 15.24, p < .001, \eta_p^2 = .24$ (see Figure 8c). Pairwise comparisons revealed significant differences between arousal ratings for losses and wins ($p < .001$), wins and near-misses ($p = .005$), and losses and near-misses ($p = .001$).

Positive Emotion. A main effect of outcome was revealed when we analysed participants' positive emotion ratings, $F(1.25, 64.99) = 84.31, p < .001, \eta_p^2 = .62$ (see Figure 8d). Pairwise comparisons revealed significant differences between ratings of positive emotion following losses and wins ($p < .001$) and wins and near-misses ($p < .001$), but no differences between losses and near-misses ($p = .564$).

Negative Emotion. Analysis of participants' negative emotion ratings revealed a main effect of outcome, $F(1.45, 47.77) = 39.13, p < .001, \eta_p^2 = .54$ (see Figure 8e). Pairwise

comparisons revealed significant differences between negative emotion ratings for losses and wins ($p < .001$), wins and near-misses ($p < .001$), and losses and near-misses ($p = .001$).

Disappointment. Our analysis of participants' disappointment ratings revealed a main effect of outcome, $F(1.52, 50.13) = 72.02, p < .001, \eta_p^2 = .69$ (see Figure 8f). Pairwise comparisons revealed significant differences between ratings following losses and wins ($p < .001$), wins and near-misses ($p < .001$), and losses and near-misses ($p = .002$).

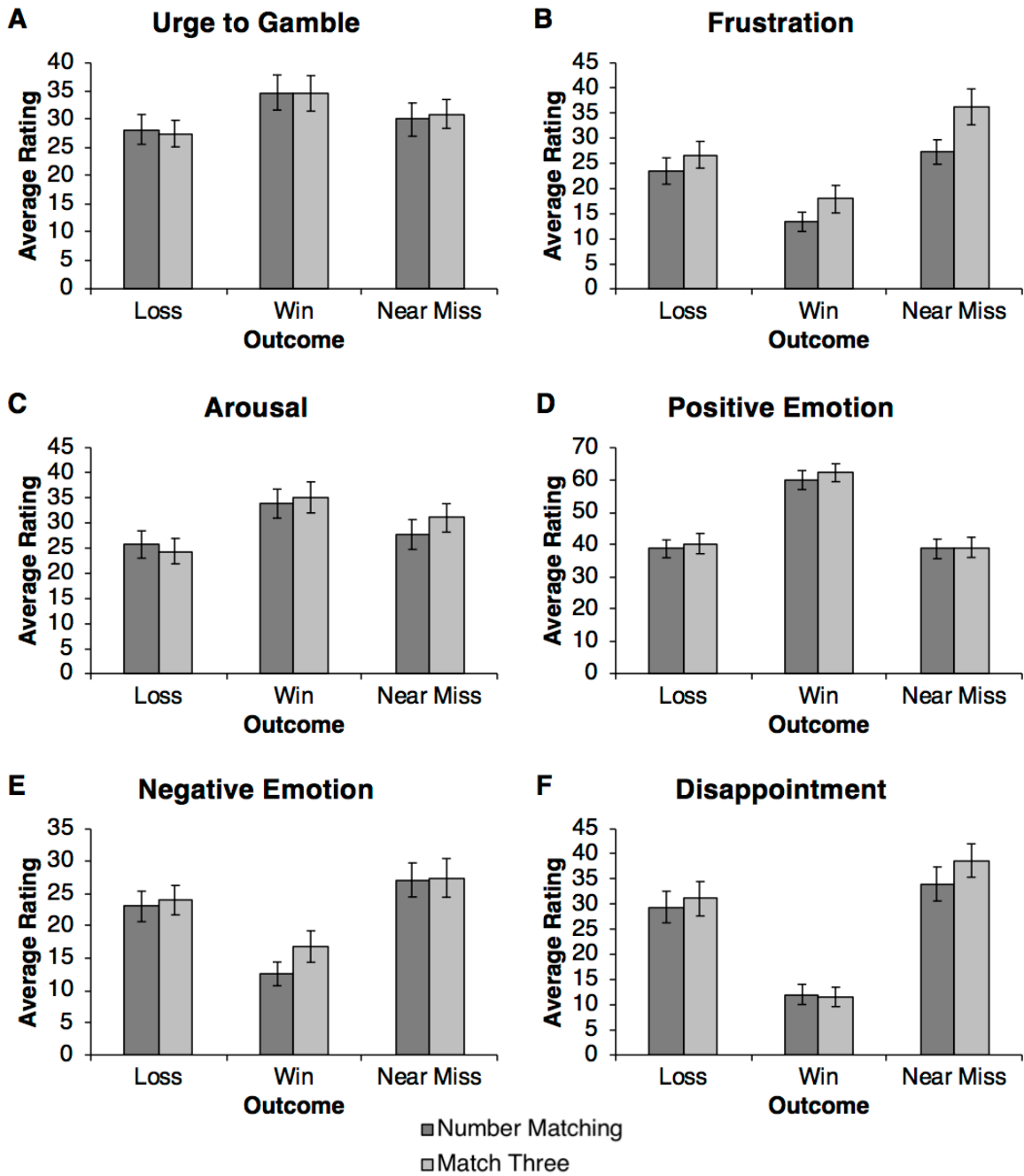


Figure 8. Subjective ratings of a) urge to continue gambling, b) frustration, c) arousal, d) positive emotion, e) negative emotion, and f) disappointment by outcome and game type. Values presented are derived from participants with valid data for all variables in the omnibus model. All error bars ± 1 SEM.

2.1.3 Discussion

In the current study, we examined the impact of scratch card game structure on psychophysiological and subjective outcome reactivity. We compared two game types: Match Three, where one aims to uncover three matching symbols, and Number Matching, where one aims to find a match between a lucky number and a matrix number. Because of the structural differences, we predicted that game type would influence psychophysiological reactivity. Specifically, we predicted that Match Three games, containing an anticipatory period, would garner an increase in psychophysiological arousal as successive matching symbols were uncovered in the pre-outcome period for wins and near-misses (i.e., leading up to the outcome reveal). Support for this prediction was partially found in skin conductance: although there was a relatively steep decline in anticipatory skin conductance levels for losses, this trajectory was less steep for near-misses and positive for wins, indicating that skin conductance rose as participants uncovered the matching \$5.00 symbols. Although we predicted positive slopes for near-misses in addition to wins, our results did not support this prediction. Further, skin conductance slopes for near-misses were found to be only marginally significantly different from regular losses in a one-sided, uncorrected test. Overall, winning outcomes showed the strongest pre-outcome effect in Match Three games. Converging evidence for this effect is found in the heart rate analysis, with the highest BPM during the anticipatory period for Match Three small wins. Contrary to our predictions, heart rate did not differ between Match Three near-misses and losses. Therefore, our results suggest that there are clear psychophysiological arousal changes during the pre-outcome period for Match Three small wins; evidence for psychophysiological changes leading up to Match Three near-misses is not as strong.

We compared these Match Three games to Number Matching games, which have a sequential matching process and no anticipatory period. For Number Matching games, we predicted significant differences post-outcome, with our hypotheses partially supported. Number Matching wins led to significantly larger SCRs than did losses and near-misses, but, contrary to our expectations, Number Matching near-misses had SCRs that were equivalent to those for losses. Thus, overall, wins in the Match Three games triggered pre-outcome increases in arousal, whereas wins in the Number Matching game triggered arousal increases after the outcome reveal.

To further understand the impact of game structure on near-miss-related psychophysiological arousal, we conducted a test of the restricted interaction between losses and near-misses across game types for pre-outcome skin conductance slopes. This analysis revealed no significant interaction, suggesting that the difference in skin conductance levels between losses and near-misses was not significantly different across games. Although the comparison between pre-outcome slope values for near-misses and losses in the Match Three game replicated past work with a one-tailed, uncorrected test, we suggest interpreting this analysis with a high degree of caution, given the lack of effect in the restricted interaction analysis. Nonetheless, although our predictions concerning near-misses were not strongly supported by our psychophysiological dependent variables, participants' subjective ratings suggest that these outcomes are very influential in shaping their experience of scratch cards and the urge to engage in further scratch card gambling.

Participants rated near-miss outcomes in both game types as being significantly more disappointing, arousing, negatively valenced, frustrating, and urge inducing than regular losses. It appears that changes in psychophysiological reactivity during gameplay are not necessary in

order to reach downstream differences in subjective evaluations after the outcome reveal. One curious finding concerns discrepancies between the psychophysiological and subjective arousal responses. Although both presumably measure arousal, it is possible that they account for different aspects of this construct. Psychophysiological arousal, as measured in the current investigation, represents a rather low-level physiological response to external stimuli. In contrast, asking participants to reflect on their experience and assign a quantitative value to a verbal descriptor may encompass a higher order cognitive evaluation. Although both may be conceptualized as measures of arousal per se, the inherent differences between these two measures may account for this discrepancy.

Structural differences also exist between the two types of near-miss outcomes. In the Match Three game, the participant uncovers two of the three necessary symbols required for the top prize, whereas in the Number Matching game, the participant finds that if their number had been one digit lower (or higher), they would have won. The uncovering of required symbols in the anticipatory period of gameplay is possibly the source of near-miss effects observed in Match Three games that have been reported in previous investigations when using similar cards (Stange et al., 2016). However, in the Number Matching game, near-miss effects likely stem from realizing that the outcome was only one digit away from a top prize. In the Match Three game, it is not unreasonable to believe that a top prize may be imminent if two of three necessary symbols for winning it are obtained. However, in the Number Matching game, a near-miss effect must necessarily occur after the symbol in the game matrix has been uncovered and the gambler realizes that they were one digit away. Despite these structural differences, (which we predicted would result in differing near-miss experiences), our results provide no substantial evidence for differences in psychophysiological near-miss effects between these games. Nevertheless, both

types of near-misses evoked significantly greater disappointment, frustration, subjective arousal, urge, and negative emotion than regular losses did.

In Match Three games, participants uncover symbols that directly represent prizes available to be won. However, in Number Matching games, participants aim to match numbers unrelated to a prize, and if a match is made, a prize is then associated with that number. In this way, Number Matching symbols are one step removed from the prizes themselves. This difference may impact outcome processing by altering the subjective proximity to game prizes. From a cue reactivity perspective, Match Three games provide stimuli directly related to the top prize, possibly eliciting a larger psychophysiological response for near-misses than in Number Matching games, in which the near-miss is delivered indirectly through numbers assigned to prizes. Despite weak evidence of psychophysiological near-miss effects in the Match Three game, and no significant difference between near-miss and losing outcome SCRs in the Number Matching game, participants still rated near-miss outcomes in both games as the most frustrating, disappointing, and negatively valenced of all three outcomes. Further, near-misses were rated as being significantly more arousing and urge inducing than regular losses, despite their objective equivalence. Therefore, despite structural differences between games, near-misses appear to preserve some consistency across game types.

Near-miss effects in the present study highlight parallels between scratch card and slot machine games regarding the experience of near-miss outcomes. Slot machine near-misses are capable of increasing physiological arousal (Dixon et al., 2011) and motivation to continue gambling (Clark et al., 2013), as well as encouraging continued gambling (Côté, et al., 2003; Kassinove & Schare, 2001), despite being monetary losses. The present study suggests that scratch card near-misses are capable of exerting somewhat similar effects on gamblers, even in

scratch cards with divergent game structures. Specifically, our results provide evidence for the subjective effects of near-misses, with the effects of near-miss outcomes on psychophysiological variables less clear. One framework put forth for understanding near-miss outcomes includes conceptualizing them as a signal of skill learning (Clark, 2014), such that the proximity of the present attempt to the goal suggests that future attempts will be successful. Therefore, the consistent increases in urge (relative to regular losses) that we observed in both scratch card types could reflect participants' belief that near-misses are a harbinger of a future win. Future research that further examines participants' cognitions surrounding these outcomes may shed light on this possibility.

Overall, these results indicate that participants subjectively react to near-misses and losses differently (despite objective equivalence). It may be that scratch card designers include these outcomes to capitalize on their motivating properties, as, unlike wins, near-misses result in no cost to the operator and provide an added “boost” of motivation for games otherwise made up of nearly 70% full losses³. In addition, our results suggest that scratch card small wins also increase psychophysiological and subjective arousal, as well as positive valence and urge to continue gambling. These results replicate our past findings (Stange et al., 2016; Stange, Grau, et al., 2017) and attest to the strong motivational power of scratch card small wins. The current study extends these findings by revealing similar effects of small wins in a previously unexplored game type.

Although participants psychophysiologicaly responded to wins in both games, the effects did differ. Match Three wins resulted in a positive skin conductance slope and an increase in

³ In a popular scratch card game available in Ontario, 15,422,400 scratch cards were printed, but only 4,468,561 contained prizes (OLG, 2019b), meaning that 71% of cards in this game were losses. Wins (only 29% of cards) tend to be small: In the current example, 99.99% of the prizes were \$100.00 or less (OLG, 2019b).

heart rate during the anticipatory pre-outcome period, suggesting that as participants uncover successive winning symbols, their psychophysiological arousal increases. However, it was only in post-outcome SCRs that Number Matching wins appeared to generate psychophysiological arousal increases. Therefore, although winning outcomes in Match Three games are associated with increases in psychophysiological arousal leading up to the outcome reveal, Number Matching wins appear to generate increases in arousal after the outcome reveal. These results fit with our hypotheses about game structure and outcome reactivity, based on a conceptualization of pre-outcome anticipation and post-outcome evaluation. Wins in both game types prompted not only increases in subjective arousal, but also significant increases in the urge to gamble, which may have implications for continued gambling behaviour. If gamblers act on this urge, using their winnings to buy more cards, those hoping to increase their gains may be set up for failure, as the most common outcome of most scratch card games is a loss (OLG, 2019b).

Limitations and Future Directions

A limitation of the current investigation is that participants were not gambling with their own money and therefore not risking anything of value. We also used a convenience sample of undergraduate students. Although all participants had played scratch cards at least once in the past year, few played frequently, and the results of the current study may differ if conducted with higher frequency gamblers. It is possible that through sensitization and cue-reactivity processes near-miss effects may be exacerbated if these outcomes are encountered more frequently. In addition, it is important to note that participants experienced only a small number of trials per outcome type. Future research should prioritize larger numbers of trials to ensure a stable estimate of the observed effects. Further, a number of participants were ultimately removed from the heart rate analyses because of movement artefacts, reducing statistical power. Future research

should use a larger sample to account for unusable psychophysiological data. In terms of the experimental procedure, having the experimenter sequence the scratch cards for the participant may have reduced participants' perceived control, a factor that is important in processing near-miss outcomes (Clark et al., 2009).

Finally, the top prizes available to be won in our custom-made games were much smaller than those available in commercial scratch card games. However, this may suggest that the present results are an underestimate of the impact of near-misses in the real world. Despite their size, it is also possible that the top prizes themselves were not perceived as equivalent by participants, given that the Cash for a Month top prize was presented as four payments of \$25, whereas the Diamond Payout top prize was simply presented as \$100. However, if participants had perceived these prizes differently, we would have expected an interaction between game type and outcome that was specific to near-misses in any of the subjective dependent variables, and no such interaction was observed. Nevertheless, this aspect of our design may be a pertinent consideration for future studies when examining the structural characteristics of scratch cards, especially given that the perceived timing of rewards has been shown to impact reward valuations (Dixon et al., 2003; Petry, 2001).

Conclusion

The current study adds to a growing body of literature examining the impact of scratch card outcomes on gamblers' experiences. Our study provides evidence that not all scratch cards should be considered equal: there are structural differences between games that appear to be associated with specific effects on the gambler, particularly on the magnitude and timing of psychophysiological responses to winning outcomes. However, we observed commonalities across game types in terms of overall subjective experience, especially for small wins and near-

misses. Therefore, although it is important to consider possible differences in experience created by game structure, there appears to be some degree of universality in the subjective and cognitive experience of scratch card play, particularly in response to winning and near-miss outcomes.

Chapter 3: Anticipatory Processing in Scratch Card Near-Miss Outcomes

3.1 Experiment 2

Currently, there are a number of limitations to the evidence investigating scratch card near-miss effects. In previously conducted experiments, subjects have only experienced a small number of scratch cards, and typically only a singular near-miss outcome during the entire experiment (Stange et al., 2016; Stange, Grau et al., 2017; Stange, Graydon et al., 2017; Stange & Dixon, 2020), or one near-miss outcome per game type investigated (Stange et al., 2020). This precludes the examination of different types of near-misses that vary on *when* during play the near-miss is revealed. For example, imagine that the goal of a scratch card game is to find three matching symbols within a matrix of nine symbols. If two top prize symbols are uncovered early on in the matrix, the gambler may potentially be anticipating the uncovering of the third top prize symbol for the remainder of the game. Contrast this type of near-miss with a situation in which the second top prize symbol is only uncovered later on in the game, resulting in a shorter period of time for which the gambler is hoping to uncover the third match. These differences in symbol arrangement may have an impact on the experience of these outcomes, either physiologically or subjectively. Based on past literature (Stange et al., 2016; Stange, Grau et al., 2017), and Chapter 2 of the present thesis (Stange et al., 2020), we predict that near-misses in which the gambler is anticipating the third and final top prize symbol for longer will result in increased physiological arousal over the duration of the pre-outcome window.

Additionally, although existing studies have allowed participants to engage in ecologically valid scratch card gambling where participants scratch the symbols at whatever rate they are comfortable with, this introduces a number of potential issues for psychophysiological data collection and analyses across the game epoch window. For example, comparisons of

psychophysiological markers across the duration of a game are difficult to make *between* participants, as participants may scratch at different rates, pause at different points, and so on. Presenting participants with a constrained window of time to complete each individual symbol in a scratch card game would address this limitation and allow us to examine fine-grained changes in psychophysiological reactions throughout the duration of game play, and document gamblers' reactions to different symbols in a given scratch card game.

Finally, existing scratch card research has only examined skin conductance and heart rate as psychophysiological variables to index arousal increases. Another psychophysiological marker of sympathetic nervous system activity is pupil dilation (Andreassi, 2000). Pupil dilation has been shown to increase during reward anticipation in both macaque monkeys (Rudebeck et al., 2014) and human subjects (Schneider et al., 2018). In the field of gambling studies, previous research has shown evidence of pupil-related changes to reward-paired cues, relative to uncued trials in a gambling task (Cherkasova et al., 2018). Together these findings suggest that cues of impending rewards may increase pupil dilation, reflecting increased physiological arousal. Despite its potential utility, this psychophysiological variable has not been measured in studies investigating scratch card gambling. Measuring changes in pupil size during scratch card gambling may provide converging evidence for increased psychophysiological arousal during reward anticipation while uncovering winning (three matching symbols) and near-miss outcomes (two matching symbols), relative to regular loss outcomes (no matching symbols).

The current study sought to ameliorate these aforementioned limitations within the literature and to examine changes in pupil size as a new psychophysiological correlate of increased arousal in scratch card gambling. To this end, we conducted an experiment in which participants experienced six scratch card outcomes, on scratch cards with real scratch-off areas.

All participants experienced a regular loss (no matching symbols), a win of \$5, and four near-miss outcomes to the top prize, which all differed in terms of the arrangement of the two top prize symbols. This manipulation enabled us to address how differently timed near-miss outcomes may impact anticipatory arousal over the pre-outcome game play epoch. To accomplish this, we continuously recorded participants' skin conductance and pupil size, while presenting participants with a structured game play session in which the timing of symbol scratching was constrained, allowing for a more straightforward, assumption-free comparison of participants' psychophysiological responses over a discrete period of time.

We predicted increases in skin conductance would accompany the uncovering of the top prize symbols, compared to other symbols. Furthermore, we predicted that near-misses which occurred “early” on in the game (e.g., when both top-prize symbols have been revealed, but there were still multiple symbols left to be scratched) would cause the greatest increases in anticipatory arousal. Across all outcomes, we predicted greater skin conductance responses to top prize symbols (e.g., after the symbol has been uncovered) compared to non-top prize symbols. Relatedly, we predicted more frequent skin conductance responses for top prize symbols compared to non-top prize symbols. We also predicted significantly more urge for near-miss outcomes compared to regular losses, and significantly more urge for winning outcomes compared to regular losses, replicating previously reported findings.

Given the importance of replicability and open science to addictions research (Gorman, 2019) and gambling studies in particular (Wohl et al., 2019), we pre-registered the above predictions and sample size using the open science framework (<https://osf.io/qup5a>)⁴. As the inclusion of eye tracking as an additional psychophysiological marker was largely exploratory,

⁴ Data collection was prematurely suspended in March 2020 due to the *Coronavirus* pandemic and restrictions on in-person research protocols, resulting in a smaller final sample size than what was indicated in our pre-registration.

we did not pre-register predictions for this dependent variable. For clarity, any exploratory analyses are labelled as such in the results section.

3.1.1 Method

Participants

A sample of fifty-eight participants were recruited from the University of Waterloo's Research Experience Group. All participants were pre-screened before the time of testing to ensure that they were 18 years of age (the legal age to purchase scratch cards in the province of Ontario), had played a scratch card at least once in the last 12 months, were not currently in or seeking treatment for problem gambling, and reported having normal or corrected-to-normal vision with contact lenses (and not glasses so as to not interfere with the eye tracking apparatus). For their participation, participants received a 0.5% course credit for a psychology course in which they were currently enrolled. All participants also received \$5.00 in scratch card winnings after completing all of the scratch card games in the experiment. All procedures were reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee.

Materials

Gambling Frequency and Demographics. Participants reported their frequency of scratch card gambling and traditional lottery (draw-based) gambling, using items modified from the Canadian Problem Gambling Index (Ferris & Wynne, 2001). Specifically, participants responded to the following items: "In the past 12 months, how often did you bet or spend money on Lottery tickets like LottoMax, Lotto 649, Super 7, or Lottario?" and "In the past 12 months, how often did you buy instant win or scratch tickets like Cash for Life or Instant Crossword?" Participants responded to these items by selecting how often they engaged in each specific form of gambling from a list of several response options (see Table 2 for all response options).

