Examining the Physiological and Subjective Effects of Near-misses in Smartphone Games

by

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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.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

The work presented in the thesis has been published in volume 33, issue 2 of the *Journal of Gambling Studies* (Larche, Musielak & Dixon, 2017).

Abstract

Like many gambling games, the exceedingly popular and lucrative smartphone game "Candy Crush Saga" features near-miss outcomes. In slot machines, a near-miss involves getting two of the needed three high-paying symbols on the pay-line (i.e., just missing the big win). In Candy Crush Saga, the game signals when you just miss getting to the next level by one or two moves. Because near-misses in gambling games have consistently been shown to invigorate play despite being frustrating outcomes, the goal of the present study was to examine whether such near-misses trigger increases in player arousal, frustration and urge to continue play in Candy Crush. Sixty avid Candy Crush Saga players were recruited to play the game for 30 minutes while having their Heart Rate, Skin Conductance Level, subjective arousal, frustration and urge to play recorded for three types of outcomes: wins (where they level up), losses (where they don't come close to levelling up), and near-misses (where they just miss levelling up). Near-misses were more arousing than losses as indexed by increased heart rate and greater subjective arousal. Near-misses were also subjectively rated as the most frustrating of all outcomes. Most importantly, of any type of outcome, near-misses triggered the most substantial urge to continue play. These findings suggest that near-misses in Candy Crush Saga play a role in player commitment to the game, and may contribute to players playing longer than intended.

Acknowledgements

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Chapter 1: GENERAL INTRODUCTION

Since the emergence of multimedia cellular phones in the mid-1990s, mobile phone gaming has claimed some degree of presence in our continuous, 'on-the-go' lifestyle. From the initial craze surrounding the game "Snake" on early Nokia devices, our mobile gaming habits have been transformed by the ever-expanding quality, sophistication and overall usage of smartphone technology. Of particular interest is the surging popularity of Candy Crush Saga - a free-to-play, candy themed puzzle game that has captivated at least 93 million daily active users in 2014, and generated $2.2 billion in profits (mostly from in-app purchases) in that same year (King Ltd., 2015).

To play Candy Crush Saga, players are allotted a fixed number of moves in which they can swap symbol positions with the goal of horizontally or vertically aligning three (or more) matching symbols. When matched symbols are aligned points are awarded and the "captured" matching symbols are removed from the game matrix. These captured symbols are replaced by other symbols, which appear to drop down to the places vacated by the captured symbols. A single successful match of three or more symbols constitutes one move. Players cannot make any moves or actions if the move does not result in at least a 3-symbol match. In each level of the game, the player must achieve a specific objective within a limited number of moves before the player can unlock the next level. The objectives can include bringing a certain number of "ingredient" symbols to the bottom of the game matrix (in game play players are instructed to "Collect all 6 ingredients!"), or "freeing" candy symbols encased in "gelatine" or "jelly" tiles (e.g. "Clear all the jellies!"). If the player meets the objective within the allotted number of moves they "win", and move on to play the next level (colloquially known as "levelling up"). If they fail to meet the objective in the allotted number of moves they lose, and remain at the

current level, which they must repeat if they wish to move on in the game.

Since games like Candy Crush Saga are typically played on smartphones, they encompass a unique set of traits that distinguish them from console-type video games but intriguingly, bring them closer to the conceptual realm of slot machines. For example, like slot machines, smartphone games are easy to learn, and players are frequently reinforced as each successful move is accompanied by eye-catching animations of points being accrued as the aligned symbols are captured. Perhaps most importantly, play is continuous- there is always a next level to play (The Economist, 2013). Although Candy Crush Saga (like most phone games) lacks a direct gambling element in that no money is wagered on outcomes, money nevertheless can change hands. Players can, if they wish, purchase game currency that can be used to gain extra lives, extra moves or bonus accessories as a way to maximize their likelihood of winning and advancing in the game. This phenomenon is known as "pay-to-win" gaming, such that players who choose to pay are given an advantage over players who continue to play for free. Although less than 3% of players end up making such transactions (Grubb, 2014), the players who do, spend on average $23.42 per month on these micro-transactions (Grubb, 2014).

The monetization of gaming through these micro-transactions blurs the dividing line separating regular, video-gaming and gambling for money. In addition to the negative impact of excessive video-game play on overall social, physical and psychological well-being (Ferguson, Coulson, & Barnett, 2011), some players can, and do spend more than they can afford on these games (Lloyd, 2016). These players are not gaining any money in return from this investment – they simply pay to regain access to the game, or to purchase items that give them an advantage in the game. This intrinsic (as opposed to monetary-centered) form of motivation in smartphone gaming is a point of interest to study.

1.1 Structural Similarities between Casual games and Gambling Games

Several speculations comparing the structural similarities of Candy Crush Saga and slot machines have been made in attempt to explain why Candy Crush Saga has such an 'addictive' quality (see Smith, 2014; Gardner, 2014). Tellingly, Candy Crush Saga players often specifically liken Candy Crush Saga to slot machine play to convey its appeal. They highlight the enticing animations that accompany successful moves and levelling-up (equivalent to a 'win' in slot machines; Smith, 2014). Moreover, the fact that a correct move is characterized by the alignment of matching candies parallels the alignment of matching symbols on the pay-line in slot machines. Furthermore, players attempting to gather (capture) candies may allude to the indirect consumption of these forms of foods- a pleasurable experience which many of us are motivated to repeat (Lowe & Butryn, 2007; Gardner, 2014). Such game themes where food symbols are paired with reward are evident in many slot machines. In fact, in the United Kingdome, slot machines are colloquially referred to as 'fruit' machines (Griffiths, 1993).

The parallels between slot machine play and Candy Crush Saga involve not only rewarding events (winning spins, levelling up), but also frustrating events. Near-misses are outcomes that come close to, but fall just short of a win (Reid, 1986). In traditional 3-reel slot machine games, a classic near-miss is represented by two high paying symbols matching up on the first two reels, and a 3rd matching symbol stopping right before or just after the pay-line ("7-7-X"). Thus, the player falls just short of the big win. In Candy Crush Saga, the program specifically highlights attempts that fall just short of the goal of levelling up. For example, if the player needed only 2 moves to level up, but ran out of the allotted number of moves they would see the move counter drop to zero, followed by a message claiming "Out of moves! You only needed 2 more jellies/moves". In contrast, if the player was not close to levelling up, the move

counter would simply drop to zero and the message would simply state "out of moves". As such there is a clear attempt to highlight to the player those instances where players came close to, but fell just short of the goal of the game. We refer to these outcomes as Candy Crush Saga near-misses.