Scratch Cards. Participants interacted with custom-made scratch cards called “Cash for a Month”, designed to emulate a popular scratch card available for sale in our home jurisdiction of Ontario, Canada (“Cash for Life”). The goal of the game is to find three matching prize symbols on one card, out of the nine symbols per card. The game symbols consisted of various monetary prize amounts ranging from \$5.00 to \$50.00, and the top prize symbol (the word “MONTH”). The top prize of the game was Cash for a Month, or \$25.00 a week for four weeks (or \$100; see Figure 9).



Figure 9. Cash for a Month scratch cards used in Experiment 2.

Urge to Gamble Ratings. Following each scratch card game, participants gave ratings of their desire to continue gambling by responding to the following item: “How would you rate

your desire to gamble on a scale from 0 (no desire to gamble) to 100 (overwhelming desire to gamble)?” The item was completed using a sliding scale presented on a tablet computer.

Problem Gambling Severity Index and Short Gambling Harm Screen. To characterize our sample, the Problem Gambling Severity Index (a sub-component of the Canadian Problem Gambling Index; Ferris & Wynne, 2001) and the Short Gambling Harm Screen (Browne et al., 2018) were administered to participants.

Gambling Related Cognitions Scale. The Gambling Related Cognitions Scale (Raylu & Oei, 2004) is a 23-item, well-validated scale to assess endorsement of five erroneous cognitions related to gambling: interpretive bias, illusion of control, predictive control, gambling-related expectancies, and inability to stop gambling. This scale was administered for purposes peripheral to the current research question and will not be analyzed further.

Near-Miss Cognitions. To assess participant’s endorsement of specific cognitions related to near-miss outcomes, we presented a visual depiction of a near-miss outcome to participants and the following items, adapted from Dixon and colleagues (2018): “Near-misses reflect my skill at this scratch card game” and “Near-misses indicate that a win is imminent”. Participants responded to these items using a sliding scale ranging from 0 (Strongly disagree) to 100 (Strongly agree). This scale was administered for purposes peripheral to the current research question and will not be analyzed further.

Apparatus

Display Case. The scratch cards that participants selected to play during the experiment were housed in display cases similar to those found in Ontario lottery retailers. Each case consisted of a wooden frame with a plexiglass top, displaying trays of available scratch cards. Each display case contained 96 scratch cards in two trays (48 scratch cards per tray). A total of

three display cases were utilized in this experiment, resulting in 6 total trays of scratch cards (one tray per outcome type).

Scratching Platform. To ensure that participants could effectively scratch their cards, each scratch card was inserted into a clipboard mounted on a scratching platform made of wood arranged at a 30-degree incline. This platform enabled participants to comfortably scratch each scratch card using only one hand (as their non-dominant hand was equipped with skin conductance electrodes).

Eye Tracking. Participants wore a Positive Science Mobile Eye-Tracking Laboratory (Positive Science, Inc., 2019), consisting of a backpack-mounted MacBook Air equipped with PSLiveCapture software, and associated recording headgear. The headgear apparatus consisted of an eye camera and infrared LED (mounted on a flexible arm that extended from the headgear), as well as a scene camera. The headgear was equipped with a headband to ensure secure placement. After adjusting the camera positioning for each participant to ensure optimal recording, a calibration was conducted at the beginning of each recording. All data processing was completed after the testing session.

Skin Conductance Recording. Participants' skin conductance was continuously recorded using an ADInstruments PowerLab equipped with a Galvanic Skin Conductance Response amplifier (sampled at 1000 Hz). Non-gelled passive electrodes were attached to the fingertips of each participant's index and middle finger of their non-dominant hand. Participants were instructed to keep the hand equipped with the electrodes as still as possible throughout the study to ensure optimal recording and minimal movement artefacts.

Design

This experiment utilized a within-subjects design, such that all participants experienced all possible scratch card outcomes. To ensure that all participants received one of each outcome type, the display cases from which participants chose their cards were arranged such that each tray contained one of the six outcome types (there were three display cases, each containing two trays to afford the six different outcomes).

Each scratch card that participants experienced contained one outcome made up of nine symbols. Each symbol represented a different prize amount (see Figure 9). To win a prize, participants were required to find three matching symbols within one game. All participants experienced a card leading to a regular loss (nine non-matching prize amount symbols), a card leading to a win of \$5.00 (six non-matching prize amount symbols and three matching \$5.00 symbols), and four cards containing near-miss outcomes (each containing two matching top prize “MONTH” symbols and seven non-matching prize amount symbols). Each near-miss outcome contained the first top prize (“MONTH”) symbol in position 4, with the second top prize symbol position occurring sequentially, in positions 5 through 8. That is, the near-miss 1 (NM1) card contained top prize symbols in positions 4 and 5, near-miss 2 (NM2) contained top prize symbols in positions 4 and 6, near-miss 3 (NM3) contained top prize symbols in positions 4 and 7, and near-miss 4 (NM4) contained top prize symbols in positions 4 and 8. Participants were randomly assigned to one of six possible outcome orders (arranged in a Latin square design) to ensure adequate counterbalancing. All participants completed a practice card containing dollar symbols (e.g., “\$\$\$”) in place of the prize amounts before completing the six scratch cards chosen from the display cases.

Procedure

All participants provided written informed consent to participate. Using a tablet computer, participants then completed items assessing the frequency with which they engage in scratch card gambling and traditional (draw-based) lottery gambling, demographic items assessing their age and gender, and the Problem Gambling Severity Index. Following these surveys, participants approached the display cases and received instructions for the gambling portion of the experiment. The researcher explained that in the study, the participant would be playing six scratch cards in total, with one additional practice card at the beginning to familiarize them with how the game works. Using a laminated example card, the researcher explained that each scratch card game contained nine symbols, with the goal of the game being to match three symbols on one card; a match of three symbols denoted a win of the corresponding prize. Participants were told that the top prize for the game was “Cash for a Month” or \$25.00 a week for four weeks, or simply \$100.00 cash, and that to win this prize, they were aiming to find three MONTH symbols on one card. The researcher told the participants that their odds of winning the top prize was approximately 1 in 100, and that there was one top prize card in each display case, to ensure that participants knew that there was a chance they could win a top prize.

Next, participants received instructions for how they would be completing the scratch card games. The researcher explained the procedure of scratching each symbol in time with a tone: each time the participant heard a tone, they were to scratch one symbol on the scratch card and not to scratch the next symbol until they heard the next tone. Participants were also told to uncover the symbols sequentially from left to right, top to bottom as they heard each successive tone.

Participants were given instructions for the urge to gamble ratings using the tablet computer. Next participants chose their scratch cards from the display cases and were instructed to choose one card from each of the six trays. The researcher then set up the eye tracking equipment for the participant, completed the calibration procedure, and attached the skin conductance electrodes to the participants' index and middle fingers of their non-dominant hand. Finally, the researcher started the computer program that would deliver the timed tones, and set up the practice card in the scratching platform for the participant.

Following the completion of the practice card, participants filled out a practice urge to gamble item using the tablet computer. After this, the researcher repeated this sequence of events for each of the scratch cards that participants chose from the display case, according to the card order to which they were randomly assigned. After removing the skin conductance electrodes and the eye tracker, the participant completed the Short Gambling Harms Scale, the Gambling Related Cognitions Scale, and the Near-Miss Cognitions items. The participant completed a receipt for their winnings (\$5.00 in total for each participant) and was given a feedback letter and responsible gambling materials upon leaving.

Data Reduction

Skin Conductance. Skin conductance data was separated into discrete epochs based on the game symbol being uncovered. As participants' scratching was time-locked based on the delivery of the tones, each symbol epoch was 15 seconds in length. The computer program inserted marker comments into the LabChart recording file that identified the beginning of each symbol (e.g., the signal tone to begin scratching). Therefore, each epoch contained the period of time when the participant scratched the symbol, and physiologically reacted to the symbol, while waiting for the next tone. As each scratch card consisted of nine symbols, and each participant

played six scratch cards, this resulted in 54 symbol epochs per participant. Two values were derived from each of these epochs for further analysis: the slope of the skin conductance level over the entire epoch length, and the skin conductance response for each epoch. Skin conductance responses were calculated in a four second window following a 0.5 second advance from the approximate point at which the participant finished scratching each symbol in each game (determined from eye tracking video footage; see Eye Tracking section below). Specifically, the value at the beginning of this four second the window was subtracted from the maximum skin conductance value within the window. Square root transformed SCR values were then submitted to statistical analysis.

Furthermore, to examine how skin conductance levels changed over time throughout the duration of each outcome, we extracted mean skin conductance level values for 15 1-second sections of each 15-second symbol epoch. Skin conductance data was recorded at 1000 Hz (1000 points per second), and this procedure essentially down-sampled the skin conductance signal to take an average over each set of 1000 points per second, resulting in a mean value for each 1-second section of the 15-second epoch. Each datapoint for each participant was then baseline corrected by subtracting the value of the average of the skin conductance level during a 1-second window immediately prior to the tone onset from each subsequent datapoint during the scratching epoch.

Eye Tracking. As a preliminary screening measure, the scene video from each participant's eye tracking video recordings was examined to ensure that the participant's hand was clearly visible during all symbol scratching periods. If the moment at which the participant finished scratching a symbol was not visible, and therefore could not be accurately marked, this participant was excluded from further analyses.

For the participants who had complete and visible video recordings, eye tracking data was rendered using Yarbus (Positive Science) software to combine the eye and scene camera recordings into a single video file. This also created a data file that contained the pupil size (width and height) and timestamp for each frame of the video. These pupil width and height values were used to calculate the area of the pupil, using the formula for area of an ellipse, as some pupil measurement readings were not of equal width and height.

Each video file was reviewed and marked for key events. The beginning of each scratching epoch was marked by locating the onset of the tone in the video's associated auditory waveform, and by recording the frame in which the tone began⁵. If the tone onset was masked by other sounds occurring in the testing environment and therefore could not be accurately marked, the participant was excluded from further analyses. Additionally, the approximate frame in which each participant finished scratching each symbol within the 15-second scratching window was located and marked.

The average pupil area was calculated across a two-second window after the participant completed scratching each symbol. Specifically, this two-second window was determined by adding 2 seconds to the timestamp at which the participant finished scratching each symbol on the card, and taking an average of the pupil area across this epoch. These values were baseline corrected for each participant, such that the pupil area value for each symbol was subtracted from the average of a 500-millisecond window immediately prior to the onset of the tone, rendering this measure a change in pupil area from baseline. Additionally, the maximum value of pupil

⁵ In most instances, this frame contained the tone onset; however, in some instances, the onset of the tone was near the border of two frames of the video (e.g., one frame contained a small part of the onset, but the following frame only contained the tone). In these instances, the latter of the two frames which were associated with the tone onset was marked and used for analysis.

dilation in this 2-second window was also examined as a percent change from the same baseline period.

As each frame of the video was associated with a timestamp in the rendered eye tracking data file, we used the video frame reference numbers to determine the length of time each participant spent scratching each symbol. This was completed by subtracting the timestamp of the point at which the participant finished scratching the symbol and the timestamp of the tone onset. This time (in milliseconds) was then used to manually place markers in the LabChart file containing the skin conductance data. This ensured that each LabChart marker was placed the appropriate amount of time following the tone onset (e.g., specific to each symbol that each participant completed), in order to calculate SCR values from the point at which the participant completed scratching each symbol.

3.1.2 Results⁶

Sample Characteristics

Self-reported age, gender, lottery gambling frequency, scratch card gambling frequency, and PGSI scores are listed in Table 2. Before conducting statistical analyses, two participants were excluded due to procedural errors during data collection, rendering their data unusable. An additional participant was removed from only the post-surveys due to a procedural error. Two additional participants were removed from only the urge ratings for providing an incorrect number of urge ratings per card. 18 participants were removed from the SCR and eye tracking analyses as their video recordings could not be accurately marked (e.g., key events occurred outside the recording frame; see Data Reduction). An additional six participants were excluded at the video marking stage due to masked tone onsets (e.g., talking or other noise occurred during

⁶ See Appendix A for additional skin conductance analyses and results.

tone onset, contaminating the audio waveform). Finally, two participants were removed from the eye tracking analyses because of missing data, based on a threshold of more than 10% of datapoints missing over the course of the experimental session.

Table 2. Experiment 2 participant characteristics.

Measure	Value
Age, mean (<i>SD</i>)	19.25 (1.39)
Gender, <i>n</i> (%)	
Female	45 (81.8)
Male	10 (18.2)
Frequency of scratch card gambling, <i>n</i> (%)	
Never	3 (5.5)
Between 1 – 5 times/year	37 (67.3)
Between 6 – 11 times/year	5 (9.1)
About Once/Month	6 (10.9)
2-3 Times/Month	4 (7.3)
About Once/Week	0 (0)
2-6 Times/Week	0 (0)
Daily	0 (0)
Frequency of lottery draw gambling, <i>n</i> (%)	
Never	19 (34.5)
Between 1 – 5 times/year	28 (50.9)
Between 6 – 11 times/year	3 (5.5)
About Once/Month	3 (5.5)
2-3 Times/Month	2 (3.6)
About Once/Week	0 (0)
2-6 Times/Week	0 (0)
Daily	0 (0)
Problem Gambling Severity Index, <i>n</i> (%)	
Non-problem gambling	38 (69.1)
Low-risk gambling	16 (29.1)
Moderate-risk gambling	1 (1.8)
Problem gambling	0 (0)

Note. Frequency of scratch card and lottery draw gambling categories represent participants' self-reported gambling over the last 12 months. PGSI categories represent cut-offs as established by Currie and colleagues (2013). *SD* = standard deviation.

Skin Conductance Changes Over Time

In our pre-registered analysis plan, we predicted that participants' skin conductance would increase when uncovering top prize symbols in the scratch card game. To test this prediction, we examined each epoch for each symbol that was uncovered (nine symbols per

game). As each symbol was scratched within a constrained time window, the epochs were all of identical length (15 seconds).

For ease of interpretation, we elected to analyze this data at the level of symbol and outcome, to simplify for the presence of slight variations between datapoints within one symbol epoch. We believe this is justified as our main prediction concerned the skin conductance level in epochs corresponding to MONTH symbols, compared to non-MONTH symbols. Therefore, we averaged the 15 1-second data points for each scratching epoch, and submitted the data to a 9 (symbol position) x 6 (outcome) repeated measures analysis of variance (ANOVA), with both symbol and outcome as within-subjects factors. Here we were expecting an interaction between symbol position and outcome, such that the overall skin conductance level during a specific symbol position would differ based on the outcome type being experienced. In symbol epochs containing top prize symbols, skin conductance should increase, compared to equivalent epochs in which there is a non-top prize symbol.

The overall repeated measures ANOVA examining outcome type and symbol position revealed a main effect of symbol position, $F(2.00, 95.82) = 19.41, p < .001, \eta_p^2 = .29$, as well as a significant interaction between symbol position and outcome type, $F(9.49, 455.69) = 3.24, p = .001, \eta_p^2 = .06$. Given that our primary preregistered analyses focused on examining skin conductance responses to MONTH symbols in near-miss outcomes compared to non-MONTH symbols in the equivalent position in other outcomes, we elected to follow-up this interaction by examining differences between outcomes at specific symbol positions, starting with symbol 4. This symbol position contained a MONTH symbol for all four near-miss outcomes, with the second MONTH symbol in these outcomes occurring on either the fifth, sixth, seventh, or eighth symbol position (see Design). Participants' skin conductance levels for the first three symbols

were not analyzed further, as these symbols were all non-MONTH symbols for each outcome (and therefore devoid of our contrast of interest).

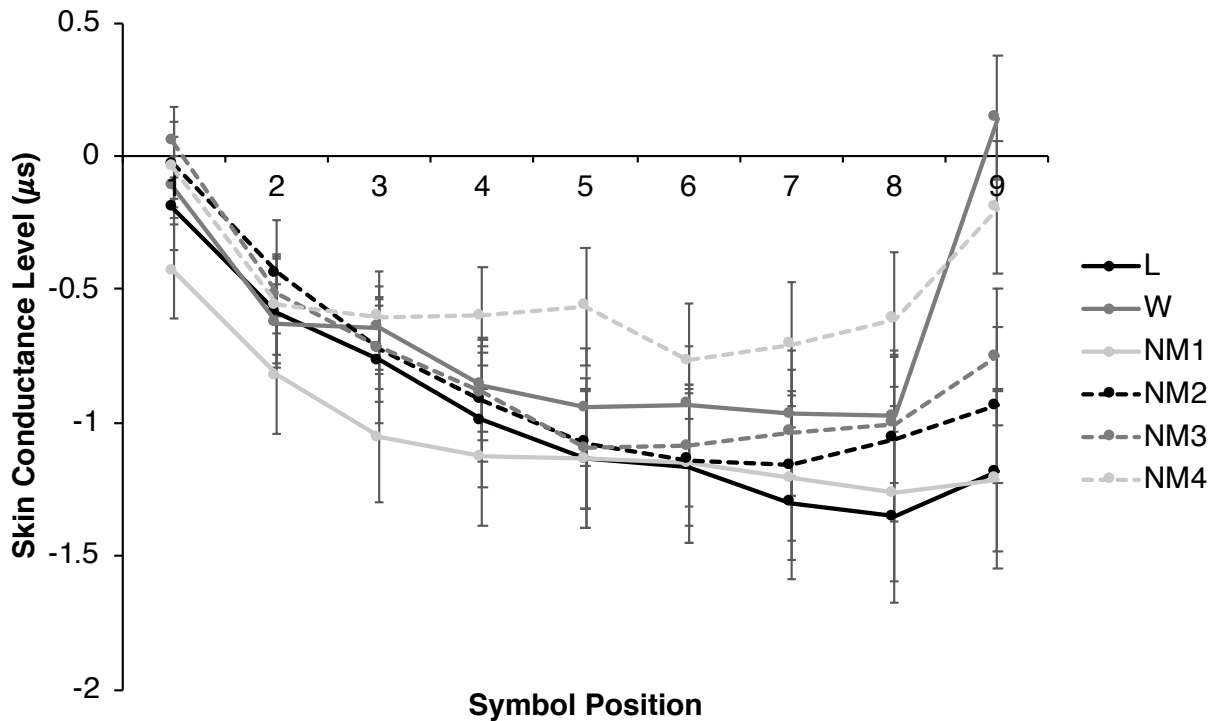


Figure 10. Baseline corrected skin conductance level by symbol position and outcome type. All error bars ± 1 SEM.

At symbol positions four through eight, the individual repeated measures ANOVAs with outcome type as the repeated measures factor revealed no significant main effects of outcome (all p 's $\geq .25$). For the ninth (and final) symbol position, this analysis revealed a significant main effect of outcome, $F(5, 265) = 5.14, p < .001, \eta_p^2 = .09$, thus constituting the source of our outcome by symbol interaction (see Figure 10). To follow-up this main effect, we conducted pairwise comparisons between outcome types at the ninth symbol position (see Figure 11). These comparisons indicated that participant's skin conductance levels differed significantly between losing and winning outcomes at this final symbol position ($p = .001$). Near-miss 1, 2, and 3 were not significantly different from the losing outcome (all p 's $> .19$), but were significantly more

negative than the winning outcome (all p 's < .005). Skin conductance levels at symbol nine of the near-miss 4 outcome were significantly different from the losing outcome ($p = .003$), but not significantly different from the winning outcome ($p = .183$). Near-miss 4 was significantly less negative than near-miss 1 ($p = .02$), and near-miss 3 ($p = .05$), and marginally different from near-miss 2 ($p = .06$).

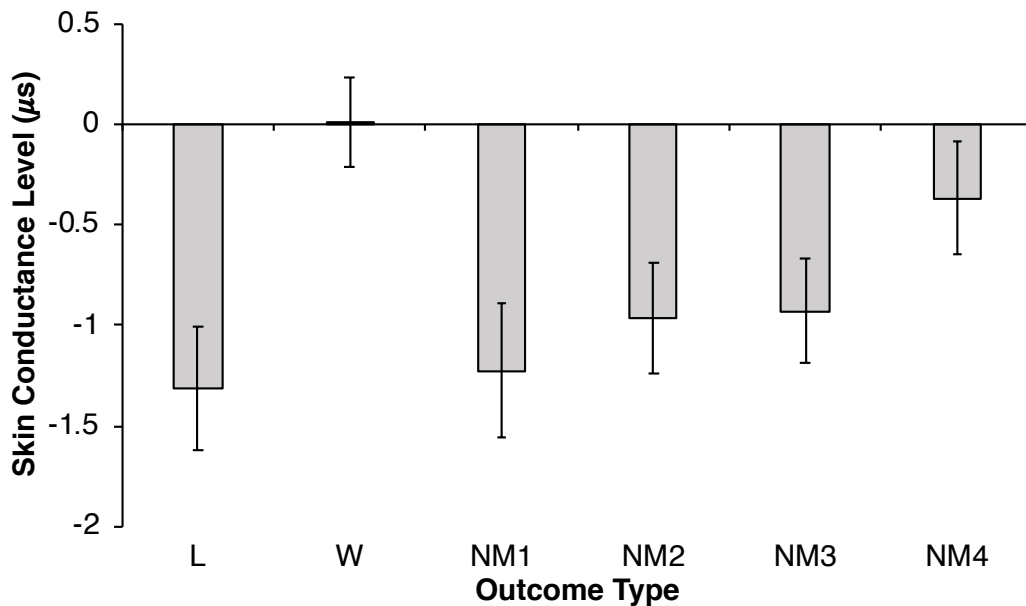


Figure 11. Skin conductance level at final symbol position (symbol 9) by outcome type. All error bars ± 1 SEM.

Skin Conductance Responses by Symbol Type

We examined how participants responded to the two symbol types in the scratch card games with a comparison of the magnitude of skin conductance responses to both MONTH and non-MONTH symbols. Further, these symbol types may have influenced the *frequency* of such skin conductance responses. As the MONTH symbol is representative of the top prize available to be won, we predicted in our pre-registration that SCRs for MONTH symbols would be greater than those for non-MONTH symbols, and further, that valid skin conductance responses would occur more often for MONTH symbols, compared to non-MONTH symbols.