Although no studies have investigated the ramifications of near-misses in smartphone games like Candy Crush Saga, one can make reasonable inferences based on near-misses in other scenarios. In slot machine games, near-miss outcomes encourage the urge to continue play despite the absence of reward (Côté, Caron, Aubert, Desrochers, & Ladouceur, 2003; Kassinove & Share, 2001; Clark, Lawrence, Astley-Jones & Gray, 2009; Billieux, Van der Linden, Khazaal, Zullino & Clark, 2012). Turning to the incentive salience literature, the mechanism facilitating urge is often attributed to the activation of the "wanting" component of the reward system as opposed to the liking component (Berridge & Robinson, 2003). More specifically, the fact that players have been shown to desire to continue play following a near-miss, a highly frustrating and unpleasant loss, is a prime example of "wanting" component activation rather than the liking component in the reward pathway (Berridge & Robinson, 2003; Dixon et al., 2013). In general, the idea of falling just short of a big win appears to facilitate players wanting to continue with the game in the belief that practice makes better, or more spins will eventually lead to success (Kassinove & Schare, 2001).

Because a near-miss reflects a thwarted goal, it tends to provoke a negative emotional experience. While players rate slot machine wins as being pleasant, they rate near-misses as being unpleasant and more aversive than regular losses (Clark et al., 2009; Chase & Clark, 2010). One means of capturing the rewarding property of wins and the aversive property of near-misses during actual play is by measuring a combination of Post-Reinforcement Pauses (PRPs)

and Skin Conductance Responses (SCRs). Post-reinforcement pauses are typically defined as the time it takes to initiate a new response after a specified reinforcement (Felton & Lyon, 1966). In slot machine play, PRPs are operationalized as the time interval between the delivery of an outcome (e.g. win, loss, or near-miss) and the initiation of the next spin (Dixon, MacLaren, Jarick, Fugelsang & Harrigan, 2013; Dixon & Schrieber, 2004; Delfabbro & Winefield, 1999). After having participants play a slot machine, Dixon and colleagues (2013) found relatively long PRPs for winning outcomes compared to near-misses (and other standard losses). Players' fast initiations of the next spin following a near-miss outcome was seen as an attempt to escape the unpleasantness of just missing the win (Dixon et al., 2013). Research measuring arousal (quantified by SCRs) complement this interpretation (Lobbestael, Arntz & Wiers 2008; Civai, Corradi-Dell'Acqua, Gamer & Rumlati, 2010). During slot machine play, wins trigger significantly larger arousal responses than losses, presumably due to their exciting properties. Near-misses, however also trigger larger skin conductance responses than regular losses – a finding Dixon and colleagues (2011, 2013, 2015), attributed to their frustrating properties. In sum the combination of long PRPs and large SCRs following wins was viewed as a signature of reward-induced arousal, whereas the combination of large SCRs but small PRPs following near-misses was seen as a hallmark of frustration. Based on the slot machine literature, it is reasonable to surmise that near-misses in Candy Crush Saga (just failing to level up by one, two or three moves) might induce similar frustration that could be operationalized by the combination of large elevations in skin conductance and short PRPs.

Near-misses influence players in different forms of gambling. For example, a recent study by Stange, Grau, Osazuwa, and Dixon (2017) investigated near-misses in scratch card play. Players uncovered a series of symbols hoping to find three matching symbols within a 3x2

symbol matrix. They compared losing outcomes (no matching symbols), winning outcomes (three $5 symbols leading to a small win) and near-miss outcomes (where only two of three needed "jackpot" symbols were uncovered and players "just missed" winning a large prize). In such a game, the outcomes are only known once the last symbol in a matrix is revealed. Stange and colleagues (2017) showed that during near-misses (compared to regular losses), as players successively revealed a first, then a second jackpot symbol, their skin conductance levels (SCLs) increased presumably due to increases in arousal in anticipation of the big win. Elevations in Heart Rate (HR) also took place during near-misses as the first and second symbol were uncovered. They also found that subjective frustration ensued when players uncovered the last symbol and their hopes were dashed. We surmise that this anticipatory build up as players get closer and closer to their goal and the frustration encountered when they "just miss" achieving their goal may occur not only during scratch card play but also during Candy Crush Saga gameplay. As players make more and more moves, they accrue points and get closer and closer to levelling up. When they run out of moves it is reasonable to assume that frustration will ensue.

1.2 The Present Experiment

To summarize, most current research on near-misses pertains to studies of gambling, limiting their application to the smartphone gaming context. In the current experiment, we will examine how winning (levelling up), losing, and just failing to win (a near-miss) in Candy Crush Saga affects players' levels of physiological arousal (as indexed by HR and SCL), emotional reactions (as indexed by subjective ratings) and reward related behaviours (indexed by PRPs). We hypothesize that near-miss outcomes will produce greater physiological arousal (higher HR and SCL) than full loss outcomes during the game. Moreover, following Stange and colleagues (2017), we will measure SCL changes that occur during the game as players get closer and closer

to levelling up. We expect near-misses to trigger similar SCL changes to actual wins since the anticipatory build-up period prior to winning or proximally winning should be comparable. Based on previous findings by Dixon and colleagues (2013), we hypothesize that players will produce longer PRPs following wins than either regular losses or near-misses. If indeed we see high arousal but small PRPs for near-misses (the aforementioned signature of frustration), we should also see greater subjective ratings of arousal and frustration for near-misses than for losses. Finally, consistent with gambling studies where near-misses trigger the urge to continue gambling, we predict that subjective ratings of urge to continue play will be stronger for near-misses compared to regular losses. The findings of this experiment will contribute to our understanding of the motivational consequences tied to the convergence of structural features found in gambling games and those found in smartphone games.

Chapter 2: EXPERIMENT

To reiterate, the purpose of the current study is to elucidate whether near-misses in casual games like Candy Crush Saga induce patterns of subjective and physiological reactivity in players that are comparable to patterns found in slot machines players. To this end, we sought to test the following hypotheses: We expect near-miss outcomes to produce greater physiological arousal (higher HR and SCL) than full loss outcomes during the game. As players gradually near levelling up, we expect SCL changes for near-misses to be similar to SCL changes for wins (since the anticipatory build-up period preceding a near-miss should be more comparable to wins than losses). We also predict players will produce longer PRPs following wins than either regular losses or near-misses. If players do experience heightened physiological arousal but small PRPs for near-misses, subjective ratings of arousal and frustration should also be greater for near-misses than for losses. Finally, we predict that subjective ratings of urge to continue play will be stronger for near-misses and wins compared to regular losses.

2.1 Methods

Participants

A total of 60 Candy Crush Saga Sag players were recruited to participate from two pools of students at the University of Waterloo. The first pool consisted of students participating in studies advertised for extra credit in a Psychology course of their choosing. Students in this pool were recruited through the University of Waterloo's SONA system – a website that manages students participating in Psychology studies. Out of the 323 students from this pool who were eligible to participate, 39 participated. The second pool consisted of students who voluntarily enrolled in a pool to participate in experiments for financial remuneration. These students submitted their contact information to the department of Psychology to be included in a database

accessed only by authorized researchers. A total of 141 students from this pool were contacted. Out of this number, 22 participants responded, and 21 participated. Students recruited from this pool were compensated $10 for their time.

Students from both pools were first asked to complete a pre-screen survey to ensure: 1) students reached at least level 70 in the Candy Crush Saga, and 2) students had played the Candy Crush Saga within the last 12 months. Assigning a cut off level of 70 in the Candy Crush Saga ensured that players were adequately experienced players.

The final results of the study are based on 57 students (48 female) between the ages of 18-24 (M = 21, SD = 1.43). Participants were excluded if they did not meet the aforementioned criteria or if there were issues in data collection (e.g. technical issues, etc). Participants on average had achieved level 287 (ranging from 70-930). In terms of playing frequency, 23.8% of players reported playing Candy Crush Saga on a daily basis, 65.7% reported that they played the game at least twice a week, and 10.5% reporting that they rarely play.

The current study's protocol was reviewed and approved by the University of Waterloo Research Ethics Committee. All participants were provided sufficient information about the study prior to participating, and were advised that they could withdraw at any point in the study without penalty.

Apparatus

Candy Crush Saga Game. Participants played a real, complete version of Candy Crush on an Android tablet device. The version of Candy Crush Saga used allowed us to set the level at which the game was played and to avoid players being "locked out" after too many successive failures to level up. A built-in video camera on a MacBook Pro laptop was used to capture the tablet screen as participants played the game. The tablet rested on a tilted platform aligned to the

tablet's camera (see Figure 1). The video was used to record the outcomes that were delivered during game play and mark the precise time of their delivery for data analysis.

Baseline Task. A digital variant of a PEBL Pursuit Rotor Task (Mueller, 2012) was used as a baseline measure (that required movement, but no "game play" per se). Participants traced their finger following a moving dot on an animated wheel presented on the screen of the tablet device. Participants did this 3 times, once at the beginning, midway, and at the end of 30-minute gameplay for a period of 120 seconds each.

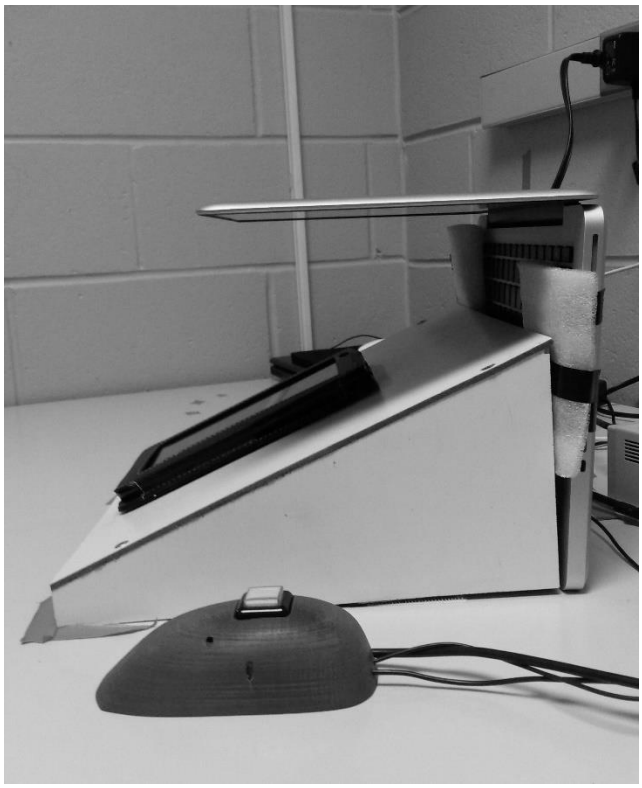

Figure 1 Specialized platform used to hold the Lenovo tablet upright. A Macbook pro camera was used to record the players' game screen in order to time-lock game events (e.g. wins, losses and near-misses). Beside the platform is a button box used to measure PRPs.

Heart Rate. Heart rate was recorded using an ADinstruments TN1012/ST pulse transducer attached to the participant's ring finger (pictured in Figure 2). The pulse transducer was fed into

a ML866 Powerlab (model 4/30), which amplified the signal and provided a digital recording of participants' physiological responses.

Skin Conductance. Skin Conductance Level (SCL) was recorded using two small metallic plates (ADinstruments MLT116F electrodes) attached to the participant's index and middle finger (see Figure 2). The electrodes were also fed into the same ML866 Powerlab (model 4/30).

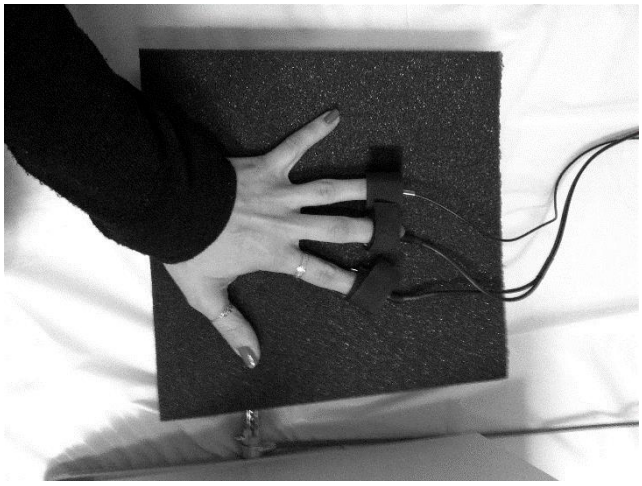

Figure 2 Pulse Transducer and metallic Skin Conductance electrodes. Participants rested their hand on a foam block during play.

Post-Reinforcement Pause. Post-reinforcement pauses (PRPs) were defined as the delay between an outcome delivery in one game and the initiation of the next game, measured in seconds. In Candy Crush Saga, a message at the end of each game appears. The messages associated with the three different outcomes are shown in Figure 3. Players were instructed to press a button on a button box adjacent to the tablet when they were ready to answer a set of subjective surveys and play the next game. The post reinforcement pause for any given outcome was the total time delay between the appearance of the outcome message and when they pressed this button.