To test these hypotheses, we examined the four near-miss outcomes that participants were presented with. For non-MONTH symbols, we took an average of the SCRs to the second and third symbols in each of the near-miss outcomes, as these symbols would only have been preceded by one non-MONTH symbol (e.g., these epochs would not have been impacted by the presence of preceding MONTH symbols). In each game, the first MONTH symbol occurred on symbol 4, however there was a systematic change in where the second MONTH symbol occurred (symbol 5, 6, 7, or 8). Therefore, we took an average of the SCRs to the two MONTH symbols regardless of where they occurred in the symbol arrangement for each near-miss outcome. We averaged the responses to the aforementioned symbols for each participant individually, resulting in an average MONTH SCR value and average non-MONTH SCR value for each participant. Responses greater than 3 standard deviations above the mean for each averaged symbol type (MONTH or non-MONTH) were removed before analysis. Given our pre-registered, directional hypotheses, we proceeded with one-tailed tests of significance. The paired samples *t*-test revealed no significant difference in SCR amplitudes between the symbol types, $t(30) = .425, p = .674$ (see Figure 12a).

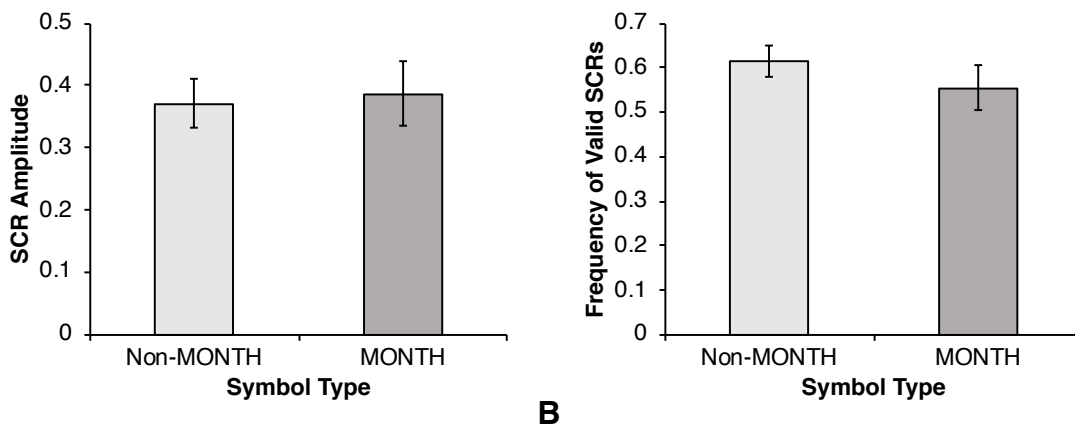


Figure 12. Skin conductance response results by symbol type for a) SCR amplitude and b) frequency of valid SCRs. All error bars ± 1 SEM.

To analyze the frequency of valid SCRs for each of the two symbol types, we calculated the proportion of SCR responses that were greater than 0.05 microsemens (Dawson et al., 2007). To compare MONTH and non-MONTH symbols in terms of the frequency of valid SCRs, we again compared the average of the proportion of valid SCRs during the two symbols preceding each card's first MONTH symbol and the two MONTH symbols. A paired samples t-test revealed no statistically significant difference between the two symbol types, $t(31) = -1.72, p = .096$ (see Figure 12b). Nominally, the non-MONTH symbols were associated with a higher frequency of valid SCRs compared to MONTH symbols.

Urge to Gamble Ratings of Near-Miss Outcomes

Participants provided urge to gamble ratings following each outcome that they experienced in the experiment. As stated in our pre-registered hypotheses, we predicted that near-miss and winning outcomes would result in increased urge to gamble ratings relative to regular losses. Average urge ratings for each outcome were compared. Participants' urge ratings were submitted to a repeated measures ANOVA with outcome as the repeated measures factor. In the event of violations of sphericity assumptions, corrected degrees of freedom and F values are reported (Greenhouse-Geisser correction).

To determine if there was a significant difference in urge for the four individual near-miss outcomes presented to participants, we first submitted these four urge ratings to a repeated measures ANOVA. This analysis showed no main effect of outcome type on participant's urge scores for the near-miss outcomes ($p = .247$). Therefore, we proceeded by averaging participant's urge ratings across all four near-miss outcomes to create a composite, average near-miss variable. We then conducted an additional repeated measures ANOVA with participant's urge ratings for the losing outcome, winning outcome, and composite near-miss outcome variable.

This analysis revealed a significant main effect of outcome, $F(1.68, 89.28) = 19.19, p < .001, \eta_p^2 = .27$. Follow-up pairwise comparisons revealed significant differences between losing ($M = 28.02, SD = 24.53$) and winning ($M = 39.48, SD = 28.39$) outcomes, $p < .001$, between winning and near-miss ($M = 34.02, SD = 25.63$) outcomes, $p = .007$, and between losing and near-miss outcomes, $p < .001$.

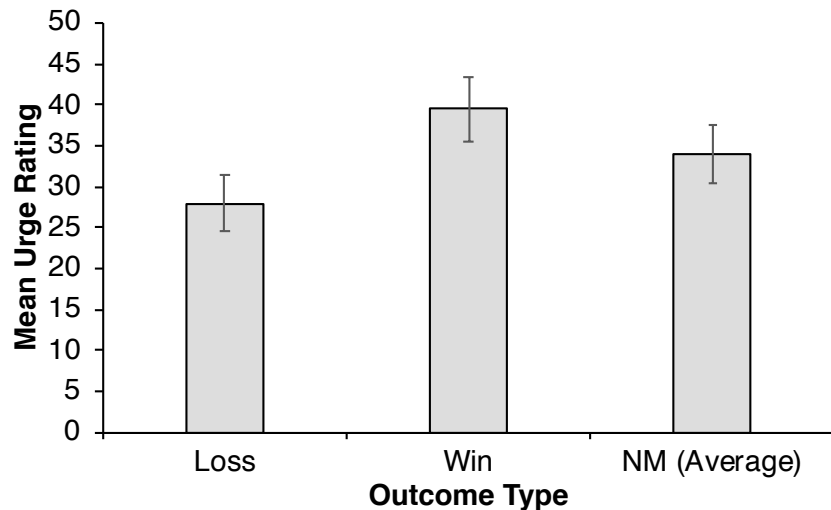


Figure 13. Urge to continue gambling by outcome type.

Exploratory Analyses

Skin Conductance Trend Analyses. As can be seen in Figure 10, the skin conductance level data over the duration of each entire game presents with a general downward trend, with differences in outcomes at the final symbol position (as explored in the pre-registered skin conductance level analyses above). To further explore the shape of participant's skin conductance levels over time, we examined within-subjects contrasts of linear and quadratic trends in the skin conductance level data for each outcome. Given the exploratory nature of these analyses, we restricted our criterion alpha level to .01 and applied a Bonferroni correction for the 12 comparisons (two trends for each of six outcomes), resulting in a significance threshold of $p =$

.0008. These analyses revealed a significant linear trend for losing outcomes ($p < .0001$, $\eta_p^2 = .258$) and NM2 outcomes ($p = .0004$, $\eta_p^2 = .202$), and significant quadratic trends for winning ($p < .0001$; $\eta_p^2 = .488$), NM2 ($p < .0001$, $\eta_p^2 = .391$), NM3 ($p < .0001$, $\eta_p^2 = .475$), and NM4 outcomes ($p < .0001$, $\eta_p^2 = .320$).

Average Change in Pupil Diameter in the 2-Second Post-Outcome Window. We examined participants' change in average pupil diameter from baseline over a 2-second epoch following the completion of scratching each symbol in each game. This resulted in 9 average pupil diameter measurements for each of the 6 outcomes. We submitted these variables to a repeated measures analysis of variance, with outcome (6) and symbol position (9) as the repeated measures factors. This analysis revealed no significant main effects or interactions (all p 's $> .142$).

With regards to the near-miss outcomes specifically, we also examined the average change in pupil diameter from baseline across non-MONTH and MONTH symbols for each of the four near-miss outcomes. In a similar manner to the SCR analyses, we averaged participants' pupillometry measurements across symbols 2 and 3 (non-MONTH symbols preceding MONTH symbols), and the respective MONTH symbols within the near-miss outcomes. We then compared these non-MONTH and MONTH pupillometry values with a paired samples t -test, which revealed no significant difference in participant's average pupil diameter after uncovering non-MONTH versus MONTH symbols within near-miss outcomes ($p = .445$).

Maximum Pupil Dilation in 2-Second Post-Outcome Window. We examined participants' change in maximum pupil dilation from baseline levels over a 2-second window following the completion of each scratch card symbol in each game. As in the previous analysis, this resulted in 9 maximum pupil dilation values for each of the 6 outcomes. We submitted these

variables to a repeated measures ANOVA, with outcome (6) and symbol position (9) as the repeated measures factors. This analysis revealed no significant main effects or interactions (all p 's > .199).

For near-miss outcomes, we also examined the average maximum change in pupil diameter from baseline across non-MONTH and MONTH symbols for each of the four near-miss outcomes. In a similar manner to the SCR analyses and the pupillometry analyses above, we averaged participants' maximum change in pupil diameter across symbols 2 and 3 (non-MONTH symbols preceding MONTH symbols), and the respective MONTH symbols within the near-miss outcomes. We compared these values with a paired samples t -test, which revealed no significant differences in participants' change in maximum pupil dilation from baseline between these symbol types ($p = .219$).

3.1.3 Discussion

We conducted a pre-registered experiment to further examine subjective and psychophysiological near-miss effects in scratch card games, specifically the impact of top prize (MONTH) symbols relative to non-top prize (non-MONTH) symbols on the timing and magnitude of these effects. Previous research on the psychophysiological correlates of near-miss effects in scratch cards have only examined single near-miss outcomes (Stange et al., 2016, Stange et al., 2017), without consideration of how the arrangement of symbols within these outcomes may impact participant reactivity. Furthermore, we controlled when participants scratched each symbol, allowing us to more accurately examine symbol-level changes in physiological arousal. Finally, we collected exploratory pupillometry measurements while participants engaged in scratch card gambling, to further understand the psychophysiological consequences of this form of gambling.

Much of our analysis focused on the effects of outcome and symbol position on participants' physiological arousal, as measured by skin conductance. Our overall analysis of skin conductance level over time revealed a downward trend as participants uncovered each sequential symbol in each outcome. However, at the final symbol position, we observed significant differences between outcomes in terms of skin conductance level. Here, wins resulted in an upward trajectory and significantly greater skin conductance levels compared to all other outcomes. At this same symbol position, losing outcomes resulted in the lowest skin conductance level. Near-misses 1, 2, and 3 were each not significantly different from this losing outcome, but were all significantly lower than the winning outcome. For near-miss 4, participants' skin conductance levels were significantly different from the losing outcome and significantly or marginally different from each of the other three near-miss outcomes, but not significantly different from the winning outcome. Exploratory trend analyses bolster these conclusions, with wins, and near-misses 2, 3, and 4 resulting in significant quadratic trends overall, and losses resulting in only a significant linear trend.

These results suggest that the placement of the top prize symbols in scratch card near-miss outcomes has an impact on participant's psychophysiology. In the near-miss outcomes we presented to participants, the first top prize symbol occurred at symbol position 4, and the timing of the second top prize symbol was systematically manipulated to occur at symbol 5, 6, 7, or 8 (in near-misses 1, 2, 3, and 4, respectively). We had originally predicted that subjective and psychophysiological effects would be stronger for near-misses where both top prize symbols occur earlier in the outcome, as this would result in a longer anticipatory window until the final symbol reveal to determine the outcome. For example, in near-miss 1, the participant uncovers top prize symbols in positions 4 and 5, and has to reveal 4 additional symbols to determine if

their card is a winner. Therefore, we expected that as the number of symbols that participants had to scratch following the first two top prize symbols increased, so too would skin conductance level.

What we observed in our data was the opposite of this pattern; participants' skin conductance levels at the final symbol position in near-miss 4 were the greatest of all the near-miss outcomes, and were not statistically different from winning outcomes. It is possible that during near-miss 4, when participants uncover the second top prize symbol in symbol position 8, that they feel as if they have *one last chance* to win the top prize by uncovering a MONTH symbol in position 9. In contrast, although participants have already uncovered both top prize symbols early on in near-miss 1, they have subsequently uncovered multiple consecutive non-MONTH symbols. In short – with each successive failure to get the third month symbol, during near-miss 1, participants become desensitized to any frustration evoked by the near-miss causing skin conductance to fall. Therefore, when uncovering the final symbol in the near-miss 1 card, it is just another non-month symbol like the three that had proceeded it – nothing to get excited, or frustrated about. For near-miss 4, psychophysiological arousal may increase due to the proximity of the near-miss to the outcome reveal; participants may realize they have one last chance to win the big prize, and are frustrated when they do not. These differences appear to impact participants' psychophysiological responses: in the final outcome position, near-misses 1, 2 and 3 resulted in skin conductance levels that were not significantly different from the losing outcome, and were all significantly different from the winning outcome, whereas near-miss 4 was not only significantly different from the losing outcome, but was not statistically different from the winning outcome.

Previous research has revealed differences between slot machine near-miss outcomes with varying proximity to the winning outcome position (Wu et al., 2017), and between near-misses that occur before and after the payline in slot machines (Clark et al., 2012), suggesting that the arrangement of symbols that make up a near-miss has an impact on gamblers. It is possible that the second MONTH symbol occurring in position 8 in near-miss 4 provides a strong cue to mentally simulate the narrowly missed top prize win, resulting in an upward counterfactual process once the outcome is revealed (Clark et al., 2012). Contrast this with near-miss 1, where the second MONTH symbol occurs near the mid-point of the outcome, and perhaps is not as strong of a cue to simulate the narrowly missed win. These differences may account for the psychophysiological effects we observed in the present experiment.

An alternative to the counterfactual processing account, lies in the aforementioned frustration that occurs following a near-miss. That is, the arousal at the final symbol position in near-miss 4 may simply reflect participants' frustration that they had "just missed" winning; the month symbol in position 8 occurring immediately before the final symbol raised the possibility of the big win, and the frustration that ensued when this did not happen may have elevated skin conductance. Therefore proximity of the second month symbol to the outcome reveal may lead to increased frustration for near-miss 4 specifically, as after uncovering all of the symbols in the outcome, participants may realize how "close" they were to obtaining the final MONTH symbol immediately prior to the outcome's conclusion. Although this interpretation of our data is not in line with our pre-registered predictions, it does fit with findings from previous studies which consistently find near-miss effects on participants' ratings of frustration and disappointment (Stange, Grau et al., 2017; Stange, Graydon et al., 2017; Stange & Dixon, 2020).

Although we observed outcome-based effects on participants' psychophysiology, we did not observe differences between the near-miss outcomes in terms of subjective urge ratings. This may be due to the fact that these ratings are made retrospectively, and at a point when the near-miss outcomes are objectively equal, and the potential effects of near-miss proximity to the outcome reveal may have subsided. Given the lack of differences in the urge ratings among the 4 near-miss outcomes presented, we collapsed these outcomes for our analysis of participants' subjective urge ratings and examined average near-miss urge compared to urge garnered by wins and losses. Participants reported significantly greater urge to continue gambling for winning outcomes compared to near-miss and losing outcomes, and near-miss outcomes resulted in significantly greater urge to continue gambling than regular loss outcomes. These latter results replicate previous scratch card studies (Stange et al., 2016; Stange et al., 2016; Stange et al., 2020), and suggests that despite their objective equivalence, near-miss outcomes are experienced differently than regular loss outcomes.

Finally, we continuously recorded participants' pupil size during the experiment to examine pupillometry as an additional correlate of physiological arousal during scratch card gambling. Both pupil dilation and skin conductance reflect the activity of the sympathetic nervous system (Andreassi, 2000), and existing research has shown that pupil size correlates with skin conductance before the presentation of emotional face stimuli (Wang et al., 2018), and when viewing emotionally arousing pictures (Bradley et al., 2008). Furthermore, pupil size has been shown to increase during reward anticipation (Schneider et al., 2018), prompting us to employ this measure to gain a more comprehensive understanding of participants' physiological arousal during scratch card gambling. However, we did not observe converging patterns of results between skin conductance and pupil size, or any effects of symbol position, outcome, or

symbol type on pupil size. This may be in part due to the small number of participants with fully usable data after taking into account data quality, procedural, and technical recording issues with the eye tracking data (after listwise exclusions for outliers, $N = 26$ for the average pupil size analyses and $N = 21$ for the maximum pupil size analyses). Future research should prioritize larger samples of participants when examining complementary psychophysiological correlates during realistic gambling scenarios to better understand the impact of various game features on these variables.

Additionally, although all symbols were printed in the same colours, symbol contrast and illumination may have differed between symbol types (e.g., depending on the characters used in the symbol). Furthermore, as shown in Figure 9, the overall contrast and illumination of a given symbol may depend on how much of the opaque layer was scratched off – that is if a participant scratched off enough of the symbol to identify its value, but left some of the opaque layer intact, that same symbol may have different contrast and total illumination values for another participant who scratched off the opaque layer in its entirety.

Limitations

The present experiment contains a number of limitations. First, the video recordings of participants' scratch card game play were marked by hand for key events. While we were able to utilize the onset of the audio waveform associated with the tone that signaled to participants that they could begin scratching a particular symbol, the frame in which this tone was initiated was selected by hand. Additionally, the point at which each participant finished scratching each symbol was identified by eye, resulting in an approximate identification of the end of each scratching epoch. Since the point at which each participant finished scratching each symbol was identified via the eye tracking video recording, there were a number of participants who did not

have key events visible within the eye tracking video frame to ensure marker placement. These participants were excluded from SCR analyses (which also relied on the end point markers of the scratching epoch) and eye tracking analyses, resulting in a smaller sample of participants to analyze, and ultimately limited our ability to detect effects.

As with nearly all gambling experiments, participants in the present study were not gambling with their own money, and therefore did not risk a personal investment for the opportunity to gamble on the scratch cards that they played in the experiment. However, to increase the ecological validity of the task, we did utilize realistic scratch card games with real scratch off coatings, and offered real monetary prizes to participants to increase the overall verisimilitude of the scratch card task. Despite these additional aspects to increase engagement in the task, the scratch card gambling in the current study does not carry the same inherent risk properties as real-world scratch card gambling. This may have dampened participants' physiological responses to the experienced scratch card outcomes, as well as their subjective urge ratings to the different outcome types. However, the present results may represent an *underestimate* of the true magnitude of near-miss effects in scratch cards in which participants are risking their own money to gamble, and vying for prizes that are many orders of magnitude larger than the prizes available in the current experiment.

A final limitation concerns our attempt to constrain participants' scratch epoch lengths during each symbol reveal. We had decided to present participants with a tone to ensure that each individual symbol was completed separately. We devised this procedure to ensure that each individual symbol could be labelled for analysis, and to ensure that each participant had scratching epochs that were the same length. However, nearly all participants finished scratching well before the end of the 15-second epoch, resulting in each 15-second epoch that contained the

symbol reveal also including a few extra seconds following the symbol reveal in which SCRs could be acquired, plus extra waiting time. It is possible that separating each symbol in this way led to the inclusion of both anticipatory *and* evaluative aspects of each symbol reveal (as discussed above). This technique also introduced an unnatural “break” between symbols during scratch card play, which may have impacted participants’ responses to the scratch card symbols or outcomes. Future research may address these limitations by utilizing computer-presented scratch card games, potentially with scratch off animations that are of an identical length, which would allow for controlled timing without relying on an external auditory cue for participants. However, such presentations may limit the sense of agency created when engaging with realistic scratch off coatings, and reduce ecological validity.

Chapter 4: Exploring Scratch Card Purchasing Behaviour

4.1 Experiment 3⁷

Although we have shown increases in arousal, frustration, negative affect, and subjective urge following scratch card near-misses, it remains unknown whether or not experiencing these outcomes would actually prolong gambling behaviour, as in slot machines (Côté et al., 2003; Kassinove & Schare, 2001). In this study our two overarching goals were to: (1) replicate our previous finding that near-miss outcomes trigger increases in the urge to gamble (Stange, Grau, et al., 2017; Stange et al., 2020; Experiment 2 of the current thesis), and (2) assess whether near-misses and their associated heightened urge would prompt participants to actually purchase more scratch cards.

We had participants play two custom-made scratch cards with three games per card. On the first card (Card 1), all participants experienced a loss, a small win and another loss. On the second card (Card 2), one group of participants experienced three consecutive losing games, while the other group experienced two losses, followed by a near-miss. Participants were asked to give ratings of their urge to gamble after each outcome. Following game play, participants were given an opportunity to use their winnings (from card 1) to purchase additional cards.

We predicted that participants would experience increases in the urge to gamble following both winning and near-miss outcomes (a replication of our previous findings). We also predicted that participants who experienced a near-miss outcome would be more likely than participants who experienced only losses to use their winnings to purchase additional cards. Finally, we predicted that this purchasing behaviour would be attributable to increases in the

⁷ A version of this Experiment is published in *Journal of Gambling Studies* (Stange, Graydon, & Dixon, 2017)

urge to continue gambling following the near-miss outcome, as compared to regular losing outcomes.

4.1.1 Method

Participants

Participants gave informed written consent before the study began, and all procedures were approved by the University of Waterloo's Office of Research Ethics. Sixty-five undergraduate students were recruited from the University of Waterloo's Research Experience Group in exchange for course credit. All participants were pre-screened to ensure that they were at least 18 years of age (the legal age to purchase scratch cards in Ontario), had experience playing scratch cards, and were not currently in or seeking treatment for problem gambling. The average age of the participants was 19.97 years ($SD = 1.57$), and the sample was predominantly female (51 females, 14 males). One participant was excluded from all analyses due to a procedural error, and six were excluded due to incomplete data (see "Analytical Strategy" section).

Instruments and Materials

Problem Gambling Severity Index. The Problem Gambling Severity Index (PGSI) is a subscale of the Canadian Problem Gambling Index (CPGI), a well-validated screen for gambling problems and overall problem gambling severity in the general population (Ferris and Wynne 2001). This measure was used to characterize our sample; no specific hypotheses concerning problem gambling status were made.

Gambling Related Cognitions Scale. The Gambling Related Cognitions Scale (GRCS; Raylu & Oei 2004) was administered for purposes peripheral to this study and will not be discussed further.

Measure of Gambling Urge. To assess participants' urge to gamble, we used the following item: "How would you rate your desire to gamble on a scale from 0 (no desire to gamble) to 100 (overwhelming desire to gamble)?" (Young et al., 2008). Participants responded by moving a cursor along a linear sliding scale (ranging from 0 to 100) to the location that best reflected their urge to gamble.

Scratch Cards. The custom-made scratch cards were modeled after Cash for Life, a scratch card game available in Ontario. In Cash for Life, the gambler is presented with game-play boxes containing symbols denoting various monetary amounts. To win a prize, a gambler must uncover three matching symbols within one game. The gambler then wins the amount specified by the symbol (i.e., three matching \$5.00 symbols would mean a win of \$5.00). Our game utilized a similar game structure and design in that three matching symbols were needed to win a prize. The cards in this study (described in detail below) were similar in design to those used in previously published studies (Figure 14; see also Stange et al., 2016; Stange, Grau, et al., 2017).



Figure 14. “Cash for a Month” scratch card. The custom-made scratch cards employed in Experiment 3 were designed to mimic a popular scratch card available in Ontario. This card contains two losses (games 1 and 2) and a near-miss for the top prize (game 3).

Procedure

Participants were brought into the laboratory, where they signed an informed consent letter. Participants then completed the PGSI (Ferris & Wynne, 2001) and demographic items on a laptop computer. Following this, participants were told that the game they would be playing was called “Cash for a Month”, and that it was similar to existing scratch card games available at Ontario retailers. Using an enlarged example of one of the cards, the experimenter showed participants that each scratch card contained three games, and within each game, there were six symbols (Figure 14). The experimenter explained that the goal of the scratch card game was to find three matching symbols within any one of the games on the card; if participants found three matching symbols, they won the corresponding prize. Participants were instructed to uncover the symbols one game at a time, and to scratch each game from left to right, and top to bottom.

Participants were told to rate their desire to continue gambling after each game (three ratings per card) using a tablet computer that was provided (Lenovo Ideatab, model A1000). The experimenter also explained that to win the top prize of “Cash for a Month” (corresponding to \$25.00 a week for 4 weeks, \$100.00 total) they would need to uncover three “MONTH” symbols within one game (analogous to the “LIFE” symbol in Cash for Life). Participants were also told that they would pick a scratch card to play from a tray of approximately 100 scratch cards, and that one of the cards in the tray was the top prize winning card. They were reminded that the odds of winning were approximately 1 in 100 and then told that the top prize had been won in past studies. Importantly, participants were told that the first two cards that they would be playing were free, but that if they won anything on those two cards, they would be able to use their winnings to purchase additional cards later on in the study. Participants were asked if they had any questions about the game structure or rules before continuing.

The experimenter then had the participant choose the scratch cards that they would play during the experiment. Participants chose their cards from a display case similar to those found in Ontario lottery retailers and identical to what has been used in previous studies (Stange et al., 2016; Stange, Grau, et al., 2017). The scratch cards were arranged in two trays to facilitate our between-subjects manipulation. In the first tray of cards, all cards contained games with a loss, a small win of \$5.00, and another loss. The single top prize card was also included in this tray. The card that participants chose from the second tray determined the condition to which the participant was randomly assigned (half loss cards and half near-miss cards). Participants in the loss group chose a card in which all three games were regular losses. Those in the near-miss group chose a card that contained a loss, a second loss, and then a near-miss (two of the three symbols needed to win the jackpot prize). After choosing their cards, the experimenter placed the

scratch card in a secure scratching platform (see Stange, Grau, et al., 2017 for a more detailed description). Participants played the three games on that card, filled out their urge ratings following each game, and repeated this process for their second card.

Once they had completed scratching both cards, the experimenter gave the participant their winnings (\$5.00) and told them they could purchase additional scratch cards to play if they wished. The experimenter explained that each card cost \$2.00, and would be chosen from another display case, but the overall odds of winning the top prize remained unchanged. If participants chose to play another card, the experimenter kept \$2.00 of the participant's overall winnings (leaving the participant with \$3.00), and let the participant choose another card. Participants then completed the scratch card games and corresponding urge ratings in a similar manner as the first two cards. Any additional cards that participants purchased contained only regular losses comprised of symbol arrangements that participants had not encountered on previous cards. Participants who played a third card were given the option to purchase a fourth card (a cost of \$2.00, leaving the participant with \$1.00). In sum, if participants chose to not purchase, they left with \$5.00, purchasing one additional card meant an overall gain of \$3.00, and purchasing two cards left the participant with \$1.00. No participants in the current sample won the top prize of "Cash for a Month".

Following the entire game-play portion of the study, participants completed the GRCS. After completing the survey, participants were given their winnings, a feedback letter, and responsible gambling resources.

4.1.2. Results

Sample Characteristics

Problem Gambling Severity Index. Scores on the PGSI indicated that 35 participants were non-problem gamblers (score of 0), 27 were low-risk (score of 1–4), 1 was moderate risk (score of 5–7), and 1 participant was a problem gambler (score above 8; Currie et al., 2013).

PGSI status was not analyzed further, primarily since no specific predictions were made about the influence of problem gambling status on our dependent variables, but also because of low numbers of problematic gamblers.

Purchasing Behaviour

Considering all participants, only 31.3% ($n = 20$) of the total sample of participants ($N = 64$) elected to purchase at least one additional scratch card with their winnings. In the loss condition, 25.8% ($n = 8$) of participants purchased at least one additional card. In the near-miss condition, 36.4% ($n = 12$) of participants purchased at least one additional card. A Chi-square test of independence revealed that these frequencies were not significantly different, $X^2(1, N = 64) = .829, p = .362$.

Urge to Continue Gambling

Analytical Strategy. Of the 65 participants recruited, 6 participants were excluded from any data analyses involving urge to continue gambling ratings due to incomplete or missing urge evaluations. Mean ratings of urge to continue gambling were calculated following each outcome, and compared across groups (loss vs. near-miss). Given the nature of the design (card 1 contained a loss, a small win, and a loss; card 2 contained two losses with the third game dependent on condition), we analyzed the cards separately. For each card we conducted a mixed analysis of variance (ANOVA) with game as the repeated factor, and group as the between-

subjects factor. In the case of tests where sphericity assumptions were violated, corrected degrees and freedom and F values are reported. Post-hoc comparisons were conducted using t -tests, and were evaluated at α/m (Bonferroni correction) to control for familywise error rate.

Card 1. For card 1 (loss, small win, loss), this analysis indicated a significant main effect of game, $F(2, 112) = 35.00, p < .001, \eta_p^2 = .385$. Collapsing across group, post hoc analyses (evaluated at $\alpha/2 = .025$) indicated that the win triggered higher urge ratings than either the loss preceding it $t(57) = 7.65, p < .001$, or following it, $t(57) = 6.65, p < .001$. Importantly, the main effect of group (loss, near-miss) was not significant, $F(1, 56) = .001, p = .974$. Therefore, there were no pre-existing differences in urge to continue gambling between the groups. The mean urge ratings for card 1 are shown in Figure 15a.

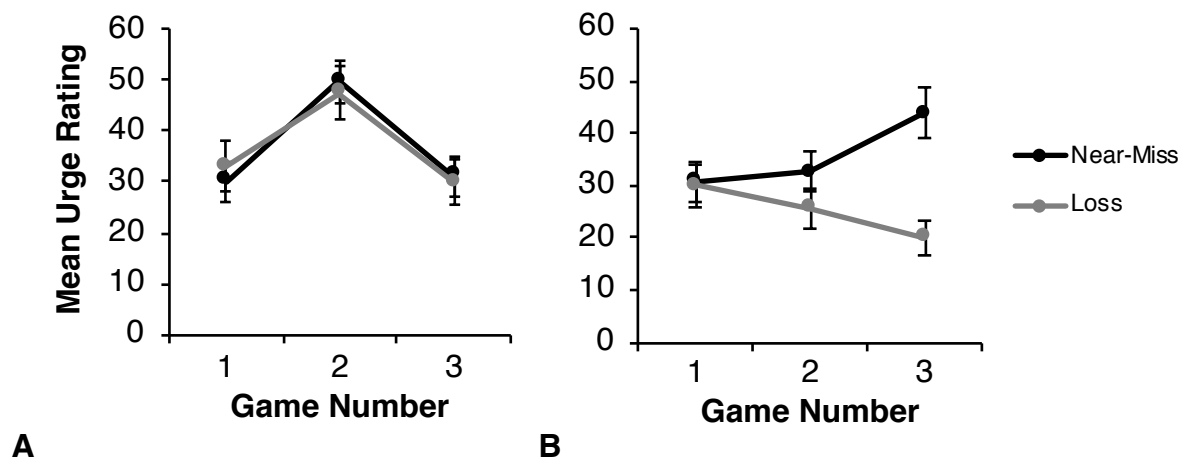


Figure 15. a) Card 1 urge ratings. Mean urge to continue gambling ratings for participants in the loss and near-miss conditions. Outcome 1 and 3 were losses, outcome 2 was a small win of \$5.00. b) Card 2 urge ratings. Mean urge to continue gambling ratings for participants in the loss and near-miss conditions. Outcome 1 and 2 were losses, outcome 3 was a loss for those in the loss condition, but a near-miss for the top prize (Cash for a Month) for those in the near-miss condition. Error bars are $\pm 1 SEM$.

Card 2. For card 2, there was no main effect of game number, $F(1.78, 99.85) = 1.04, p = .35, \eta_p^2 = .018$. There was a main effect of group, $F(1, 56) = 4.07, p = .049, \eta_p^2 = .068$. The interpretation of these main effects were qualified by a significant interaction between game

number and group, $F(1.78, 99.85) = 18.96, p < .001, \eta_p^2 = .253$. This interaction is depicted Figure 15b. Post hoc t -tests (evaluated at $\alpha/3 = .017$) indicated there were no significant differences between the groups for the first loss, $t(56) = .15, p = .88$, or the second loss, $t(56) = 1.26, p = .21$ but urge ratings at game 3 were significantly higher for those exposed to the near-miss than those exposed to the loss, $t(56) = 4.04, p < .001$.

Relationship Between Urge and Purchase Status

To assess whether different scratch card outcomes in the very last game on card 2 (loss or near-miss) fostered differences in post-game urge and subsequent scratch card purchasing behaviour, we conducted point-biserial correlations separately for each group (loss, near-miss), correlating post-outcome urge with purchasing behaviour (non-purchasers coded as 0, purchasers as 1). For the near-miss group, urge ratings immediately following the near-miss were significantly positively correlated with purchasing status, $r_{pb} = .49, n = 29, p = .007$. For the loss group, however, urge ratings following the loss showed no relationship with purchasing status, $r_{pb} = -.018, n = 29, p = .926$. Using Fisher's r -to- z transformations, these correlations were significantly different from each other, $Z = 1.99, p = .046$.

As a supplementary means of assessing whether the near-miss-induced elevations in urge actually triggered purchasing behaviour, we compared the urge levels of purchasers to non-purchasers. We reasoned that if near-misses triggered increases in urge for at least some participants, that those participants should be the ones who would be most likely to purchase additional cards. If so, then purchasers should show higher urge levels than non-purchasers. A between-subjects ANOVA, with group and purchase status as the between-subjects variables indicated a significant interaction between group and purchase status, $F(1, 54) = 4.90, p = .031, \eta_p^2 = .083$. Follow-up t -tests (evaluated at $\alpha/2 = .025$) indicated that there were no significant

differences in urge between participants who did and did not purchase additional cards in the loss group, $t(27) = .09, p = .926$. However, for participants in the near-miss condition, purchasers showed significantly higher urge ratings than those who did not purchase additional cards, $t(27) = 2.92, p = .007$. Table 3 displays the means and standard deviations of urge to continue gambling ratings for participants in each condition.

Table 3. Urge to continue gambling ratings by condition.

Purchase Status	Loss Condition	Near-Miss Condition
Non-Purchasers	20.18 (20.41)	34.74 (25.15)
Purchasers	19.43 (9.64)	61.00 (17.94)*

Note. * = statistically significant differences between purchase status at $p < .01$

4.1.3 Discussion

We ran an experiment to determine whether near-misses would trigger increases in gambling urge, and whether this increased desire to continue gambling would translate into participants using their winnings to purchase additional scratch cards. Near-misses dramatically increased the urge to gamble – a finding that replicates our previous study (Stange et al., 2016). Figure 15a shows that the random assignment of participants into the two groups was effective; there were no differences between the urge ratings of the groups prior to the key manipulation (the introduction of the near-miss for one of the groups). Figure 15b shows that the groups continued to show similar urge trajectories for the two losses on card 2. The groups only diverged following the third game when the key manipulation was delivered (a near-miss for half of the participants, and another loss for the other half of the participants). Those who experienced a loss in their third game showed a decline in their urge to gamble, whereas those who experienced a near-miss showed a clear spike in gambling urge. In sum, the finding that scratch card near-misses trigger increases in the urge to gamble is a robust one that replicates

across studies using different procedures (e.g., the within-subjects design in Stange et al., 2016, and the between-subjects design employed in the present study).

In this and previous studies we provide converging evidence for this chain of events in scratch card gambling. Near-miss outcomes in scratch cards are associated with increased physiological and subjective arousal, and heightened subjective negative emotion and frustration (Stange et al., 2016; Stange, Grau, et al., 2017). Yet, regardless of their objective monetary status, near-misses have distinct motivational consequences for the gambler. In the current study they served to increase the urge to gamble compared to those who were exposed to a standard losing outcome.

Our second prediction was that the spikes in urge caused by the near-miss would trigger the purchase of additional scratch cards. Within the group exposed to the near-miss, those who purchased more cards appeared to be those who experienced this spike in urge. The purchasers showed far higher urge ratings following the near-miss than the non-purchasers. Furthermore, there was a positive point-biserial correlation between participants' ratings of their urge to gamble following near-misses and their purchasing behaviour. This lends support to the idea that near-misses trigger increases in the urge to gamble, which can in turn prompt some individuals to buy more cards.

An unexpected finding concerned those in the loss group. Despite three successive losses in card 2, eight participants still purchased at least one more card. In the loss group, urge to gamble was significantly lower than in the near-miss group, and (unlike in the near-miss group) there were no differences in the urge ratings between purchasers and non-purchasers. Additionally, urge ratings following losses were uncorrelated with purchasing behaviour. Thus, despite not showing an increase in urge to continue gambling, a small subset of people in the loss

group still chose to purchase additional cards. This puzzling finding hints at the importance of considering other individual differences among gamblers and how these may relate to purchasing behaviours. Some candidate variables that may be informative include impulsivity (MacLaren et al., 2012) and the closely related concept of delay discounting (Callan et al., 2011; Dixon et al., 2003) in which deficits are strongly related to gambling behaviour. Research examining differences in delay discounting have shown that participants who chose to purchase scratch cards from an experimenter in an unrelated experimental context discounted delayed rewards at a steeper rate than those who did not purchase scratch cards (Callan et al., 2011). The inability of some individuals to delay larger, later rewards and instead engage in less-rewarding behaviour in the short term may explain some differences in purchasing behaviour within the current study. For example, individual differences in delay discounting could potentially account for why some participants with low urges to gamble nonetheless purchased an extra card (i.e., the purchasers in the loss group), and might also explain why some participants with high urge to gamble following a near-miss might have been able to refrain from making a purchase (they may have been able to discount the slim possibility of earning money immediately, for the surety of having an extra \$5.00 to spend that evening).

4.2 Experiment 4⁸

In Experiment 3, although participants rated the near-miss outcome as more urge inducing than the regular loss, there was no significant difference between the conditions in terms of rates of purchasing an additional card. However, a significant correlation between urge to continue gambling at the final outcome and the decision to purchase an additional card was found, but only for participants in the near-miss condition; no such relation was present in the

⁸ A version of this Experiment is published in *Journal of Gambling Studies* (Stange & Dixon, 2020).

loss condition. These results suggest that the urge to continue gambling induced by near-miss outcomes is associated with an individual's decision to purchase additional scratch cards (Stange, Graydon, et al., 2017).

In Experiment 3, some participants elected to purchase another card in the absence of an increase in the urge to gamble (i.e., in the loss condition; Stange, Graydon, et al., 2017). This could have been due to the relatively low cost of purchasing the additional card (only \$2.00) after having won \$5.00 overall in the experiment. That is, if a participant decided to purchase an additional card, they were only risking 40% of their total winnings for another chance at the top prize. Due to the low-stakes nature of this gamble, it is possible that a number of participants who purchased an additional card were doing so not because they felt particularly motivated *per se* (i.e., due to an increase in urge), but rather they purchased on a whim due to the low cost involved in this decision. In this study, urge ratings for purchasers in the loss condition were lower than urge ratings for purchasers in the near-miss condition, but there were only nominally more purchasers in the near-miss condition than in the loss condition (Stange, Graydon, et al., 2017). Further, as previously discussed, a significant positive correlation between urge at the final outcome and purchase status was found *only* in the near-miss condition, suggesting that the decision to purchase an additional card is related to experienced urge following near-miss outcomes, but not losses. It is possible that making the decision to purchase an additional card riskier may reduce the number of participants who purchase in the absence of any increase in the urge to gamble. Additionally, having to risk all of one's winnings in order to purchase another card is a common scenario in scratch card gambling. In most games the most likely "winning" prize is not in fact a true win, but what gamblers refer to as a *push* – a gain equivalent to a

gamblers' original wager, and equivalent to the price of another card.⁹ Here we sought to create a more ecologically valid test of participants' gambling behaviour following pushes, and subsequent regular losses and near-misses.

Although near-miss outcomes do reliably lead to increases in the urge to continue gambling (Stange, Grau, et al., 2017; Stange, Graydon, et al., 2017), the previously reviewed evidence suggests that the decision to purchase additional scratch cards is not entirely based on this subjective motivational state. We propose that this decision may reflect an interaction between momentary, state-level motivational processes and more stable, individual trait-level factors. A potential candidate for the latter is the illusion of control, a common gambling-related cognition (Langer, 1975). As a construct, the illusion of control suggests a sense of agency over events that in actuality cannot be controlled, in the form of an inflated sense of personal skill (Langer, 1975; Raylu & Oei, 2004). In games of pure chance (e.g., scratch cards), each outcome is independent from the next. While near-miss outcomes are objectively losing outcomes, gamblers who endorse the illusion of control may see a near-miss as a signal of increasing skill (Sescousse et al., 2016) and believe that the *true* win may soon follow, should they continue to gamble (Reid, 1986). Studies examining slot machine gambling have found that the desire to continue gambling following a near-miss is correlated with illusion of control scores (Billieux et al., 2012), although the illusion of control was not found to be a significant predictor of the desire to gamble after near-miss outcomes when included in a model with pleasure experienced after wins, social desirability bias, and endorsement of predictive and interpretive control over outcomes (all found to be significant predictors; Billieux et al., 2012). In another study

⁹ A sampling of Ontario Lottery and Gaming Corporation scratch cards at the time of writing confirms this, with prizes equivalent to the value of the card (e.g., a push) the most common prize in a sample card from each of the card price categories: \$1 (OLG, 2019c), \$3 (OLG, 2019d), \$4 (OLG, 2019e), \$5 (OLG, 2019f), and \$20 (OLG, 2019g).

examining erroneous cognitions and stop-button use in slot machine gambling, endorsement of skill-related cognitions regarding near-miss outcomes (e.g., “near-misses reflect my skill at this slots game and indicate that I was close to winning” and “near-misses indicate that a win is imminent”) were related to illusion of control scores (Dixon et al., 2018). These results suggest that endorsement of the illusion of control may play a role in the motivational impact of near-miss outcomes and, by extension, the subsequent decision to purchase additional scratch cards following them.

The current study had two central aims. The first was to investigate the influence of bet size and the endorsement of the illusion of control on the decision to purchase additional scratch cards, following both losing and near-miss outcomes. We predicted that a riskier gamble (a larger bet size involving 100% of the participants’ prior winnings) would lead to fewer participants purchasing in the absence of any sizable increase in urge (e.g., in the loss condition). Additionally, by potentially eliminating participants who make low-cost purchases on a whim (as in Experiment 3), we sought to show that more participants in the (urge inducing) near-miss condition would purchase than participants in the loss condition. In terms of the illusion of control, we predicted that participants who purchase an additional scratch card following a near-miss outcome would score higher in endorsement of this erroneous cognition than participants who do not purchase an additional card following the near-miss. Finally, we predicted that the pattern of urge responses across the scratch card outcomes would replicate past findings, such that wins will be rated as significantly more urge inducing than regular losses, and that participants would report significantly more urge following the near-miss outcome than a regular losing outcome in the equivalent position (Stange, Grau, et al., 2017; Stange, Graydon, et al.,

2017). We also predicted that previously observed associations between urge following the near-miss outcome and participants' decision to purchase would be replicated.

The second aim of the current study was a more pragmatic one. As this study incorporates a replication attempt of results obtained with a relatively small sample size, we thought it imperative to replicate these findings with a larger sample. This, coupled with the inclusion of an original hypothesis to extend these findings, prompted us to pre-register our sample size, hypotheses, and data analysis plan in advance of data collection (registered on the Open Science Framework: <https://osf.io/cbxrm>). Although such practices are not currently universal in peer-reviewed addiction journals (Gorman, 2019), pre-registered replications are extremely important given ongoing issues of reproducibility within psychological research (Open Science Collaboration, 2015), and we believe are of utmost significance for investigations of addictive behaviours that have potential ramifications for clinical practice and potential policy changes.

4.2.1 Method

Participants

A sample of 138 undergraduate participants was recruited from the University of Waterloo Research Experience Group. All participants were pre-screened to ensure that they were 18 years of age or older (the legal age to purchase scratch cards in Ontario), had experience with scratch card games, and were not in or had previously received treatment for problem gambling. One participant was excluded from all analyses due to a procedural error.