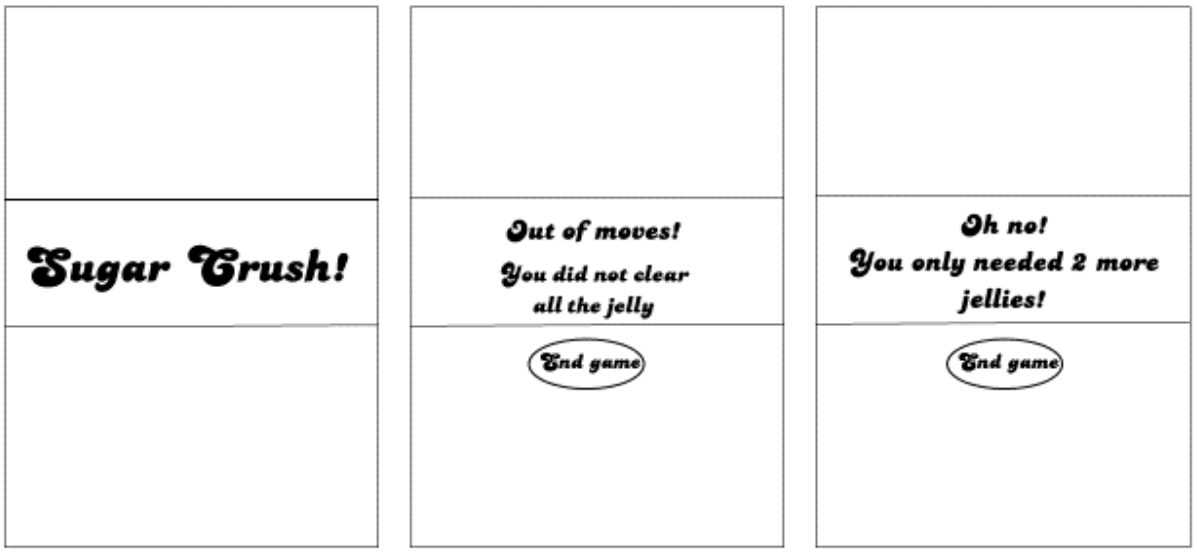

Figure 3 Outcome delivery messages in Candy Crush Saga. These messages are what players would see for wins (left), losses (center), and near-misses (right).

Materials

Pre-test questionnaire. Prior to commencing the study, participants were asked to complete a brief questionnaire (using the Qualtrics survey system) composed of demographic information (age, gender), as well as their experience with the smartphone game (current Candy Crush Saga level, playing frequency, and an estimate of the amount of time they allocated to the game).

Subjective Ratings of Arousal. The Self-Assessment Manikin (SAM; Lang, 1985) measure is a non-verbal, self-report tool used to measure one's immediate experience of arousal. Subjective arousal was measured using a single item in which participants were shown a scale comprised of five manikins with each manikin pictorially displaying different degrees of arousal intensity (Figure 4). Participants were asked to indicate their level of arousal by placing an 'x' under the manikin that best matched their level of arousal. They did this immediately following

the delivery of each game outcome that they experienced during the study. Manikin selections were transformed into a 0 (rightmost manikin) to 4 (leftmost manikin) numerical scale.

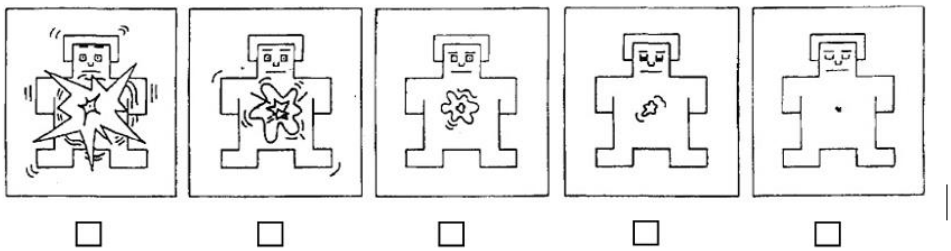

Figure 4 Self-assessment Manikin (SAM) used to rate subjective arousal following each outcome type (i.e. losses, wins and near-misses).

Subjective Ratings of Frustration. Subjective frustration was measured by having participants evaluate how much they agree/disagree with the statement "I feel frustrated" on a 7-point Likert scale after each game outcome was delivered. The scale ranged from 1-7, with 1 representing *'Strongly Disagree'* and 7 representing *'Strongly Agree'*.

Subjective Ratings of Gaming Urge. Two items derived from The Gambling Urge Scale (GUS; Raylu & Oei, 2004) measured urge to continue playing the game following each outcome experienced. These two items included "All I want to do is keep playing" and "I want to play so badly that I can almost feel it". (The wordings used above excluded the gambling terminology used in the original GUS). Participants were asked to rate their desire to continue playing using a 7-point Likert scale, with 1 indicating *'Strongly Disagree'* and 7 indicating *'Strongly Agree'*. Both items of urge were summed (in accordance to scoring guidelines of the regular GUS), and averaged to generate a single "urge" score for each outcome type.

Design

The present study consisted of gameplay epochs and baseline epochs (rotor pursuit task).

During game play epochs each participant was asked to play up to four games of Candy Crush Saga. There were two such game-play epochs totalling eight games. During the eight games, it was anticipated that most players would encounter all three possible outcome types, (wins, losses and near-misses). Players were instructed to play a ninth game if they did not experience all three outcome types within the initial eight games. As mentioned, each outcome was demarcated by a specific message at a game's end: a 'sugar crush' demarcated a win, an 'out of moves' message demarcated a regular loss, and a message unambiguously specifying how close the player was to a win (e.g "You only needed two more jellies!") demarcated a near-miss (refer to Figure 3). An a priori decision was made to only consider as near-misses those outcomes whose proximity message indicated that they were three moves away or less.

Baseline epochs occurred: just prior to game play, after the player had completed four games, and after eight games had been completed.

Procedure

Participants were invited into the testing room and were first asked to complete a consent form, and the pre-test questionnaire. Following the completion of the questionnaire, the skin conductance electrodes and the pulse transducer were attached to their left hand which participants rested on a foam block.

Once the electrodes were attached, the experimenter provided the participant with verbal instructions for game play and baseline epochs. All participants started with an acclimatization period. They were given 3 minutes to play two easy practice games (level six and level seven in the Candy Crush Saga). This allowed the participant to adjust to playing the game with the electrodes attached to their left hand. Next was the first baseline task where participants completed a digitized rotary pursuit task on the tablet. They simply traced their finger over a dot

moving in a circle. Following the baseline task, participants then completed the first game play epoch comprising four games on the tablet device. To maximize the probability that participants would experience wins, losses and near-misses during gameplay, the researcher preselected game levels set at 15 levels below his or her personal best. Each of the four games took approximately 5 minutes to complete. Before initiating the first gameplay epoch, participants were shown a button box placed beside the tablet (refer to Figure 1). They were told to press the button when they wished to start gameplay, and to press the button once again when the game was over. Once players indicated that the game had ended (via a button press), they were administered the self-report items assessing subjective arousal, frustration, and urge to continue playing. This questionnaire was administered following each game. After answering questions related to the fourth game, a second baseline session (rotor pursuit task) was administered followed by four more games, followed by a final baseline epoch. The conditional ninth game followed the 3rd baseline epoch.

2.2 Results

Out of the 60 participants recruited, 57 had valid data for all subjective measures, while only 56 participants had valid data for the physiological data. Three participants were discarded as they did not experience all three possible game outcomes during the experiment. One participant's physiological data had been lost due to technical difficulty with the apparatus during the test session. This single case was therefore not included in the final analyses for the physiological data. Participants ranged in their frequency of play from those who played very seldom to those who played multiple times per day. Most participants reported playing between 20 and 30 minutes in a game session. Frequency of play and reported session lengths are shown in Table 1 and Table 2.