Materials

Canadian Problem Gambling Index and Problem Gambling Severity Index. The Canadian Problem Gambling Index (CPGI) is a well-validated measure for assessing the

frequency of specific gambling behaviors and gambling-related harm in the general population (Ferris & Wynne, 2001). The CPGI contains the 9-item Problem Gambling Severity Index (PGSI), which screens for gambling harm and results in a numerical score ranging from 0 to 27 (the sum of all items). Participants respond to each item by stating how frequently the behaviour in question had applied to them over the last 12 months, with response options ranging from never (scored as 0), sometimes (1), most of the time (2), or almost always (3). Based on established criteria (Currie et al., 2013), PGSI scores can be used to categorize participants as non-problem (scores of 0), low-risk (scores of 1-4), moderate risk (scores of 5-7), or problem gamblers (scores of 8 or above). The CPGI and PGSI were administered to characterize our sample and were not analyzed further (the distribution of PGSI scores can be found in Table 4).

Gambling Related Cognitions Scale. The Illusion of Control subscale of the Gambling Related Cognitions Scale (GRCS; Raylu & Oei 2004) was administered to participants before the testing session in a survey of measures administered to the entire participant pool. This subscale consists of four items, each scored on a 7-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (7).

Scratch Cards. The scratch card games that participants experienced during the experiment were the same as those utilized in Experiment 3 (“Cash for a Month”; see Section 4.1.1).

Measure of Gambling Urge. We utilized the same measure of gambling urge as in Experiment 3 (see Section 4.1.1), with the exception of presenting these items on a different model of tablet computer (Lenovo TB-X103F).

Design

The present study utilized a between-subjects design, such that participants were randomly assigned to experience either a regular loss (made up of no matching symbols within the game square) or a near-miss (consisting of 4 non-matching symbols and two top prize symbols within the game square) for their final outcome. All participants experienced a regular loss, a small win of \$5.00, and another regular loss on their first card. On the second card, all participants experienced two regular losses before the between-subjects manipulated outcome in the final position.

Participants were randomly assigned to a condition based on the scratch cards that they chose. Scratch cards were housed in a display case that contained two removable trays which each held 48 scratch cards (a total of 96 scratch cards per display case). The first tray contained scratch cards with the following outcomes: a regular loss, a small win of \$5.00, and another loss. The second tray contained a mixture of cards that contained either three regular losses or two regular losses and a near-miss. All participants chose a scratch card from both trays in the display case, ensuring both equal remuneration across participants and random assignment to condition.

After completing the first two scratch cards, participants were given the choice to purchase another card for \$5.00. If participants decided to purchase, they chose an additional card from a second display case that contained two losses and a win of \$5.00 (equating remuneration among participants). In both display cases, one top prize card was included within the array of cards.

Procedure

Participants entered the lab room and were provided with an information letter outlining the details of the study. If participants chose to participate, they provided written consent. Upon informed consent, participants completed the CPGI using a laptop computer (Lenovo ThinkPad model 4446-25U). Participants were then given instructions for the scratch card games.

Participants were told that they would be starting with two scratch cards, that these first two cards would be free, and that they could potentially purchase another card at a later point in time, but that this would be explained later on in the study. The researcher introduced the game of Cash for a Month and showed the participant an example scratch card. Participants were told that to win on the scratch card game, they had to match three symbols within a given game square. The researcher explained that in order to win the top prize of Cash for a Month, corresponding to \$25.00 a week for 4 weeks or \$100.00 cash, participants needed to uncover three matching “MONTH” symbols within one game matrix, which would denote a top prize win. Participants were told that their odds of winning the top prize of the game were approximately 1 in 100. The researcher then informed participants that after each scratch card game, they would give a rating of their current desire to gamble on a scale from 0 to 100. The participant was shown an example of the desire to gamble item and the sliding scale used to indicate a response. The researcher instructed the participant to slide the indicator to the position on the scale that accurately reflected their current desire to gamble.

Participants selected their cards from the display case of scratch cards. The researcher removed the two trays of scratch cards from the display case and instructed the participant to choose one card from each tray. Once participants had chosen their scratch cards, the researcher directed them to a desk where they would scratch the cards.

The researcher inserted the first scratch card into a platform in front of the participant to ensure a consistent scratching experience between participants (see Stange et al., 2016). Participants were given a plastic scratching device to uncover the symbols. When participants had completed their first two scratch cards, the experimenter gathered the participant's winnings (\$5.00), placing a \$5.00 bill on the display case. The researcher explained to the participant that since they had won \$5.00 on their first card, that they could now purchase another card if they wanted. The researcher explained that they would be choosing a scratch card from a second display case of cards, but that their odds of winning the top prize of the game were the same, approximately 1 in 100. The researcher then asked the participant if they wanted to purchase another card.

If participants chose to purchase another card, the researcher took back the participants' winnings (\$5.00), and instructed the participant to choose one scratch card from any location in the second display case. When the participant selected a card, the experimenter again placed the card in the secure scratching platform and reminded the participant to fill out the desire to gamble items for each outcome on the tablet computer as they had for the first two scratch cards. After completing the third scratch card (if they elected to purchase) or after declining to purchase another card, participants were remunerated with the winnings from their scratch cards (\$5.00 for purchasers and non-purchasers) and given a feedback letter outlining the details of the experiment as well as lottery-specific responsible gambling resources.

4.2.2. Results

Sample Characteristics

Age, gender, self-reported frequency of scratch card gambling, and PGSI scores are listed in Table 4. Participants' scores on the PGSI were calculated according to established cut-off criteria (Currie et al., 2013).

Table 4. Experiment 4 participant characteristics.

Measure	Value
Age, mean (<i>SD</i>)	20.48 (1.95)
Gender, <i>n</i> (%)	
Female	108 (78.8)
Male	28 (20.4)
Gender queer/gender non-conforming	1 (0.7)
Frequency of Scratch Card Gambling, <i>n</i> (%)	
1 – 5 times	114 (83.2)
6 – 10 times	18 (13.1)
11 – 15 times	3 (2.2)
16 – 23 times	1 (0.7)
24 or more times	1 (0.7)
Problem Gambling Severity Index, <i>n</i> (%)	
Non-problem gambling	86 (63.2)
Low-risk gambling	47 (34.6)
Moderate-risk gambling	2 (1.5)
Problem gambling	1 (0.7)

Note. One participant did not submit data for the Problem Gambling Severity Index due to a technical error (and therefore counts for this measure will add to $N = 136$). Frequency of scratch card gambling categories represent participants' self-reported gambling over the last 12 months. *SD* = standard deviation.

Purchasing Behaviour

Of the entire sample ($N = 137$), only 18% of participants chose to purchase an additional scratch card with their winnings ($n = 25$). In the loss condition ($n = 68$), 21% ($n = 14$) of participants purchased an additional card, and in the near-miss condition ($n = 69$), 16% ($n = 11$)

of participants decided to purchase. A chi-square test of independence revealed that these frequencies were not significantly different from each other, $\chi^2(1) = 0.50, p = .481$. Based on our pre-registered hypotheses and data analysis plan, we also examined relations between participants' endorsement of the illusion of control and their decision to purchase another card. This point biserial correlation was not significant, $r(80) = .088, p = .435$, indicating that there was no association between participants' illusion of control scores and their purchasing behaviour. In line with this result, a factorial ANOVA examining illusion of control scores with condition and purchase status as between-subjects factors revealed no significant effects (all p 's $> .1$).

Urge to Continue Gambling

Analytical Strategy. Recall that all participants received an identical sequence of outcomes on card 1 (loss, win of \$5.00, loss) but a different sequence of outcomes on card 2 (either loss, loss, loss, or loss, loss, near-miss) with condition assignment based on the type of card 2 participants happened to choose. To examine participants' urges to continue gambling, average urge ratings for each outcome type were calculated for each condition (those who chose a loss card compared to a near-miss card for card 2). This resulted in six average urge ratings for each condition of our design. Three participants were removed from all urge analyses and three were removed from card 1 urge analyses for giving an incorrect number of ratings per card. Participants' urge ratings for card 1 and card 2 were compared separately. In the case of violations of sphericity assumptions, degrees of freedom and F values are reported with a Greenhouse–Geisser correction. Follow-up comparisons between outcomes were conducted using t -tests. Mean urge ratings for both conditions across both cards are depicted in Figure 16.

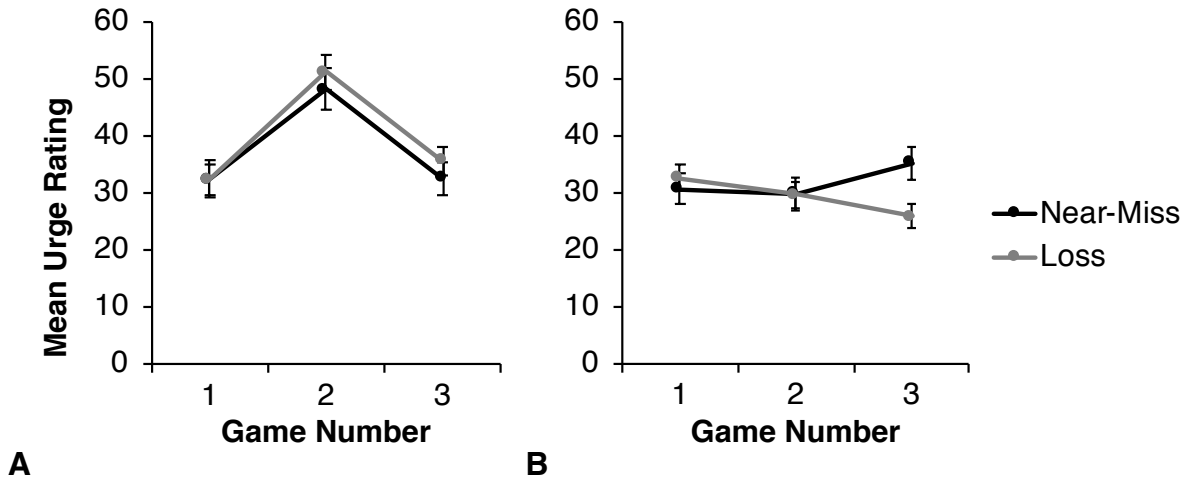


Figure 16. Urge to continue gambling ratings for loss and near-miss conditions for a) Card 1 and b) Card 2.

Card 1. The overall mixed factorial ANOVA for card 1 revealed a significant main effect of outcome, $F(2, 258) = 105.52, p < .001, \eta_p^2 = .45$, with no significant main effect of condition or outcome by condition interaction (both p 's $> .1$). Collapsing across condition, paired samples t -tests revealed significant differences between urge ratings for game 2 (the winning outcome, $M = 49.56, SD = 26.67$) and urge ratings for the losses both before ($M = 32.40, SD = 23.73; t[130] = 12.01, p < .001$) and after ($M = 34.05, SD = 21.75; t[130] = 12.42, p < .001$) this win. No significant differences in urge ratings for the two losses were observed, $t(130) = 1.34, p = .182$.

Card 2. The overall mixed factorial ANOVA for card 2 revealed no significant main effects of outcome or condition (both p 's $> .1$), but did reveal a significant outcome by condition interaction, $F(1.56, 205.42) = 11.36, p < .001, \eta_p^2 = .08$. To identify the source of the interaction, independent t -tests between the conditions were conducted at each outcome. These tests revealed no significant differences in urge between conditions at the first outcome, a loss for both conditions (loss condition: $M = 32.49, SD = 18.77$; near-miss condition: $M = 30.73, SD = 22.87$), $t(132) = 0.49, p = .627$, or at the second outcome, also a loss for both conditions (loss condition: $M = 29.61, SD = 18.71$; near-miss condition: $M = 29.84, SD = 22.89$), $t(132) = 0.06, p = .951$.

However, there was a significant difference between conditions at the third outcome (loss for the loss condition: $M = 25.81$, $SD = 17.68$; near-miss for the near-miss condition: $M = 35.19$, $SD = 24.27$), $t(132) = 2.56$, $p = .012$.

Association Between Urge and Purchase Status

As outlined in our pre-registered data analysis plan, we conducted a point-biserial correlation to examine the association between urge at the final outcome and purchase status in each of the conditions. In both the loss and near-miss conditions, urge at the final outcome was not associated with purchase status (all p 's $>.1$). An additional test of this association was conducted with a factorial ANOVA examining urge ratings at the final outcome with purchasing status and condition as the between-subjects factors, replicating an analysis in our previous investigation (Stange, Graydon, et al., 2017) and as outlined in our pre-registration. This analysis revealed a main effect of condition, $F(1, 30) = 6.10$, $p = .015$, $\eta_p^2 = .05$, and a marginal main effect of purchase status, $F(1, 30) = 3.68$, $p = .057$, $\eta_p^2 = .03$ (see Figure 17). However, we did not replicate the purchase status by condition interaction as reported in our previous investigation and as predicted in our pre-registered hypotheses (Stange, Graydon, et al., 2017).

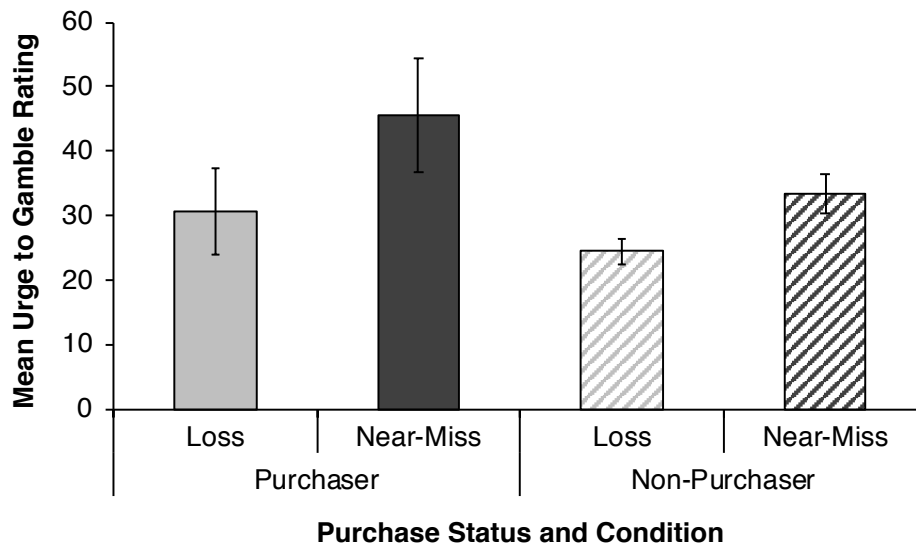


Figure 17. Urge to continue gambling ratings at the final outcome on card 2 by condition and purchase status.

Illusion of Control Scores and Purchasing Behaviour

To examine the influence of illusion of control scores on the decision to purchase additional cards, we conducted a *t*-test on illusion of control scores between purchasers and non-purchasers in the near-miss condition. This *t*-test did not reveal a significant difference between purchasers and non-purchasers in terms of illusion of control, $t(41) = 0.52, p = .604$. A second pre-registered analysis concerned increases in urge following near-miss outcomes relative to losing outcomes. Within the near-miss condition, we calculated a difference score to examine the change in urge to gamble from the second outcome on card 2 (a loss) to the third outcome on card 2 (the near-miss), and correlated this change in urge with illusion of control scores. This correlation was not significant ($p = .854$), indicating no significant association between the magnitude of urge increases following a near-miss relative to losses and endorsement of the illusion of control.

Exploratory Analyses

Purchasing Behaviour Across Bet Sizes. One goal of the current investigation was to examine the influence of an increased bet size on the decision to purchase additional scratch cards during our experimental paradigm. Given the close procedural similarity between this experiment and our previous investigation, we decided to compare rates of purchasing between the two experiments, the first utilizing a gamble of \$2.00 (40% of the participant's total winnings; Stange, Graydon, et al., 2017), and the current study utilizing a gamble of \$5.00 (100% of the participant's total winnings). To examine differences in overall levels of purchasing between the samples, a chi-square test of independence was conducted to compare the frequency of non-purchasers and purchasers in the previous study ($n = 44$ non-purchasers, $n = 20$ purchasers [30.3% of all participants]) to the current study ($n = 112$ non-purchasers $n = 25$ purchasers [18.24% of all participants]). This test revealed a significant difference between experiments, such that the percentages of those purchasing in the current investigation were significantly lower than in the previous study, $\chi^2(1) = 4.24, p = .039$.

4.2.3 Discussion

In an effort to further open science practices within the field of gambling studies, as well as to address issues of replicability in psychological research, we conducted a pre-registered experiment to investigate factors that may influence scratch card purchasing behaviour. In our pre-registration and experimental design, we included a built-in replication of previous findings concerning the influence of specific game outcomes on urge to continue gambling (Stange, Graydon, et al., 2017), as well as new hypotheses concerning the role of the illusion of control in the impact of near-miss outcomes on behaviour. The current study also utilized a far larger sample size than our previous investigation to ensure adequate power for replication, and this

sample size was included in our pre-registration. Although we did not find support for our hypotheses concerning the illusion of control, the results of the current study did replicate our previously reported pattern of urge ratings following specific scratch card outcomes (Stange, Grau, et al., 2017; Stange, Graydon, et al., 2017; Stange et al., 2020).

Further, support for nearly all of our pre-registered predictions concerning the role of illusion of control in purchasing decisions was not observed. As near-miss outcomes have been shown to invigorate motivated behaviour in gambling (Clark et al., 2009, 2013), and neural activity to near-miss outcomes has been associated with endorsement of erroneous gambling cognitions as a whole (Clark et al., 2009; Dymond et al., 2014), we believed that illusion of control may be involved in the processing of near-miss outcomes (e.g., Clark et al., 2009). If, when uncovering two top prize symbols, a participant sees these symbols as harbingers of a future win, they may be more likely to purchase additional scratch cards. However, we found no difference in illusion of control scores between purchasers and non-purchasers in the near-miss condition as predicted. There was also no association between illusion of control scores and change in urge from a regular loss to the near-miss outcome, a measure of the degree of reactivity created by near-miss outcomes. Therefore, the results of this study do not offer support for the hypothesis that erroneous cognitions related to the illusion of control play a role in scratch card purchasing behaviour, particularly after experiencing a near-miss. It is possible that other gambling related cognitions may interact with the motivational impact of near-miss outcomes to influence gambling decision making, and that including all subscales of the GRCS may have been more informative. Future research should investigate the role of other gambling cognitions in the influence and experience of scratch card near-miss outcomes, such as predictive control and interpretive bias (Billieux et al., 2012).

Although we predicted that more participants in the near-miss condition would purchase additional scratch cards, we observed roughly equal numbers of purchasers in each condition. We observed this despite increasing the cost to purchase an additional card, in an effort to capture purchasing behaviour directly related to changes in subjective experience due to specific outcomes presented in the scratch card games. In our previous study we observed that some participants decided to purchase an additional card despite not reporting an increase in urge; we suggested that this may have been due to some gamblers purchasing on a whim given the relatively low cost of the card that participants could purchase (only risking 40% of their winnings). By increasing the cost to purchase an additional card, we reduced the rates of purchasing overall, but counter to our expectation, this reduction was not specific to those with low urge in the final game of the loss condition. Roughly equal proportions of participants in each condition elected to purchase an additional scratch card, with some purchasing an additional card after experiencing relatively low levels of urge after encountering the loss in the third game of card 2.

When discussing the purchasing behaviour results, it is worth considering the structural aspects of the study that may have played a role. The current purchasing scenario differs substantially from our previous investigation. Here, participants had to risk all of their winnings – \$5.00 in total – to get another chance at the top prize. In our previous study, participants only had to risk \$2.00 of their \$5.00 in winnings (or 40%). In this lower-stakes scenario, one may expect a stronger association between urge at the final outcome and purchasing, as this purchase does not come at a very high cost and may be more strongly influenced by structural factors of the game, such as experiencing a near-miss. Indeed, in our previous investigation we did find a correlation between urge at the final outcome and purchase status, but only for the near-miss

condition. However, in the current study we did not find a correlation between urge at this final near-miss outcome and purchasing behaviour suggesting that within the higher-cost purchasing situation, urge at the final outcome was not sufficient to prompt gamblers to risk all of their winnings and purchase an additional card. This higher cost purchasing scenario leaves open the possibility that a greater amount of urge must be experienced in order for it to factor into purchasing decisions. Perhaps when costs are lower (e.g., participants are foregoing only 40% of their winnings), there is a tighter coupling between moment-to-moment increases in urge due to game features (e.g., a near-miss) and the decision to purchase. When costs increase, this relation disappears, as suggested by the decreased number of purchasers overall within the current study.

Therefore, although near-misses in scratch cards have been shown to reliably increase the urge to gamble, they are clearly not the defining factor when it comes to the decision to purchase additional scratch cards. What else might factor in to the decision to purchase? The current study suggests that bet size has some influence on this decision, as increasing the cost of another card did significantly reduce purchasing overall. However, there was still no difference in terms of the number of participants who decided to purchase within each outcome condition. While bet size seems to play some role in the decision to purchase, the influence of the effects of individual game outcomes over and above this factor do not seem as impactful, as evidenced by the lack of difference between the near-miss and loss conditions in terms of further scratch card purchasing.

Finally, when considering the results of the current experiment, it is interesting that self-reported increases in the urge to continue gambling following near-miss outcomes are not *more* closely related to the decision to purchase additional cards. In the current study, we did see a marginal effect of purchasing status on urge at the final game outcome, but we did not replicate our previous finding which showed that urge significantly correlated with the decision to

purchase after experiencing a near-miss in the final game, but not after experiencing a loss in the final game. Although we speculate that our inability to redemonstrate this relationship may be related to the increase in card cost in the current experiment, this finding also highlights the notion that if the decision to purchase is not entirely based on situational, outcome-level influences, perhaps there is an individual difference that makes some participants more likely to purchase additional cards *regardless* of their experiences during the game. That is, regardless of their responses to specific outcomes. The current results suggest that perhaps individuals who purchase additional cards are more reactive to scratch card outcomes in general (regardless of the outcome), as evidenced through the (marginal) main effect of purchase status on urge at the final outcome. Additionally, even though rates of purchasing decreased in the current investigation from our previous study, there were still participants who elected to purchase an additional card. Further research should attempt to determine what other situational factors or individual difference variables may be influential in these decision-making processes. To this end, in the next experiment we examined individual differences in probability discounting and delay discounting.