Table 1 *Baseline Playing Frequencies on a Weekly Basis*

Weekly Playing Frequency (N = 57)	# Responses
Daily, multiple times a day	13
7 or more times a week	7
5-6 times a week	5
3-4 times a week	5
1-2 times a week	21
Rarely, Almost Never	6

Table 2 *Reported Session Length*

Session Length *(N = 57)*	# Responses
3-4 hours	0
1-2 hours	5
40-50 minutes	10
20-30 minutes	35
0-10 minutes	7

Data Reduction and Analysis Strategy

All measures were subject to outlier rejection analyses. Data points more than 3 standard deviations away from the cell mean were considered outliers. Heart rate was measured in Beats per Minute (BPM). To circumvent the fact that games could be of different temporal lengths we analyzed BPM and SCLs only for the last 30 seconds of each game (ending with the posting of one of the outcome delivery messages in Figure 3), and the last 30 seconds of the baseline periods. Changes in SCL were measured by calculating the slope of SCLs over this 30-second epoch. For all measures, outcomes of the same type were averaged. For instance, if the player experienced four losses, two wins and two near-misses, the data for each measure would be reduced to three numbers (e.g. there would be four arousal ratings contributing to the average for losses, and two each contributing to averages for wins and near-misses). For data analyses

involving the physiological measures (HR and SCLs), there were four data points per participant-three data points related to game outcomes (average of wins, average of losses, average of near-misses) and an additional data point reflecting the average of the baselines. For HR, SCLs and PRPs, we conducted repeated measures analyses of variance (ANOVA) involving all outcomes followed by Fisher's Least Significant Difference (LSD) Comparisons. In instances where there were violations of the sphericity assumptions, Greenhouse-Geisser corrections to the degrees of freedom were applied.

For the subjective data, we employ planned contrasts between near-misses and losses, wins and losses, and wins and near-misses for all of the subjective measures. The rationale for these planned contrasts was prompted by our supposition that the main effects in an analysis of variance would be underpowered since for many measures no difference was predicted between two of the three means. For example, similarly high subjective arousal should occur for wins and near-misses.

Physiological Measures. As shown in Figure 5, the baseline condition was associated with the lowest heart rate. During game play, the 30 seconds leading up to either a win or a near-miss appeared to trigger relatively high heart rates, with losses triggering lower heart rates. A repeated measures ANOVA with a Greenhouse-Geisser correction revealed a significant main effect of condition, $F(2.427, 133.50) = 18.75$, $p < .001$, $\eta^2 = .25$. Fisher's LSD post-hoc tests showed that baseline heart rate was slower than any of the game play outcomes ($p < .001$ for all values). Near-misses triggered significantly higher heart rates than regular losses ($p = .05$) but the average HR for wins did not statistically differ from near-misses ($p = .30$). Wins had higher heart rates than regular losses ($p = .03$).

The changes in skin conductance levels (SCLs) over the final 30 seconds leading up to a

win, loss or near-miss (or the last 30 seconds of the baseline period) are also shown in Figure 5. This figure shows a general reduction in SCLs over time during the baseline period, an increase in SCLs over time for wins, and little change for losses and near-misses. A repeated measures ANOVA with a Greenhouse-Geisser correction indicated a significant main effect of SCL change by condition type, $F(2.11,107.79) = 3.11$, $p = .04$, $\eta^2 = .06$. Fischer's LSD post-hoc comparisons showed significantly larger slope increases for wins compared to near-misses ($p = .02$), but not losses ($p = .13$). Losses and near-misses were not statistically different ($p = .83$). The baseline epoch had significantly lower slopes than wins ($p = .01$) but not near-misses ($p = .34$) or losses ($p = .21$).

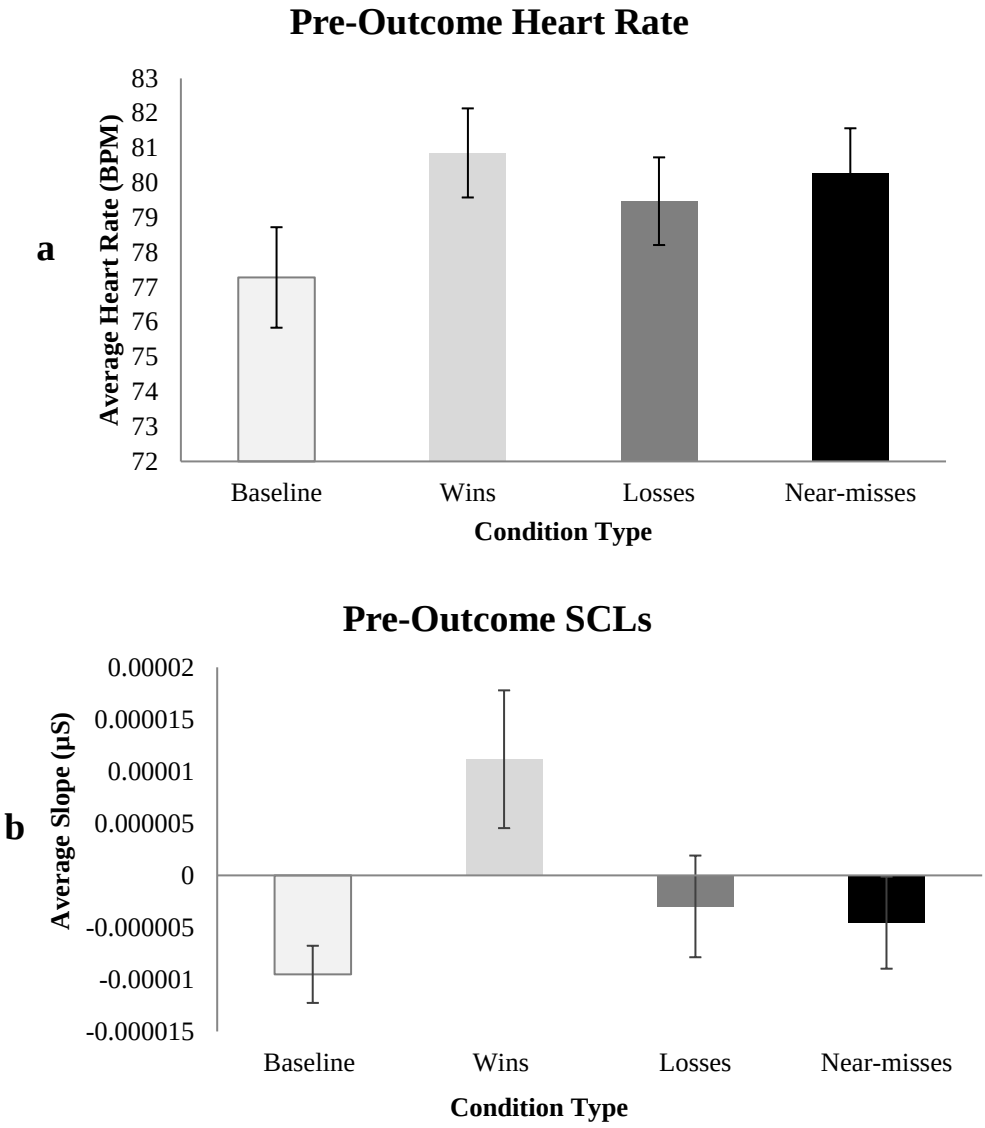

Figure 5 a) Average BPM sampled 30 seconds prior to the end of each condition type. Error bars ±1 SE. **b)** Average SCL sampled 30 seconds prior to the end of each condition type. Error bars ±1 SE.

Post-Reinforcement Pauses. Near-misses (M = 1.85, SD = .89), and losses (M = 1.92, SD = 1.03) had short PRPs compared to wins (M = 12.05, SD = 8.85). Repeated measures analyses with a Greenhouse Geisser correction indicated that there was a significant main effect of outcome type, $F(1.01, 50.76) = 71.29$, $p < .001$, $\eta^2 = .58$. Post-hoc comparisons indicated that PRP lengths for near-misses did not statistically differ from PRPs for losses ($p = .60$). However,

PRPs for wins were statistically longer than PRPs for losses (p <.001) and near-misses (p <.001).

Subjective Measures. Average arousal ratings are shown in Figure 6. The planned comparison between arousal ratings for near-misses and losses revealed that near-misses were more arousing outcomes than regular losses, $t(56) = 2.16$, $SE = .077$, $p = .03$. By contrast, the planned comparison of arousal ratings between wins and losses was not significant, $t(56) = -1.37$, $SE = .124$, $p = .17$, nor was the planned comparison between arousal ratings for wins and near-misses, $t(56) = .05$, $SE = .05$, $p = .95$.

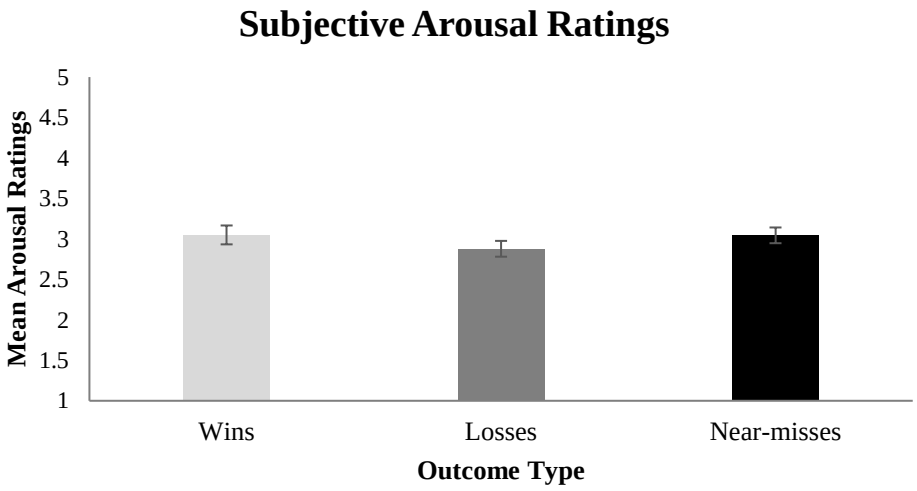

Figure 6 Subjective ratings of arousal for each outcome type on a scale from 1 (least aroused) and 5 (most aroused). Error bars are ± 1 SE.

For frustration (shown in Figure 7), near-misses had the highest frustration ratings, followed by losses, and wins. The planned comparison between frustration ratings for near-misses and losses indicated that near-misses were significantly more frustrating than losses, $t(56) = 2.01$, $SE = .12$, $p = .04$. Expectedly, frustration following wins was statistically lower than losses, $t(56) = 10.50$, $SE = .19$, $p < .001$, and statistically lower than near-misses, $t(56) = -10.41$, $SE = .21$, $p < .001$.

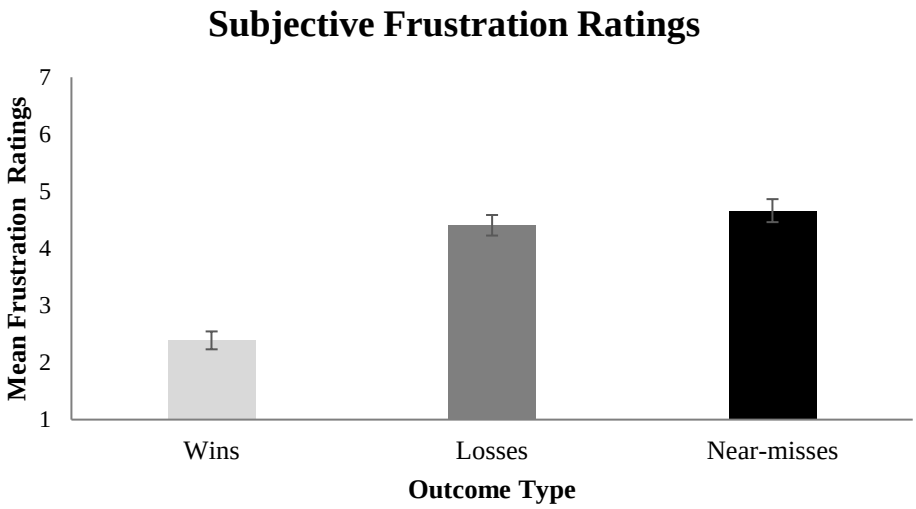

Figure 7 Subjective ratings of frustration for each outcome type on a scale from 1 (no frustration) to 7 (extremely frustrated). Error bars are ±1 SE.

Average urge ratings are shown in Figure 8. The planned comparisons revealed that near-misses triggered significantly greater urge than losses, $t(56) = 1.95$, $SE = .19$, $p = .05$. The planned comparison between urge ratings for wins and losses was not statistically significant, $t(56) = -.52$, $SE = .24$, $p = .60$. Additionally, the planned comparison between urge ratings for wins and near-misses was also not statistically significant, $t(56) = -1.11$, SE = .22, $p = .27$.