4.3 Experiment 5

It is possible that the increase in bet size in Experiment 4 may have prevented those who felt strong urge from purchasing these (more expensive) additional cards, thereby eliminating the association between urge and behavioural purchasing (Stange & Dixon, 2020). In Experiments 3 and 4, participants who experienced a near-miss card felt a greater urge to keep gambling than those who experienced a regular loss card, but in neither study did these urge differences translate into greater numbers of purchasers, resulting in statistically equivalent numbers of purchasers between the loss and near-miss groups. Therefore, current evidence suggests that urge

induced by a scratch card near-miss does not appear to influence the decision to continue gambling on scratch cards.

Given this apparent lack of effect of near-miss-related urge on purchasing behaviour, we turned our attention towards individual differences between gamblers that may help explain the decision to continue gambling. Delay discounting – the tendency to choose smaller, immediate rewards over larger, delayed rewards (Ainslie, 1975) – has been associated with gambling severity, such that individuals with gambling disorder tend to show steeper discounting of delayed rewards across various time delays relative to controls (Dixon et al., 2003). Furthermore, problem gambling severity has been shown to be a significant predictor of impulsivity measured via delay discounting procedures (Alessi & Petry, 2003), and a recent meta-analysis reported that gambling disorder was associated with a range of aspects of impulsivity, including discounting (Ioannidis et al., 2019). Overall, these results suggest impulsive choice among individuals experiencing addictive behaviours, including gambling (Petry, 2001).

Within an investigation of relative deprivation on gambling, Callan and colleagues (2011) tested the hypothesis that delay discounting was associated with objective gambling behaviour, utilizing scratch card purchases as their dependent variable. The authors measured each participants' area under the discounting curve (AUC), a measure of how individuals subjectively value delayed rewards, with lower AUC values indicating those who tended to discount delayed rewards in favour of immediate rewards (Myerson et al., 2001). Participants' AUC values were negatively correlated with scratch card purchasing, such that individuals who purchased scratch cards with their participation remuneration discounted delayed rewards to a greater extent than those who did not purchase. Further, AUC was the only significant predictor of scratch card gambling behaviour in a regression model also containing age and gender (Callan et al., 2011).

Although this finding provides evidence that individuals who purchase additional scratch cards in laboratory experiments may discount the value of delayed rewards, and choose to purchase another card immediately, participants in the study by Callan and colleagues (2011) were choosing to purchase scratch cards with their study remuneration, outside of any prior gambling experience. As such, this decision may be viewed as representing the *initiation* of gambling behaviour. While this is valuable to our overall understanding of the experience of scratch card gambling, it remains unknown if delay discounting is related to *continued* scratch card gambling behaviour in which participants are reinvesting scratch card winnings to buy additional cards. Given the importance of considering behavioural persistence (Graydon et al., 2018) in a comprehensive understanding of gambling behaviour, and the continuous nature of scratch card gambling (Griffiths, 1995) it is paramount to understand how purchasing decisions are made in the context of experienced scratch card games and outcomes.

A related construct is probability discounting, which assesses the degree to which individuals prefer probabilistic versus certain outcomes (Green & Myerson, 2004). When individuals choose a gamble for a larger prize over taking a certain, smaller prize, they are favouring a probabilistic choice. Probability discounting has been shown to be inversely related to gambling severity (Kyonka & Schutte, 2018), as individuals who place more value on probabilistic or risky outcomes (i.e., discount these probabilistic outcomes less) report more gambling harm than those who value certain outcomes. Given the probabilistic nature of gambling behaviour itself, individuals who choose to purchase an additional scratch card in laboratory gambling experiments may retain a greater subjective value for larger, uncertain gains (e.g., the potential for winning the top prize on the next card purchased), compared to those who opt for the smaller, certain gain (e.g., the already secured winnings).

The current study sought to replicate previous findings of increases in the urge to gamble following scratch card near-miss outcomes relative to regular loss outcomes, and attempt to reconcile mixed evidence surrounding the relation between urge following near-misses and purchasing behaviour (Stange & Dixon, 2020; Stange, Graydon, et al., 2017). We extended these findings by examining the role of delay and probability discounting on the decision to purchase scratch cards, as previous studies in our lab have been unable to identify any individual difference variables that may influence this decision.

We predicted that participants who purchase during the study would report an overall lower AUC for the subjective value of delayed rewards than non-purchasers, regardless of outcome condition. Further, purchasers should report a greater AUC for probability discounting than those who do not purchase additional cards, regardless of condition. We also predicted that we would replicate past findings, such that near-misses would be rated as significantly more urge inducing than regular losses in an equivalent position. Further, based on past results (Experiments 3 and 4), we predicted that despite their urge-inducing properties, there would be no difference in the number of participants who purchased when comparing those who see a losing, versus a near-miss outcome immediately before the purchasing decision. However, we predicted a significant correlation between urge at the final outcome and the decision to purchase another card only in the near-miss group (replicating the finding shown in Stange et al., 2017). Finally, we predicted a significant interaction between condition and purchase status for urge ratings, such that purchasers who experience a near-miss will show significantly higher levels of urge than non-purchasers who experience a near-miss (with no difference in urge between purchasers and non-purchasers in the loss condition). Given the importance of open science practices in behavioural addiction research (Gorman, 2019), we pre-registered our sample size,

the aforementioned hypotheses, and data analysis plan on the Open Science Framework (original pre-registration: <https://osf.io/7d6pb>, and related pre-registration with an updated methodological change: <https://osf.io/fkq9m>).

4.3.1 Method

Participants

A sample of 160 undergraduate participants from the University of Waterloo Research Experience Group was recruited for the study. All participants were pre-screened to ensure that they were 18 years of age or older (the legal age to purchase scratch cards in our home jurisdiction of Ontario, Canada), had played a scratch card game at least once in the last 12 months, and were not currently in or seeking treatment for problem gambling. Four participants were excluded from all analyses due to procedural and/or administrative errors, resulting in a final sample of 156 participants.

Materials

Scratch Cards. We utilized the same scratch card game as Experiments 3 and 4 (“Cash for a Month”; see Sections 4.1.1 and 4.2.1).

Measure of Gambling Urge. We utilized the same measure of gambling urge as in Experiments 3 and 4 (see Sections 4.1.1 and 4.2.1).

Gambling Frequency and Demographics. We administered two items assessing how often participants bet or spent money on lottery tickets (e.g., traditional lottery draw games such as LottoMax, Lotto 6/49) and on instant win or scratch tickets (e.g., Cash for Life or Instant

Crossword; for response options, see Table 5). Participants also indicated which gender they identified with, and their age in years.¹⁰

Problem Gambling Severity Index. The Problem Gambling Severity Index (PGSI; a subscale of the Canadian Problem Gambling Index [Ferris & Wynne, 2001]), was used to determine the level of harm that an individual may be experiencing due to gambling. Using established range criteria, participants were classified as non-problem, low-risk, moderate-risk, or problem gamblers (Currie et al., 2013). Sample characteristics are presented in Table 5.

¹⁰ Participants completed additional surveys and items for reasons peripheral to the current research question. These surveys included items about everyday scratch card behaviours and qualitative items about decision making in the study, endorsement of near-miss erroneous cognitions and prospective near-miss experiences, as well as Barratt's Impulsiveness Scale (Patton, Stanford, & Barratt, 1995). See Section 4.4.1 for items.

Table 5. Experiment 5 participant characteristics.

Measure	Value
Age, mean (<i>SD</i>)	20.20 (2.78)
Gender, <i>n</i> (%)	
Female	116 (74.4)
Male	39 (25.0)
Prefer not to say	1 (0.6)
Frequency of scratch card gambling, <i>n</i> (%)	
Never	26 (16.7)
Between 1 – 5 times/year	91 (58.3)
Between 6 – 11 times/year	17 (10.9)
About Once/Month	11 (7.1)
2-3 Times/Month	8 (5.1)
About Once/Week	1 (.6)
2-6 Times/Week	2 (1.3)
Daily	0 (0)
Frequency of lottery draw gambling, <i>n</i> (%)	
Never	65 (41.7)
Between 1 – 5 times/year	72 (46.2)
Between 6 – 11 times/year	8 (5.1)
About Once/Month	3 (1.9)
2-3 Times/Month	5 (3.2)
About Once/Week	1 (.6)
2-6 Times/Week	2 (1.3)
Daily	0 (0)
Problem Gambling Severity Index, <i>n</i> (%)	
Non-problem gambling	97 (62.2)
Low-risk gambling	54 (34.6)
Moderate-risk gambling	5 (3.2)
Problem gambling	0 (0)

Note. Frequency of scratch card and lottery draw gambling categories represent participants' self-reported gambling over the last 12 months. PGSI categories represent cut-offs as established by Currie et al., (2013). *SD* = standard deviation.

Delay and Probability Discounting. Participants completed two sets of dichotomous choice tasks to assess their valuation of delayed and probabilistic rewards. Participants were initially asked to select their preferred choice between two monetary amounts, one half the size

of the other (e.g., \$500 and \$1000). In the delay discounting task, the smaller option was available immediately, while the larger option was available after a delay. In the probability discounting task, the smaller option was available with certainty, while the larger option was available probabilistically. Depending on whether the participant chose the larger or the smaller of the two amounts, the smaller amount in the next set of items was adjusted with an increase or a decrease by half of the initial value of the smaller amount, respectively (e.g., in a choice between \$500 immediately or \$1000 at a later time, the smaller amount in the next set of items would be \$250 vs. \$1000 if they chose the smaller amount, or \$750 vs. \$1000 if they chose the larger amount). A series of six choices were carried out in this manner, for six different time delays (1, 7, 30, 90, 180, and 365 days) and six different probabilities (95, 90, 75, 50, 25, and 5%), resulting in an estimate of each participant's subjective value of the reward at each delay and probability level. We calculated each participants' AUC for both types of discounting utilizing the method put forth by Myerson et al., (2001).

Design

Each participant experienced six outcomes across two scratch cards (three games per card). On the first card (card 1), all participants experienced a regular loss (six non-matching game symbols), a win of \$5.00, and another regular loss. On the second card (card 2), participants either experienced three regular losses, or two regular losses and a near-miss to the top prize, constituting our between-subjects manipulation.

Participants chose their scratch cards from a facsimile lottery display case, with each participant choosing one scratch card from each of two trays, which contained 48 scratch cards (96 scratch cards per display case, 1 card containing a top prize). One tray contained card 1 scratch cards (loss, win, loss), while the other contained card 2 scratch cards. The tray of card 2

scratch cards contained 24 cards with three consecutive regular losses, and 24 cards with two regular losses followed by a near-miss. By having participants choose their own scratch cards, participants randomly assigned themselves to experience either a loss or a near-miss immediately before choosing to purchase (the between-subjects manipulation of our design). If participants elected to purchase an additional card later in the study, they chose from a second display case which also contained 96 scratch cards (95 card 3 scratch cards containing three successive losses, and 1 top prize card).

Procedure

To begin, participants provided written consent to participate. Participants completed the measures of gambling frequency, demographic items, and the Problem Gambling Severity Index using a laptop computer (Lenovo ThinkPad model 4446-25U). The researcher explained that participants would start by playing two scratch cards and have an opportunity to purchase another card later on. They explained the game structure and rules using a laminated example card. Participants were told that the goal of the game was to find three matching symbols among the six symbols within each game square; if three matching symbols were found, the participant won the corresponding prize. Participants were told that the top prize for the game was Cash for a Month, and that to win it they would need to uncover three “MONTH” symbols within one game square. Participants were told that their odds of winning the top prize were approximately 1 in 100. Participants were instructed to uncover the symbols in each game by scratching in three rows, from left to right, top to bottom, and to ensure that they uncovered all of the symbols within the game square before moving on to the next game. The researcher provided instructions for completing the urge ratings following each game. The procedure sequence was reiterated for

clarity and the participant was given an opportunity to practice the scratching pattern on the laminated example card and ask questions.

Participants were shown the display case of cards and instructed to choose two scratch cards (one from each tray) that they would experience during the study. The participant then scratched all three games on the first card, provided urge ratings following each, and repeated this process for the second card. The researcher explained that because they won \$5.00 on their first card, they could choose to play another card and that these subsequent cards each cost \$2.00 to play, but overall the odds of winning the top prize remained the same, about 1 in 100. If the participant elected to purchase, the researcher took \$2.00 from the \$5.00 in winnings and invited the participant to approach the second display case and choose a card. The participant progressed through each of the games on the third card in a similar manner to the first two, reporting an urge rating after each game.

After the scratch card task, participants were directed to the laptop computer to complete supplementary surveys (for reasons peripheral to the current research question) and delay and probability discounting tasks. The participant received their winnings (\$5.00 if they did not purchase, \$3.00 if they did, and \$100.00 if they were a top prize winner), a feedback letter, lottery-specific responsible gambling materials, and government helpline resources for problem gambling, mental health, and addictions.

4.3.2. Results

Purchasing Behaviour

In our pre-registered analysis plan, we predicted similar rates of purchasing behaviour between the loss and near-miss conditions. In the loss condition ($n = 86$), 41 participants did not

purchase and 45 participants did; in the near-miss condition ($n = 70$)¹¹, 34 participants did not purchase and 36 participants did. These frequencies were compared with a chi-square test, which revealed no significant difference between the conditions, $X^2(1) = 0.012, p = .911$, thus supporting our pre-registered prediction.

Urge to Continue Gambling

Analytical Strategy. Each participant played two scratch cards, with each card containing three outcomes. Card 1 outcomes were identical in both conditions (loss, \$5.00 win, loss), whereas card 2 presented either all losing outcomes, or two losing outcomes and a near-miss. Therefore, all participants provided urge ratings for six outcomes. If participants purchased a third card, they also provided urge ratings for each of the three successive loss outcomes on card 3.

Two participants were excluded from all urge ratings for providing an incorrect number of ratings per card. A further two participants were excluded from card 3 urge analyses as they provided an incorrect number of ratings for that card. Participants with urge ratings exceeding 3 standard deviations above the mean were excluded from analysis as outliers (by condition). For each card, average urge ratings for each outcome in each condition were submitted to a mixed factorial analysis of variance (ANOVA), with condition as the between-subjects factor and outcome as the repeated measures factor. In the event of sphericity assumption violations, corrected degrees of freedom and F values are reported (Greenhouse-Geisser correction). Follow-up comparisons between outcomes or conditions were conducted with t -tests.

¹¹ The slight discrepancy in the number of participants in each outcome condition (loss: $n = 86$; near-miss: $n = 70$) was random, due to the structure of the random assignment to condition (e.g., participants chose their own scratch cards, which corresponded to one of the outcome conditions).

Card 1. The overall mixed factorial ANOVA for card 1 indicated a significant main effect of outcome, $F(2, 304) = 82.62, p < .001, \eta_p^2 = .35$, with no significant main effect of condition or outcome by condition interaction (both p 's $> .1$). Paired samples t -tests collapsed across condition indicated a significant difference between urge ratings for the first outcome, a loss ($M = 31.85, SD = 24.03$), and the second outcome, a win ($M = 49.38, SD = 26.77$), $t(153) = 12.14, p < .001$. These tests also revealed a significant difference between the winning outcome in game two and the third outcome, which was a loss ($M = 34.32, SD = 24.34$), $t(153) = 10.15, p < .001$. Urge ratings for the two losing outcomes did not differ significantly ($p = .091$; see Figure 18a).

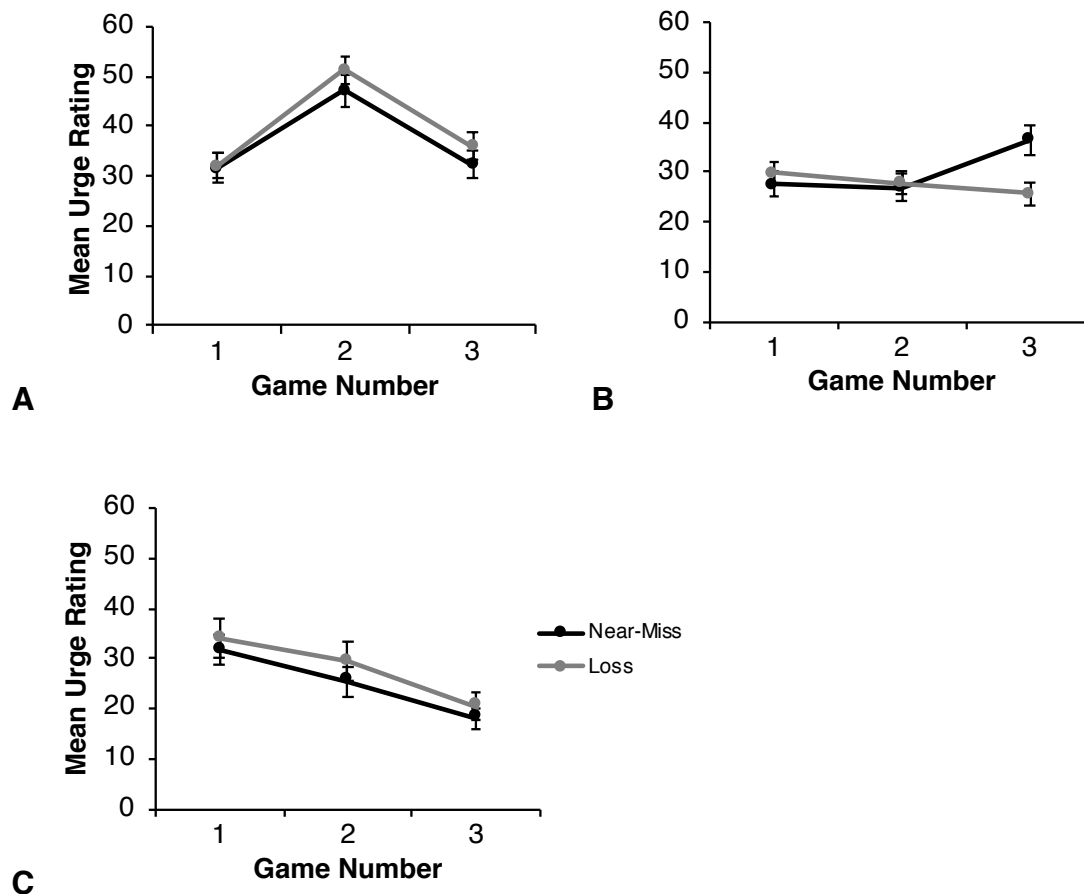


Figure 18. Urge to continue gambling ratings by condition for a) card 1, b) card 2, and c) card 3.

Card 2. The overall mixed factorial ANOVA for card 2 indicated a significant main effect of outcome, $F(1.68, 249.97) = 3.84, p = .03, \eta_p^2 = .03$, and a significant outcome by condition interaction, $F(1.68, 249.97) = 14.34, p < .001, \eta_p^2 = .09$. To localize the source of this interaction, independent samples t -tests between conditions were conducted at each outcome position. These tests indicated no significant differences between conditions at the first outcome (a loss for both conditions; loss condition, $M = 29.84, SD = 21.55$; near-miss condition, $M = 27.55, SD = 20.38$), $t(150) = 0.67, p = .50$, or the second outcome (also a loss for both conditions; loss condition, $M = 27.73, SD = 21.01$; near-miss condition, $M = 26.90, SD = 22.47$), $t(150) = 0.24, p = .81$, but a significant difference between conditions at the third outcome (the between-subjects manipulated outcome; a loss in the loss condition, $M = 25.64, SD = 21.03$, and a near-miss in the near-miss condition, $M = 36.44, SD = 25.86$), $t(151) = 2.85, p = .005$.

Card 3. Due to the number of purchasers, we were able to analyze urge ratings across the three losing games in the optional third card. Overall, there was a sequential reduction in urge over the course of the three losing games. The overall mixed factorial ANOVA for card 3 indicated a main effect of game, $F(2, 148) = 34.66, p < .001, \eta_p^2 = .32$, but no main effect of condition or game by condition interaction (both p 's $> .1$). Follow-up paired samples t -tests collapsed across condition indicated significant differences between urge ratings for the first game ($M = 32.96, SD = 21.88$) and the second game ($M = 27.57, SD = 21.80$), $t(76) = 3.87, p < .001$, the second and third game ($M = 19.33, SD = 16.31$), $t(75) = 5.07, p < .001$, and between the first and third games, $t(75) = 7.42, p < .001$.

Association Between Urge and Purchasing Behaviour

In our pre-registered hypotheses, we predicted an interaction between condition and purchase status on urge ratings at the final outcome before purchasing. We conducted a factorial

ANOVA on urge to continue gambling ratings at the final outcome of card 2 (before the purchasing decision) with condition (loss or near-miss) and purchase status (purchasers versus non-purchasers) as the between-subjects factors. This analysis revealed a main effect of condition, $F(1, 149) = 8.36, p = .004, \eta_p^2 = .05$, but no main effect of purchase status or condition by purchase status interaction (both p 's $> .1$). A related prediction concerned the point-biserial correlation between urge at the final outcome and purchase status in each of the two conditions. This correlation was not significant in either condition (both p 's $> .06$).

Probability and Delay Discounting

We predicted that purchasers would report a greater discounting of delayed rewards (i.e., across time delays, their subjective evaluation of rewards would decrease) compared to participants who did not purchase an additional card, regardless of outcome condition. Furthermore, we predicted that participants who purchased would report less discounting of probabilistic rewards (i.e., across uncertainty levels, their subjective evaluation of rewards would remain high) than participants who did not purchase. We assessed these predictions by comparing the average AUC for purchasers and non-purchasers, for both delayed and probabilistic rewards. Given our preregistration and the directional nature of our hypotheses, we proceeded with one-tailed evaluations of significance. We found no significant difference between probability discounting AUC values for purchasers ($M = 0.10, SD = 0.08$) and non-purchasers ($M = 0.09, SD = 0.08$), $t(154) = 0.81, p = .21$, but did observe a significant difference between delay discounting AUC values for purchasers ($M = 0.68, SD = 0.27$) versus non-purchasers ($M = 0.75, SD = 0.23$), $t(154) = 1.85, p = .034$.