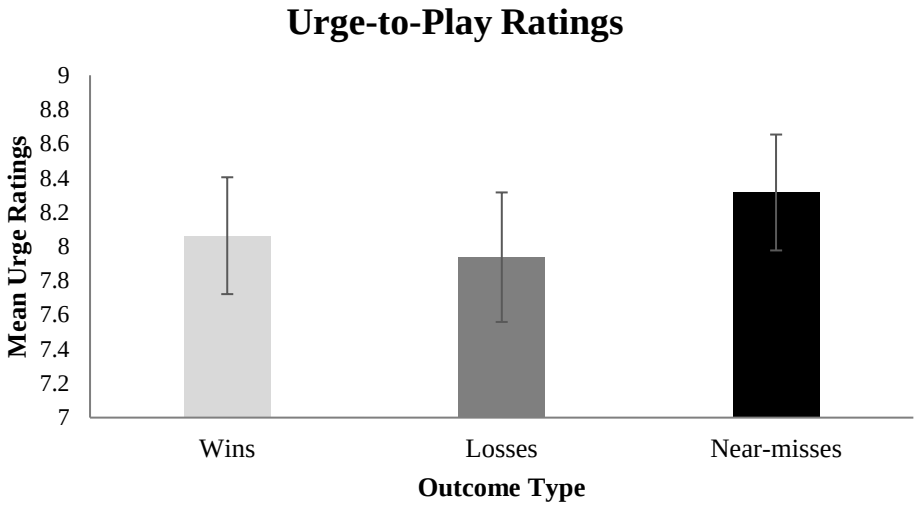

Figure 8 Urge to play for each outcome type. Two items measured urge on a scale from 1 (least urge) to 7 (most urge), and were scored by summing the two obtained values. Error bars ±1 SE.

2.3 Discussion

Taken together, the physiological, subjective and behavioural findings yielded by the present experiment confirmed a subset of our initial hypotheses. Specifically, near-misses in Candy Crush Saga had a profound impact on player's level of physiological arousal, subjective frustration, and importantly, the urge to continue gameplay compared to regular losses. It is clear that near-misses are treated very differently by players, despite the fact that both near-misses and losses result in non-reward. In addition to the observed effects of near-misses, winning in Candy Crush Saga was considered to be the most arousing and rewarding outcome in that players elicited significantly higher level of physiological and subjective arousal compared to any other outcome. Wins also generated significantly longest post-reinforcement pauses and the lowest subjective frustration compared to near-misses and losses. Such findings map on to what is commonly observed in slot machine play. This correspondence between Candy Crush Saga play and slot play is of particular interest considering that, unlike gambling games, Candy Crush Saga is a game that does not offer any tangible, useable reward to the player. Thus, it appears that

simply “levelling-up” is a form of (intrinsic) reward type that is clearly meaningful to players despite the lack of any monetary gain.

The physiological effects of game play in this experiment appeared to be better captured by Heart Rate measures than Skin Conductance measures. For Heart Rate, game play itself appeared to have a pronounced effect of players’ heart rates – regardless of the outcome heart rates were always significantly higher than in the baseline condition. More importantly, heart rate reactivity was much more pronounced following a near-miss compared to losses – despite the fact that these two outcomes objectively result in non-reward. Moreover, the level of heart rate reactivity following the delivery of a near-miss was more akin to wins (comparisons of these two values were not significant).

This pattern of reactivity was not captured by our SCL findings, in that near-misses yielded nominally smaller rather than larger changes in SCLs compared to losses (with the two conditions not being statistically different, and wins did not differ from losses). It may well be that our SCL measures were more affected by movement (finger swiping during game play) than heart rate and that such contamination by movement may have masked the true effects on electrodermal activity. Future studies might be more mindful of electrode placement in a way that cannot be contaminated by movements (e.g. placing SCL electrodes on the toes of participants or the soles of the feet, see Weber et al., 2009).

Subjective ratings of arousal dovetailed nicely with our heart rate findings, such that wins triggered the most robust levels of subjective arousal in players, and near-misses triggered higher ratings of subjective arousal in participants than regular losses. With respect to emotional reactivity, near-misses triggered the greatest level of frustration in players compared to regular losses and wins. Not surprisingly, wins were the least frustrating outcome out of the three

possible outcomes. This heightened frustration is crucial in differentiating wins and near-misses. In terms of heart rate both outcomes trigger increases in arousal. The subjective ratings of frustration suggest that the source of these arousal changes are from different generators – excitement for wins and frustration for losses.

In terms of our behavioural findings, PRPs seemed to be sensitive to detecting differences in the appetitive reactions to rewarding (winning) and non-rewarding (losing) outcomes. Indeed, wins triggered significantly longer PRPs compared to both losses and near-misses, indicating that participants enjoyed winning events and thus paused longer as a result. The PRP length for near-misses and losses did not statistically differ. This pattern of high arousal but short PRPs for near-misses is another means of differentiating wins and near-misses. While both outcomes trigger arousal (elevations in heart rate relative to losses in this experiment) near-misses and wins differ dramatically in PRP length with players pausing to internally celebrate the win, and quickly moving on to get to the next game. This finding, along with the subjective ratings, converge to suggest that near-misses in Candy Crush Saga are frustrating losses that nonetheless trigger the urge to gamble.

Chapter 3: GENERAL DISCUSSION

In the present experiment, participants experienced three types of outcomes in Candy Crush Saga during 30 minutes of playing an actual version of the game: Wins (when they levelled up), full losses (when they failed to level up) and near-misses (when they came close to levelling up). Based on previous research, we expected wins to be highly arousing, highly rewarding, and highly motivating.

At the most general level, our heart rate findings show that compared to the baseline epoch, playing Candy Crush Saga is an exciting, arousing experience. Heart rate for game play overall was elevated compared to baseline heart rate. Importantly, such increases in arousal were likely due to game excitement as opposed to differences in the movements required in the game compared to the baseline condition. As a baseline, we specifically chose a standard, unexciting rotor pursuit task, which nonetheless required finger movements comparable to those required in the game. This greater HR reactivity during gameplay has been consistently observed in previous research even when (as in this study) researchers controlled for metabolic demands due to movement (Turner, Carroll, & Courtney, 1983; Carroll et al., 1984).

Our analysis of changes in skin conductance levels provided some, albeit weaker, converging evidence for this relationship. Baseline periods were associated with the largest decreases in SCLs, converging with the lowest heart rates. We note however, that for SCL changes, the baseline was only different from wins, not from losses or near-misses. It is quite possible that SCL changes may have been contaminated by the periodic swiping movements in the game. If so, the changes in SCL slopes over time may depend on how many moves were made in the last 30 seconds and the delays between swipes. As such we placed greater import on

the heart rate measures which were not influenced by play movements.

As predicted, near-miss outcomes in Candy Crush Saga produced significantly greater elevations in heart rate compared to regular losses. The subjective arousal ratings converge to show that just failing to level up in these games is significantly more arousing than not coming close to winning. It is reasonable to assume that as the number of available moves declines, players become more aroused in anticipation that they can attain a win. Specifically, the player begins to strive to make the correct moves with the expectation that a win is close at hand. Such mentations serve to increase heart rate and subjective arousal. When, however, they run out of moves just prior to levelling up players become frustrated (as evidenced by their high frustration ratings)- significantly more frustrated than for regular losses. Such frustration is nonetheless highly motivating, as players report greater urge to play following near-misses than following regular losses. Although near-misses are objectively equivalent to regular losses in that neither outcome results in goal attainment, gambling research suggests that near-misses trigger the urge to continue play and can lead to excessive play (Clark et al., 2009; Côté et al., 2003; Billieux et al., 2012).

As predicted, wins were highly arousing both subjectively and physiologically as evidenced by notable augmentations in heart rate and subjective ratings of arousal. They also appeared to be rewarding – wins triggered longer post-reinforcement pauses than any other outcome. Yet, despite their rewarding properties, urge following wins did not differ statistically from urge ratings following losses or near-misses. Since Candy Crush Saga wins are periodic and unpredictable (likely occurring in a random ratio schedule similar to slot machines), it was expected that wins would be a powerful reinforcement of behaviour in this context (Ferster & Skinner, 1957; Haw, 2008). The absence of significantly greater urge ratings for wins compared

to losses warrants further investigation in order to reliably understand the reinforcing nature of wins in Candy Crush Saga. If players are less inclined to continue play following wins, it can be speculated that winning may actually be a natural stopping point for these players as the incentive to continue may temporarily dwindle with goal achievement (e.g. completing a level) (Berridge, 2004). However, wins may still be particularly crucial for maintaining player commitment to the game in the long-term.

The findings concerning how near-misses trigger increases in the urge to continue play are particularly intriguing. The significantly greater urge-to-play following near-misses compared to losses suggests that anticipatory arousal can be a primary motivator of future behaviour without the necessity of monetary reward. This finding supports the contention that near-misses can impact motivation regardless of the nature of the reward (Anderson & Brown, 1984; Brown, 1986). The anticipatory arousal prior to the near-miss in Candy Crush Saga and the frustration that follows appears to be potent enough to invigorate further play even in a game where there is no possibility of monetary gain. Thus, Candy Crush Saga appears to be intrinsically motivating to players, and near-misses invigorate this motivation to the similar extent of wins as demonstrated in the gambling literature (Clark, Crooks, Clarke, Aitken, & Dunn 2012; Côté et al., 2003; Kassinove & Share, 2001; Billieux et al., 2012).

In sum, we show that near-misses have profound effects on arousal, frustration and urge even in games where there is no possibility of monetary reward. These findings may have implications for more complex videogames as discussed by Karlsen (2011). For example, in the realm of Massive Multiplayer Online Role Playing Games (MMORPG), the arousal, frustration and urge-to-continue triggered by near-misses (just failing to achieve an objective) may impact decision-making in terms of when to quit a given game session. Moreover, our findings may also have implications toward other forms of decision-making during gameplay, such as the desire to purchase virtual items/currency in the game – a phenomenon that is further unpacked in the subsequent section.

Limitations and Future Directions

One limitation of this study was our inability to show near-miss induced increases in arousal using both heart rate and skin conductance levels. Although the predicted effects were shown in heart rate, we failed to find converging evidence from our skin conductance measures. We attributed this failure to movement artifacts having larger effects on SCLs than heart rate. Research in the video game addiction literature suggests that placing the skin conductance electrodes on extremities that are not susceptible to these movement artifacts (e.g. soles of feet or toes; Weber et al. 2009) may ensure that any changes in SCLs are attributed to the game events and less influenced by movements intrinsic to game play.

Because we used a real version of Candy Crush Saga we could not manipulate (and counterbalance) the order in which outcomes occurred. Additionally, the fact that we had participants play levels slightly below their skill level (to maximize the likelihood of them getting an actual win) and play on a tablet rather than on a participants preferred device, may have disrupted the naturalism of game play. Thus, future research could consider having players

play games directly from their device at their current level of success to maximize the potential of affective responses to outcome events. Moreover, since the effect of Candy Crush Saga near-misses on urge has now been observed, future research can investigate the behavioural consequence of such urge in terms of persistence in play.

Another limitation of this study concerns the post-reinforcement pause lengths following winning outcomes. In Candy Crush Saga, following a winning outcome the players experience a series of eye-catching animations and exciting sounds. Unlike in slots games where players can, with the press of a game button, immediately advance to the next game, Candy Crush Saga players must wait until the cessation of these animations before playing a new game in naturalistic play. Thus, had we used the temporal duration between the outcome being revealed and the actual initiation of the next game as a measure of PRPs, these PRPs would be artificially inflated following wins by the presence of the uninterruptable animations. To circumvent this problem, we had players press an external button (that was not part of the game itself) when they were ready to answer the subjective questions pertaining to that outcome and proceed to the next game. Thus, theoretically they could press button this at any time following outcome delivery (either immediately, or following a delay of variable length). Although a substantial portion of our sample initiated a button press during the playing of the animations some players waited until the end of the animations. Therefore, it is difficult to get a precise estimate of the length of the true post-reinforcement pause for all participants. To get such a precise estimate, one would have to remove the animations that are played following wins – an empirical move that would dramatically reduce ecological validity.

In our version of Candy Crush Saga, we did not subject players to "lock out" periods. In normal game play, players are only given a few chances to level up before being 'locked-out of

the game for a set period of time (i.e. 30 minutes). A fruitful area of future investigation involves the fact that players can avoid these lock-out periods, by making a purchase (termed a micro-transaction) that lets them resume play immediately. Although we did not use "lock out" periods our findings nonetheless may have implications toward this micro-purchasing behaviour. Specifically, as players get "locked out" following a certain number of failures, the combination of frustration and urge to continue play following a near-miss may lead players to actually pay to continue their play. Thus, it would be of interest to see if the frequency of micro-transactions is higher following near-misses relative to standard losses.

Recent research has suggested that micro-transactions made in casual games, especially in those that feature gambling relevant themes, are a risk factor to migration to online gambling-even in players who have not engaged in the activity before (Kim, Wohl, Salmon, Gupta, & Derevensky, 2015). This link is especially concerning considering that players who engage in regular social games like Candy Crush Saga may potentially play gambling relevant social games as well (King, Gainsbury, Delfabbro, Hing, & Abarbanel, 2015). Such purchasing behaviour made in these "pay-to-win" games may as such have broader, more nefarious implications. While games like Candy-Crush have no gambling elements per se, the feature of micro-transactions may bring players a theoretical "step closer" to gambling games that are readily available in social networks sites such as Facebook. Naturally, more investigation is necessary to actually demonstrate that near-misses preferentially influence one's decision to make micro-transactions in these types of games.

In conclusion, the present study demonstrated that Candy Crush Saga near-misses appear to have similar psychological and physiological impacts on Candy Crush Saga players as slot machine near-misses have on gamblers. Specifically, Candy Crush Saga near-misses, just like

their gambling-game counterparts are physiologically arousing, and frustrating, yet motivate the urge to play.

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