4.3.3 Discussion

The present experiment examined the impact of near-miss outcomes on participants' urge to gamble and their decision to purchase another scratch card in a simulated scratch card gambling scenario, with a pre-registered sample size, hypotheses, and primary data analyses. Further, we examined the role of individual differences in delay and probability discounting on purchasing behaviour. Overall, we replicated previously reported results in terms of participants' experienced urge following individual scratch card outcomes (Stange & Dixon, 2020; Stange, Grau, et al., 2017; Stange, Graydon, et al., 2017), with higher urge following near-misses than regular losses. We also replicated the failure to act on this elevated urge – the percentage of purchasers exposed to near-misses versus losses were the same. However, we failed to replicate a previously reported interaction between purchase status and outcome type on urge (Stange et al., 2017). We add to the scratch card gambling literature by providing evidence of differences in delay discounting between individuals who did and did not purchase additional scratch cards within our experiment, replicating a previously published result (Callan et al., 2011). This finding provides insight into the decision to purchase additional scratch cards, which previous studies were unable to explain (Stange & Dixon, 2020; Stange, Graydon, et al., 2017).

Slot machine near-miss studies suggest that when delivered at the optimal rate, these outcomes can prolong gambling (Côté et al., 2003; Kassinove & Schare, 2001). While participants' subjective urge ratings support the notion of increased motivation following near-misses, as mentioned, we did not observe any behavioural difference in terms of the number of purchasers in the loss and near-miss conditions of our experiment. This result replicates two previous studies which found no difference in purchasing behaviour among individuals exposed to either a near-miss or a regular loss (Stange & Dixon, 2020; Stange, Graydon, et al., 2017).

Importantly, this study resolves the potential issue of increased card cost influencing purchasing rates in Stange & Dixon (2020), by utilizing the identical card price to that of the original investigation (Stange, Graydon, et al., 2017, or see Experiment 3 in the present thesis). In the present study, we did not find a difference between conditions in terms of the number of purchasers, or a correlation between urge at the final outcome and purchase status. Therefore, it is possible that the significant correlation between urge and purchase status reported by Stange, Graydon, and colleagues (2017) was a type 1 error, and that as experienced in the present paradigm, urge following a near-miss has little influence on the decision to purchase an additional scratch card.

Given previous null findings of behavioural near-miss effects, and mixed results surrounding the association between urge and purchasing, we examined individual differences that might influence purchasing behaviour. As predicted in our pre-registration, we observed a significant difference in delay discounting AUC values between purchasers and non-purchasers in the study, suggesting that individuals who purchase tend to discount delayed rewards. This finding aligns with existing research linking delay discounting to gambling behaviour (Callan et al., 2011) and gambling severity (Dixon et al., 2003; Petry, 2001). In the present study, we reinforce the relevance of this concept to scratch card gambling behaviour and extend a previously observed result (Callan et al., 2011) by showing that delay discounting is associated with continued gambling behaviour in a realistic scratch card gambling scenario. Given that two prior experiments offered little explanation for why some participants purchased while others did not, we believe this finding makes an important contribution to our understanding of scratch card gambling behaviour. Interestingly, we did not observe a difference between purchasers and non-purchasers in terms of probability discounting AUC values as predicted and despite evidence that

would suggest otherwise (Kyonka & Schutte, 2018). It is possible that our sample of undergraduate students hindered our ability to detect this effect, given the overall low probability AUC values obtained.

4.4 Individual Differences Predicting the Urge to Continue Gambling

Although Experiment 5 offers insight into the factors that may influence participants' scratch card purchasing behaviour, it remains unknown why participants reliably report increases in their urge to continue gambling following near-miss outcomes, but that experiencing a near-miss compared to a loss in the final outcome position has no effect on purchasing behaviour. In Experiments 3, 4 and 5, although participants reported a significantly greater urge to gamble following near-misses relative to losses, purchasing behaviour did not differ between the two conditions and in Experiments 4 and 5, urge was unrelated to participants' purchase status. What could explain this discrepancy between participants' cognitions and behaviour? We assessed the possibility that participants' urge ratings following near-miss outcomes might be a consequence of their endorsement of near-miss erroneous cognitions, rather than a predictor of their subsequent likelihood to continue gambling. For example, for those who think that near-misses mean a win is imminent, *seeing* a near-miss might lead to increased urge.

Given that scratch cards are a chance-based gambling form, skill cannot be developed and each outcome is independent. Near-miss outcomes in these games do not give any indication of future success and have no bearing on future outcomes. Items that measure the degree to which one believes near-miss outcomes indicate one's skill at scratch cards, or indicate that a win is forthcoming represent erroneous cognitions about near-miss outcomes. Individuals vary with regards to their endorsement of near-miss erroneous cognitions (Dixon et al., 2018), and such erroneous cognitions are associated with general gambling-related erroneous cognitions

(Dixon et al., 2018). We posited that strongly endorsing near-miss erroneous cognitions may lead to enhanced motivation to continue gambling after experiencing a near-miss, as the outcome believed to be a harbinger of skill and success has just been encountered. This would suggest that the replicable, motivational effect of near-miss outcomes we observed in Experiments 1 through 5 is perhaps not an indicator of future behaviour per se, but of cognitions and beliefs about near-misses and what they represent.

We utilized the dataset in Experiment 5 to examine the role of erroneous near-miss cognition endorsement on experienced urge to gamble during a laboratory scratch card gambling task. Within each group of participants in the experiment (near-miss or loss), we expected variability in the level of endorsement of near-miss erroneous cognitions. Among the participants who endorse higher levels of these cognitions, those who go on to see a near-miss outcome should report preferentially greater urge to continue gambling, as holding such a belief about near-misses should lead to reactivity when they are encountered. Regular losses, even when encountered by those who strongly endorse near-miss erroneous cognitions, should not result in such increases in urge, as they are unrelated to the erroneous beliefs. Therefore, the predictive value of erroneous cognitions on urge ratings should depend on which outcome is experienced. Thus, near-misses should trigger high urge in erroneous belief holders, whereas losses should not. Statistically, in a multiple regression framework we expected a significant interaction between condition (loss vs. near-miss) and erroneous cognition endorsement on urge to gamble ratings. Additionally, we included measures of everyday experiences with scratch cards to explore how these factors may relate to near-miss experiences and gambling behaviour within the experiment.

4.4.1 Method

Participants

As this analysis utilized a subset of the data reported in Section 4.3 of the current thesis, the participants included in this analysis are identical to those reported in Section 4.3.1.

Materials

Scratch Card Decision Making. Participants were asked, “In everyday life, how often do you re-gamble what you won on a scratch card immediately after winning? (For example, going back into the store to buy another card if the one you bought was a winner).” Responses for this item were recorded on a sliding scale with two anchors (“0% of the time” and “100% of the time”). Participants also responded to two open-ended questions (“During the study, we asked you if you would like to purchase an additional scratch card to play. Why did you decide to purchase/not purchase another card?” and “In everyday life, do you ever feel close to winning on a scratch card game, but then end up losing?”) and used a free-entry text box with no character limit to record their answers. These open-ended items were included for reasons peripheral to the current study.

Near-Miss Erroneous Cognitions and Experiences. Participants were shown an example of a Cash for a Month near-miss outcome, and asked to indicate the degree to which they agreed with the following statements, using a sliding scale ranging from 0 (strongly disagree) to 100 (strongly agree), adapted from Dixon and colleagues (2018): “Near-misses reflect my skill at this scratch card game,” and “Near-misses indicate that a win is imminent.” Participants also rated their agreement with prospective statements that “Uncovering a near-miss would be frustrating,” and “Uncovering a near-miss would be disappointing.”

Barratt's Impulsiveness Scale. This 30-item scale (Patton et al., 1995) was administered to participants as a measure of trait-level impulsivity to converge with measures of probability and delay discounting (thought to be related to impulsive choice). Participants selected one of four response options for each item: rarely/never, occasionally, often, or almost always/always.

Design

As this analysis utilized a subset of the data reported in Section 4.3 of the current thesis, the experimental design of this study is identical to that reported in Section 4.3.1.

Procedure

As this analysis utilized a subset of the data reported in Section 4.3 of the current thesis, the experimental procedure is identical to that reported in Section 4.3.1.

4.4.2. Results

Correlations

We explored the associations between our measured variables (see Table 6; see Appendix B for descriptive statistics), applying a Bonferroni correction to account for increases in the family-wise error rate (criteria alpha level of $\alpha/66 = .05/66 = .00076$). Participants' self-reported scratch card gambling frequency was positively correlated with their lottery gambling frequency, $r(156) = .709, p < .0001$. However, only self-reported scratch card gambling frequency was significantly correlated with participants' PGSI scores, $r(156) = .297, p = .0002$. The percentage of time that participants purchased additional scratch cards with winnings in everyday life correlated with lottery gambling frequency, $r(156) = .344, p < .0001$, and scratch card gambling frequency, $r(156) = .378, p < .0001$. This "re-gamble" item also correlated with participants' PGSI scores, $r(156) = .302, p = .0001$, as well as their purchase status within the experiment, $r(156) = .390, p < .0001$, and their endorsement of the erroneous cognition that near-misses

signal an imminent win, $r(156) = .294, p = .0002$. Endorsement of near-misses indicating an imminent win was also correlated with endorsement of the erroneous cognition that near-misses indicate skill at scratch card games, $r(156) = .40, p < .0001$. Participants' prospective ratings of near-misses being frustrating was strongly correlated with their ratings of near-misses being disappointing, $r(156) = .734, p < .0001$. Finally, probability discounting AUC scores were correlated with total BIS scores, $r(156) = .391, p < .0001$.

Table 6. Zero-order correlations among measured variables.

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Purchase Status	-											
2. Re-gamble	.39*	-										
3. Lotto Frequency	.09	.34*	-									
4. SC Frequency	.16	.38*	.71*	-								
5. PGSI	.18	.3*	.25	.3*	-							
6. DD	-.15	-.16	-.08	-.11	-.03	-						
7. PD	.06	.25	.19	.18	.15	-.004	-					
8. BIS	-.03	.22	.11	.04	.07	-.1	.39*	-				
9. NM Skill	-.03	.13	.19	.12	.07	-.1	.13	.08	-			
10. NM Win	.11	.29*	.18	.15	.14	-.09	.26	.12	.4*	-		
11. Frustration	.04	.24	.12	.07	.17	-.08	.06	.05	.17	.18	-	
12. Disappointment	.1	.25	.15	.08	.22	-.04	.08	.12	.09	.15	.73*	-

Note. SC = scratch card; PGSI = Problem Gambling Severity Index; DD = Delay Discounting; PD = Probability Discounting; BIS = Barratt's Impulsivity Scale; NM = Near-Miss. * = significant after Bonferroni correction ($p < .00076$).

Given that one's frequency of gambling could theoretically be elevated *because* of re-gambling, these two variables may have complete overlap in their explanatory variance involving PGSI. Therefore, we assessed the contribution of the re-gamble item over and above scratch card gambling frequency in predicting PGSI scores using hierarchical linear regression. We entered scratch card gambling frequency on the first step, followed by our re-gamble item on the second step. This analysis suggests that the re-gamble item accounts for unique variance in PGSI scores over and above scratch card gambling frequency, with a change in R^2 of approximately 4.2% (see Table 7).

Table 7. Hierarchical regression predicting PGSI scores from self-reported amount of re-gambling on scratch cards and self-reported scratch card gambling frequency.

	<i>B</i>	<i>SE B</i>	β	<i>t</i>	<i>p</i>
Step 1:					
Constant	.348	.155		2.24	.027
Scratch Card Frequency	.341	.088	.297	3.86	.0002
Model: $F(1, 154) = 14.93, p < .001; R^2 = .088, \text{Adjusted } R^2 = .082$					
Step 2:					
Constant	.194	.163		1.19	.236
Scratch Card Frequency	.245	.094	.214	2.62	.01
Re-gamble Item	.01	.004	.222	2.72	.007
Model: $F(2, 153) = 11.48, p < .001; R^2 = .130, \text{Adjusted } R^2 = .119$					
$F_{\Delta}(1, 153) = 7.41, p = .007$					

Near-Miss Erroneous Cognitions

Prior to conducting the regression, we determined that there were no differences between the two outcome conditions in terms of their overall endorsement of near-misses reflecting skill, $t(154) = .41, p = .69$, or near-misses reflecting an imminent win, $t(154) = .16, p = .87$.

We created hierarchical linear regression models predicting urge to gamble ratings following the final outcome before the purchase decision with condition (loss, near-miss) and near-miss erroneous cognitions as predictors. We tested separate models for each erroneous cognition, with condition on the first step and erroneous cognition endorsement on the second step. For the interaction term, we regressed condition and erroneous cognition endorsement from the product of these two variables, creating a residual term of the interaction between the two variables that was uncorrelated with both constituent parts (see Dixon et al., 2019 for another example). For each regression model, this residual interaction term was entered on the third step.

First, we examined the erroneous cognition that near-misses reflected skill at scratch card games. Both condition (step 1) and erroneous cognition endorsement (step 2) resulted in a

significant increase to R^2 (both p 's $\leq .005$; Table 8), but the third step containing the residual interaction term did not result in a significant change to R^2 ($p > .1$), suggesting that no additional variance in urge ratings was accounted for by the interaction of these two factors. Variance inflation factors for the model were low (maximum of 1.009), indicating that multicollinearity was not a concern.

Next, we performed an equivalent analysis assessing the erroneous cognition that near-misses indicate an imminent win. Condition (step 1) and erroneous cognition endorsement (step 2) each resulted in a significant increase in R^2 (both p 's $\leq .015$), and at step 3, the inclusion of the residual interaction term accounted for a significant ($p = .015$) 3.1% of additional variance in urge ratings over and above the effects of condition and erroneous cognition endorsement separately (maximum variance inflation factor of 1.001). This analysis suggests that the effect of near-miss win-related erroneous cognitions on experienced urge to gamble differs depending on which outcome (loss or near-miss) participants experienced during the experiment.

Table 8. Hierarchical regression predicting urge to continue gambling ratings at final outcome from condition and erroneous cognition endorsement.

	<i>B</i>	<i>SE B</i>	β	<i>t</i>	<i>p</i>
Near-Misses Reflect Skill					
Step 1:					
Constant	25.64	2.56		10.00	< .001
Condition	10.80	3.79	.23	2.85	.005
Model: $F(1, 151) = 8.12, p = .005; R^2 = .051, \text{Adjusted } R^2 = .045$					
Step 2:					
Constant	22.11	2.72		8.13	< .001
Condition	10.87	3.68	.23	2.95	.004
Erroneous Cognition Endorsement	.24	.07	.25	3.22	.002
Model: $F(2, 150) = 9.50, p < .001; R^2 = .112, \text{Adjusted } R^2 = .101$					
$F_{\Delta}(1, 150) = 10.38, p = .002$					
Step 3:					
Constant	22.11	2.72		8.14	< .001
Condition	10.97	3.68	.23	2.99	.003
Erroneous Cognition Endorsement	.23	.07	.24	3.10	.002
Interaction Term	.18	.15	.09	1.19	.236
Model: $F(3, 149) = 6.82, p < .001; R^2 = .121, \text{Adjusted } R^2 = .103$					
$F_{\Delta}(1, 149) = 1.42, p = .236$					
Near-Misses Mean an Imminent Win					
Step 1:					
Constant	25.64	2.56		10.00	< .001
Condition	10.80	3.79	.23	2.85	.005
Model: $F(1, 151) = 8.12, p = .005; R^2 = .051, \text{Adjusted } R^2 = .045$					
Step 2:					
Constant	17.74	2.73		6.49	< .001
Condition	10.60	3.46	.22	3.06	.003
Erroneous Cognition Endorsement	.39	.07	.41	5.60	< .001
Model: $F(2, 150) = 20.54, p < .001; R^2 = .215, \text{Adjusted } R^2 = .205$					
$F_{\Delta}(1, 150) = 31.33, p < .001$					
Step 3:					
Constant	17.67	2.69		6.58	< .001
Condition	10.77	3.40	.23	3.17	.002
Erroneous Cognition Endorsement	.38	.07	.40	5.61	< .001
Interaction Term	.34	.14	.17	2.47	.015
Model: $F(3, 149) = 16.19, p < .001; R^2 = .246, \text{Adjusted } R^2 = .231$					
$F_{\Delta}(1, 149) = 6.09, p = .015$					

4.4.3 Discussion

An explanation for the disconnect between participants' urge and objective gambling behaviour is that the increase in subjective urge to continue gambling that participants report following a near-miss relates more strongly to cognitions surrounding near-miss outcomes than to future behaviour. For example, participants may see near-misses as more motivating if they strongly endorse the belief that they are indicative of an imminent win. Our exploratory hierarchical regression analyses support this contention. The degree to which participants held this belief interacted with seeing a near-miss, leading to an amplification in urge ratings – an amplification that was not present for participants presented with a loss. Interestingly, we did not observe this activating effect on urge ratings for those who held the belief that near-misses reflected one's skill at scratch card games – near-misses were only associated with urge increases among those who believed that near-misses meant a win was imminent. Therefore, there appears to be a salient link between urge and the imminence of a win, whereas the link between urge and skill at scratch cards is less apparent.

The effect of near-misses on urge among those who believe that near-misses are harbingers of imminent wins suggest that trait-level beliefs about what near-misses mean may activate a motivational response to these specific outcomes. It is reasonable to assume that participants who harbor these types of cognitions would likely be more affected by near-misses when they appear in scratch card games, as they see these outcomes as indicating that a win is near. Unfortunately for gamblers who hold such beliefs, as a purely chance-based gambling form, scratch card near-miss outcomes have no bearing on, or contain information related to, future outcomes. Other authors have demonstrated that cognitions related to interpretive bias and predictive control in gambling are related to the motivational impact of near-miss outcomes in

slot machines (Billieux, et al., 2012). Our results suggest that erroneous cognitions, particularly those which relate to omens of impending success, may be an important aspect of the near-miss experience to consider within the domain of scratch card gambling as well.

Finally, we conducted exploratory analyses to examine associations between individual differences, self-reported gambling characteristics, near-miss related cognitions and perceptions, and in-study purchasing. Self-reported scratch card gambling frequency, but not lottery gambling frequency, was significantly correlated with PGSI scores, supporting the idea that various lottery forms are differentially associated with harm (Griffiths, 2002; Short et al., 2015). How often participants re-gambled scratch card winnings in everyday life was the only variable to correlate with participants' in-study purchasing behaviour. This suggests that purchasing, as presently measured, might be more related to behaviour following wins, or pushes, in which a gambler "wins" back the value of a card. This may explain the lack of behavioural near-miss effects in this paradigm. Since all participants experienced a win of \$5, the impact of a single near-miss following this win may be negligible. Future research could attempt to explore the independent contribution of winning outcomes to purchasing behaviour, and disentangle the influence of outcome combinations as they occur in scratch cards (e.g., with multiple outcomes per card).

Participants' endorsement of the re-gamble item also correlated with self-reported lottery and scratch card gambling, PGSI scores, and endorsement of the erroneous cognition that near-misses suggest an imminent win. Interestingly, scratch card gambling frequency was not correlated with this erroneous cognition, potentially suggesting something unique about the reinvestment of winnings specifically, outside of the fact that re-gambling winnings means that one will necessarily play more scratch cards. It is reasonable to contend that individuals who believe that near-misses signal that a win is imminent would be willing to part with winnings to

play again, as this presents an additional opportunity to uncover the sought-after win. That using scratch card winnings to continue gambling on scratch cards in everyday life is related to erroneous cognitions, as well as to PGSI scores (and predicts unique variance in PGSI scores above scratch card gambling frequency alone) is concerning; it suggests that individuals investing their winnings on additional scratch cards experience more gambling-related harm, and may purchase to chase improbable wins, a behaviour potentially fueled by erroneous cognitions about near-misses.

Chapter 5: General Discussion

Scratch card games are an exceedingly popular and accessible form of gambling that is often engaged in by youth (despite legal restrictions; Adebayo, 1998; Boldero et al., 2010; Donati et al., 2013; Elton-Marshall et al., 2016; Felsher et al., 2004a, 2004b; Griffiths 2000; Wood & Griffiths, 1998, 2004) and has been shown to be associated with gambling harm (Papoff & Norris, 2009; Raposo-Lima et al., 2015; Rush et al., 2002; Stange et al., 2018; Williams et al., 2015, 2021; Wood & Griffiths, 1998), notwithstanding the pervasive innocuous appearance of lottery games overall (Lange, 2001; Wood & Griffiths, 1998). Furthermore, gambling researchers have remarked for decades about concerning scratch card structural characteristics that may have a negative influence on gamblers (Ariyabuddhiphongs, 2011; Griffiths, 1995, 2002; Moran 1979). The most striking of these characteristics is that of the near-miss: an outcome that falls *just* short of a jackpot win (Reid, 1986). Although scratch card near-miss outcomes had been speculated to impact gambler behaviour for some time (Griffiths, 1995; Moran, 1979), only recently has experimental psychology begun to systematically measure and understand near-miss effects in this form of gambling (Stange et al., 2016; Stange, Graydon et al., 2017; Stange, Grau et al., 2017). In light of their popularity, accessibility, uptake by youth, and concerning characteristics, remarkably little empirical research has been devoted to the psychophysiological, subjective, and behavioural sequelae of scratch card gambling.

The central aim of this thesis was to further our understanding of scratch card near-miss outcome processing. Specifically, we investigated the influence of game structure and near-miss symbol arrangement on subjective and psychophysiological responses, and explored the downstream effects of these experiences by examining continued gambling behaviour in the laboratory. Throughout the present body of work, we approached these questions by using a host

of methodologies, including multiple psychophysiological measures, ratings of subjective experience, and behavioural measures involving scratch card purchasing, in addition to incorporating individual difference analyses. Collectively, these studies address gaps in the gambling literature and further our understanding of the influence of scratch card structural characteristics on gamblers.

Overview of Findings

Chapter 2 compared the impact of two different scratch card game structures on outcome-based effects on skin conductance, heart rate, and subjective evaluations. The game structures utilized in Experiment 1 allowed for the systematic investigation of pre- and post-outcome processing. The results of this experiment revealed that scratch card game structure impacted the timing of psychophysiological responses. Participants experienced greater pre-outcome physiological arousal for wins in the scratch card game associated with building up a match of three symbols, and more post-outcome physiological arousal for wins in the game associated with sequential matching. Based on these results, it appears that the structure of the scratch card outcome plays a role in determining the physiological sequelae of scratch cards. Pragmatically, this experiment also helped to address a key limitation of the existing evidence, which was that only one scratch card game structure had been investigated in this manner.

Although we observed significant effects of small wins on physiological arousal in Experiment 1, we did not observe strong effects of near-misses on participants' arousal. Despite this lack of support for psychophysiological near-miss effects, we did observe significant effects of outcome on participants' subjective ratings. Specifically, near-misses resulted in increased frustration, disappointment, and urge to gamble, relative to regular losses – despite their objective equivalence.

To build on these results, we further explored the anticipatory period of scratch card gambling in Chapter 3, with a particular focus on the timing and arrangement of top prize symbols within the near-miss outcome. We presented participants with multiple near-miss outcomes that all presented the first top prize symbol in the same position, but varied in the position of the second top prize symbol; this effectively manipulated the length of the anticipatory window during which the gambler only requires one additional top prize symbol to win. The results of this experiment showed that participants' skin conductance levels over the course of the scratch card game changed depending on the arrangement and timing of the symbols presented in each outcome. Specifically, the near-miss which resulted in the narrowest window for a win to occur resulted in significantly greater skin conductance levels at the final symbol reveal compared to regular losses and the other near-miss outcomes. SCLs for this near-miss type were not significantly different from winning outcomes. In line with these findings, three of the four near-misses (near-misses 2, 3, and 4) resulted in significant quadratic trends over the course of the outcome reveal, whereas losses resulted in only a significant linear trend. This pattern of results suggests that near-miss outcomes that are structured with a last-minute chance at the top prize (e.g., in which the participant uncovers the second top prize symbol in the second last symbol position), result in greater physiological arousal at the final symbol position, perhaps due to a ramping up of arousal at the prospect of a nearly-obtained jackpot win, and the frustration that ensues when one's hopes are immediately dashed.

Although the varied near-miss outcomes that participants experienced resulted in slight differences in terms of physiological arousal during game play, there were no differences between the near-miss outcomes in terms of participants' subjective urge experience. No matter the top prize symbol placement, participants' urge ratings were strikingly similar between the

near-miss outcomes. After collapsing across near-miss type, we observed significant outcome-level differences between near-misses, wins, and losses, such that wins were associated with the greatest levels of urge to continue gambling, followed by near-misses, and finally regular losses. This pattern of results replicates previous studies and Experiment 1 of the current thesis which have reported that subjective urge is typically highest for winning outcomes, and that near-miss outcomes result in significantly greater urge to continue gambling than regular losses (Stange et al., 2016; Stange, Grau et al., 2017). This difference persists despite the objective equivalence between near-misses and regular losses (both cost the gambler the price of the card).

The aforementioned findings highlight the impact that near-miss outcomes can have on gamblers' experiences – however, the reliable impact of small wins cannot be overlooked. In Experiments 1 and 2, small wins significantly impacted participants' psychophysiological responses and subjective experiences. In fact, in Experiment 1, participants experienced the greatest skin conductance changes when exposed to small wins. For Match three small wins, these effects were found leading up to the outcome reveal; in Number Matching small wins, they were observed following the outcome reveal. Furthermore, participants' pre-outcome heart rate was highest leading up to small wins in Match Three games compared to both losses and near-misses. In Experiment 2, small wins resulted in the greatest skin conductance level at the final game symbol position out of all of the experienced outcome types – and were only not significantly different from the most arousing near-miss outcome. In line with these psychophysiological results, small wins resulted in the highest levels of subjective urge out of all three outcome types in both experiments. This finding is especially important when one considers participants' responses to the re-gamble item in Experiment 5, which was positively correlated with gambling-related harm. In summary, it appears that even small wins can have an

appreciable impact on gambler psychophysiology, subjective responses, and potentially even gambling harm.

To further understand the scope and consequences of these outcome-based effects, Chapter 4 presented three experiments designed to understand how near-miss outcomes, and the increased urge to continue gambling that they are associated with, might influence gamblers' behaviour. Specifically, we investigated if experiencing a near-miss leads to increased levels of purchasing behaviour, when participants are given the opportunity to "cash in" their winnings for an additional scratch card, and therefore an additional chance to win the top prize. The results of Experiment 3 suggested that although near-miss outcomes do indeed reliably increase the urge to gamble, experiencing a near-miss outcome does not impact subsequent purchasing decisions (at least in the laboratory). The near-miss and loss conditions of our experiment exhibited similar rates of purchasing, despite their distinct subjective consequences. Interestingly, we observed an interaction between the condition participants were randomly assigned to, and their purchase status, on their experienced urge before the purchase decision. That is, participants who experienced a near-miss outcome and purchased an additional card experienced the greatest amount of urge – suggesting that the combination of experiencing a near-miss *and* reporting increased urge may lead to purchasing behaviour.

Experiment 4 aimed to replicate the above findings and extend them by investigating the influence of individual differences in the endorsement of illusion of control. Experiment 3 suggested that simply experiencing a near-miss does not influence purchasing behaviour, but rather that the interaction between seeing a near-miss and reporting an increase in urge was associated with purchasing. Therefore, we decided to examine the illusion of control as an individual difference that might predispose gamblers to experiencing higher urge ratings

following near-miss outcomes. Participants who endorse the illusion of control and erroneously believe they can control chance-based outcomes may experience heightened near-miss effects, due to an interpretation of near-miss outcomes as feedback that a win is imminent – and that surely the next gamble will result in the top prize (Reid, 1986). Although near-miss outcomes reliably increased the urge to gamble relative to regular losses, endorsement of the illusion of control did not differ between purchasers and non-purchasers following near-miss outcomes. Furthermore, we failed to replicate the previously observed interaction between condition and purchase status on experienced urge at the final outcome.

Taken together, the results of Experiments 3 and 4 suggest that although near-miss outcomes are associated with a reliable increase in urge, this urge does not necessarily translate into increased purchasing behaviour. However, based on the results of these experiments, the purchasing data clearly show that some participants choose to purchase while others do not. Therefore, we sought to understand what factors might influence a gamblers' decision to purchase an additional scratch card, regardless of outcome and subsequent urge experienced. To better understand the factors that might influence a participants' decision to purchase additional scratch cards, we turned our attention to delay and probability discounting as candidate individual differences in Experiment 5. Measuring these constructs allowed us to examine the role of impulsivity in the decision to purchase scratch card games, a widely recognized individual difference in determining gambling behaviour and engagement. In line with our predictions, the results of Experiment 5 showed that participants who purchased additional scratch cards more steeply discounted delayed rewards – a key hallmark of impulsivity (Petry, 2001; MacKillop et al., 2016). Finally, although participants rated near-miss outcomes as more

urge-inducing than regular loss outcomes, we did not replicate the interaction between condition and purchase status on urge ratings as reported in Experiment 3.

In all 5 Experiments presented in the current thesis, near-miss outcomes led participants to report significantly greater urge to continue gambling relative to regular losses, despite their objective equivalence. However, one key remaining question from the purchasing experiments presented in Chapter 4 was what the reliable increase in urge following near-miss outcomes represents, given that experiencing a near-miss outcome (and therefore heightened urge to gamble) did not seem to impact purchasing behaviour. If these increases in urge are not a harbinger of future behaviour, what are they? An additional analysis of Experiment 5 data (see Section 4.4 above) revealed an interaction between participants' degree of endorsement about the *meaning* of near-miss outcomes (e.g., whether uncovering a near-miss means a win is imminent) and whether or not they experienced a near-miss in the experiment on experienced urge to gamble. Those who thought that near-misses were a harbinger of an upcoming win *and* saw a near-miss in the experiment showed greater increases in the urge to continue gambling. This suggests that the reliable increase in urge following near-misses that we observed in each of the experiments may reflect participants' global beliefs concerning near-miss outcomes, which become activated upon encountering such an outcome. Therefore, as measured in the current thesis, urge to continue gambling should perhaps not be thought of solely as a predictor of future gambling behaviour, but rather a consequence of whether participants experience these outcomes *and* how they conceptualize these outcomes when they do.

The results of the present thesis strongly reinforce the appreciable impact that scratch card near-miss outcomes can have on participants' subjective experience. Despite being a monetary loss, near-miss outcomes increase gamblers' motivation to play, a finding observed in

other forms of gambling such as slot machines (Billieux et al., 2012; Sharman & Clark, 2016). We see a similar pattern of increased motivation following small wins in scratch cards, also a finding echoed in other forms of gambling (Billieux et al., 2012; Clark et al., 2012, 2013). The psychophysiological variables examined in the present thesis confirm prior evidence of the arousing nature of scratch card gambling outcomes, in particular the impact of winning and near-miss outcomes on participants' physiology (Stange et al., 2016; Stange, Grau et al., 2017). These findings are largely in line with literature examining other forms of gambling, suggesting that both winning – and almost winning – can impact gamblers.

Although we observed reliable effects on participants' motivation to continue gambling following near-miss outcomes, and some evidence of increased physiological arousal during the unfolding of these outcomes, we did not observe any effects of near-miss outcomes on overt purchasing behaviour. These results are largely *inconsistent* with previous studies examining the behavioural consequences of these outcomes in other forms of gambling (Côté et al., 2003; Kassinove & Schare, 2001). However, despite this discrepancy, the results of Experiment 5 with regards to participants' purchasing behaviour and individual differences are consistent with prior research examining the role of delay discounting and scratch card purchasing behaviour (Callan et al., 2011), and gambling behaviour generally (Dixon et al., 2003). Curiously, we did not observe an association between purchasing behaviour and probability discounting, which is typically a fairly robust effect (Kyonka & Schutte, 2018). However, this may have been due to a relatively restricted range of probability discounting scores, which limited our ability to observe a correlation. Another influence on participants' decision to purchase additional scratch cards appears to be bet size. In an exploratory analysis between the purchasing rates in Experiments 3 and 4, we observed that more participants purchased additional scratch cards in Experiment 3,

when the cost to purchase an additional card was \$2, compared to \$5. These results are in line with an in-store study of scratch card chasing behaviour, suggesting that gamblers are more likely to chase losses on lower-denomination scratch cards (Whiting et al., 2016).

In Experiment 4 we did not observe any difference in participants' endorsement of the illusion of control based on purchase status, or a correlation between illusion of control scores and change in urge from regular loss outcomes to near-miss outcomes. This was not in line with prior research suggesting a correlation between illusion of control scores and desire to continue gambling ratings following near-misses (Billieux et al., 2012). However, in previous studies, illusion of control scores were also found to be related to the endorsement of skill-oriented cognitions in slot machine gambling, such as believing that a near-miss means a win is imminent, or that a near-miss indicates increasing skill at a slot machine game (Dixon et al., 2018). In Experiment 5 we did observe an interaction between experiencing a near-miss in the experiment and endorsing the notion that near-miss outcomes suggest an imminent win on participants' urge scores. Therefore, it is possible that there is a complex set of relations between illusion of control, experienced urge, and skill-oriented cognitions of relevance to scratch card gambling.

As a whole, the results of the present studies are generally consistent with prior research reporting effects of specific gambling outcomes on gamblers. Although near-miss outcomes have long been shown to impact gambler psychophysiology and subjective responses (Billieux et al., 2012; Clark et al., 2013; Dixon et al., 2011, 2013; Sharman & Clark, 2016;), we observed mixed evidence for the impact of near-misses on gamblers' psychophysiology in Experiment 1. These results are inconsistent with this prior research which suggests reliable psychophysiological near-miss effects, largely observed in slot machine gambling (Clark et al., 2013; Dixon et al., 2011,

2013). One potential explanation for this mixed evidence may stem from the way that scratch card near-misses are presented, compared to slot machines. In a prototypical slot machine near-miss, symbols are presented in relation to the payline. Differences have been observed between near-miss outcomes that involve the final symbol landing before or after the payline: near-misses resulting in the third symbol falling *after* the payline result in greater psychophysiological responses when considering electrodermal activity (Clark et al., 2013), and more activity concerning electroencephalogram components such as frontal related negativity (Dores et al., 2020). The main type of near-miss investigated in the current thesis involved uncovering 2 of the 3 required symbols to win, and therefore may have impacted the strength of the effects we were able to uncover. Relatedly, in Experiment 2, we only observed psychophysiological near-miss effects for one of the presented near-miss types, suggesting a subtle effect of these outcomes on gambler psychophysiology.

Although the psychophysiological results of the current thesis were present, but subtle, we did not observe any behavioural impacts of near-miss outcomes in Experiments 3 through 5. One possible reason for the lack of these near-miss behavioural effects (despite urge increases) is the number of near-misses presented in the current study. In slot machine experiments, participants generally experience many spins over a single session. In one such study, participants were first exposed to 48 slot machine spins with 9 wins and 12 near-misses (Côté et al., 2003). Following this, participants could play up to 240 spins on the slot machine, but experienced only losses (control condition) or losses and near-misses occurring on 25% of spins (experimental condition; Côté et al., 2003). Thus, a participant who played all 240 spins would have been exposed to 60 near-misses as opposed to the single near-miss in the current purchasing

paradigm. It is therefore possible that behavioural effects of near-misses are observed only when many of these outcomes are experienced within a gambling session.

The rate at which near-misses occur may also play a role. Another slot machine near-miss study utilized a pre-programmed slot machine game and presented participants with 50 trials, where near-misses occurred on 15, 30, or 45% of spins (Kassinove & Schare, 2001). Following this, participants were presented with an extinction phase of losses in which they could play for as long as they wanted. Participants who experienced near-misses at a rate of 30% gambled for longer than those in the 15 and 45% conditions (Kassinove & Schare, 2001). Therefore, it is possible that we did not present near-miss outcomes at a rate high enough to influence behaviour, as the near-miss condition in Experiments 3 through 5 only experienced these outcomes on 16.7% of games prior to the purchasing decision.

Although participants exposed to near-misses were no more likely to purchase additional scratch cards, we observed consistent effects of near-misses on participants' subjective urge to continue gambling. One possible reason for why participants report an increase in their subjective motivation to continue gambling, but do not choose to act on this urge when given the opportunity, is that participants' subjective ratings may be more indicative of their *beliefs* about near-miss outcomes. This notion is in line with prior gambling research. For example, gamblers who reported an increased likelihood of winning following near-miss outcomes were found to be more likely to persist at gambling (Clark et al., 2013), suggesting a link between beliefs about the meaning of near-miss outcomes and their consequences for the gambler. Although we did not observe increased overt gambling behaviour following near-misses, in Experiment 5, gamblers who more strongly endorsed the notion that that near-misses suggest a win is imminent and were exposed to this outcome in the experiment reported the highest level of urge to continue

gambling, suggesting that such beliefs about near-miss outcomes may interact with the gambling environment to produce effects on subjective experience.

Limitations

One of the main limitations of the current thesis concerns the simulated scratch card gambling experience to which participants were exposed. To allow for increased experimental control over the outcomes that participants experienced in each of the experiments, we designed our own scratch card games. Although advantageous for internal validity, this choice limited the scope and size of prizes that we were able to offer participants. Additionally, the scratch card games that we created were not as visually complex as commercially available scratch cards (e.g., including multiple colours on scratch-off areas, complex printing features such as metallic elements, etc.). These factors may have influenced participants' responses to the scratch card outcomes we presented. However, it is possible that the results presented in the current thesis may in fact be an underestimate of the magnitude of effects that occur in the real world, with real, commercially-available scratch cards.

Additionally, the studies presented relied exclusively on samples of undergraduate students, who generally reported low levels of problem gambling symptomatology and frequency of scratch card gambling. Although all participants were pre-screened to ensure that they did have experience playing scratch cards (i.e., they were not novices), our samples were limited in terms of scratch card gambling experience, which precluded any analyses based on this factor. Therefore, it remains unknown if and how prior scratch card gambling experience may modulate the near-miss effects reported in the current thesis. A similar issue is presented with gambling harm. As we did not recruit participants on the basis of experienced gambling harm, we were

unable to compare groups of participants reporting varying levels of harm with regards to their experience of the reported effects.

Future Directions

There are a number of unexplored areas of scratch card gambling to be addressed with future research. First, it is unknown how the influence of prior gambling experience and level of gambling harm experienced influence outcome-specific responses in scratch card games. The studies presented here utilized a recruitment strategy that ensured participants had experience playing scratch cards at least once in the past 12 months, but we did not actively recruit gamblers with varying levels of experience or gambling harm to make comparisons among these groups. Given that frequency of scratch card gambling has been shown to be correlated with experienced gambling harm (Short et al., 2015; Stange et al., 2018; Williams et al., 2015, 2021), examining how individuals who experience gambling harm react to near-misses, and further, how these outcomes may impact continued gambling behaviour for these individuals, represent important areas of exploration for future research.

Additionally, as outlined in the limitations section, the current studies used small prizes, relative to real scratch card games available in the marketplace. Future studies could attempt to recruit gamblers who have just purchased their own (real) scratch cards at lottery retailers, to enable the measurement of psychophysiological and subjective reactions to games with prize amounts many orders of magnitude larger than the prizes in the current set of studies. This type of design would introduce challenges related to experimental control of outcomes and the presentation of various other game structures (e.g., number of games, types of games, etc.), but would also address another key limitation of the current studies, in that participants did not risk their own money to play the scratch card games presented. There are very few studies examining

scratch card gambling behaviour in real-world contexts (see Whiting et al., 2016 for one example), which is concerning given the aforementioned associations between frequency of scratch card gambling and experienced gambling harm (Short et al., 2015; Stange et al., 2018; Williams et al., 2015, 2021).

Conclusion

Overall, the collection of experiments in the present thesis adds to the growing body of literature examining scratch card lottery gambling, with a specific focus on how the structural features and outcomes of this gambling form influence gambler motivation, emotion, physiological arousal, and behaviour. We find evidence to suggest that discrete scratch card game types have disparate influences on the timing of psychophysiological responses, as does the arrangement of individual game symbols in near-miss outcomes. Throughout the present thesis, we observe replicable effects of winning and near-miss outcomes on urge to continue gambling. Finally, although structural features such as near-misses do not seem to exert a direct influence on gamblers' continued gambling behaviour, individual differences related to impulsivity appear to play a role in the decision to continue gambling. Furthermore, how participants conceptualize near-misses may interact with the experience of a near-miss outcome to influence motivation to gamble. In conclusion, the present body of work highlights the importance of studying the structural features of gambling games, particularly with regard to popular and accessible forms of gambling such as scratch cards – an area in which empirical psychological research has only begun to scratch the surface.

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Appendix A: Additional Skin Conductance Analyses

Early vs. Late Near-Miss Outcomes

Including multiple types of near-miss outcomes in our design allowed us to test the influence of symbol arrangement on psychophysiological responses to these outcomes. In particular, we were interested in participants' skin conductance levels as they uncovered symbols following an "early" near-miss (e.g., NM1), in which the two top prize symbols are uncovered in symbol positions 4 and 5, and a "later" near-miss (e.g., NM2), in which the two top prize symbols are uncovered at positions 4 and 6. To this end, we examined the slope of participant's skin conductance levels over the final three symbol epochs in near-miss 1 and 2 (one early and one late, respectively), which were all non-MONTH symbols (i.e., symbols 7, 8, and 9). In our pre-registered analysis, we predicted that skin conductance in the early near-miss outcome would be greater than in the later near-miss outcome. We conducted a 3 (symbol) by 2 (outcome) repeated measures ANOVA on skin conductance slopes, with a planned comparison between outcomes. This analysis revealed only a main effect of symbol position, $F(2, 102) = 11.58, p < .001, \eta_p^2 = .185$, with a non-significant main effect and interaction involving outcome type.

Yoked MONTH vs. Non-MONTH Symbol Analysis. One limitation of the SCR analysis by symbol type described above is the averaging of symbol types across different outcome types. To address this, we compared SCLs for yoked pairs of symbols in specific symbol positions, across near-miss and loss outcomes. For example, we compared symbol 8 from NM4 (MONTH symbol) to symbol 8 (non-MONTH symbol) in the losing outcome. We conducted paired samples t-tests for each of the symbol pairs. The MONTH SCL value for the symbol 4 position was made up of an average of all of the near-miss symbol 4 MONTH symbols,

compared to the non-MONTH symbol in the equivalent position in the losing outcome. For each of the second MONTH symbol positions, the MONTH symbol was compared to the symbol in the equivalent position in the losing outcome. After a Bonferroni correction (threshold alpha level of .0025), this analysis did not reveal any significant differences ($p > .025$).

Appendix B: Section 4.4 Descriptive Statistics

Variable	Value
Purchase Status, $N_{\text{Purchasers}}$	81
Re-gamble, $M (SD)$	29.19 (30.52)
Lotto Frequency, $M (SD)$	0.86 (1.12)
Scratch Card Frequency, $M (SD)$	1.33 (1.16)
Problem Gambling Severity Index, $M (SD)$	0.80 (1.33)
Delay Discounting, $M (SD)$	0.71 (0.25)
Probability Discounting, $M (SD)$	0.10 (0.08)
Barratt's Impulsiveness Scale, $M (SD)$	62.31 (10.17)
Near-miss skill, $M (SD)$	15.44 (25.74)
Near-miss imminent win, $M (SD)$	21.03 (24.88)
Frustration, $M (SD)$	66.44 (28.19)
Disappointment, $M (SD)$	71.11 (26.17)

Note. See Table 5 for Lotto Frequency, Scratch Card Frequency, and PGSI response options.