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Trait gambling cognitions predict near-miss experiences and persistence in laboratory slot machine gambling

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'Near-miss' outcomes (i.e., unsuccessful outcomes close to the jackpot) have been shown to promote gambling persistence. Although there have been recent advances in understanding the neurobiological responses to gambling near-misses, the psychological mechanisms involved in these events remain unclear. The goal of this study was to explore whether trait-related gambling cognitions (e.g., beliefs that certain skills or rituals may help to win in games of chance) influence behavioural and subjective responses during laboratory gambling. Eighty-four individuals, who gambled at least monthly, performed a simplified slot machine task that delivered win, near-miss, and full-miss outcomes across 30 mandatory trials followed by a persistence phase in extinction. Participants completed the Gambling-Related Cognitions Scale (GRCS; Raylu & Oei, 2004), as well as measures of disordered gambling (South Oaks Gambling Screen [SOGS]; Lesieur & Blume, 1987) and social desirability bias (DS-36; Tournois, Mesnil, & Kop, 2000). Skill-oriented gambling cognitions (illusion of control, fostered by internal factors such as reappraisal of losses, or perceived outcome sequences), but not ritual-oriented gambling cognitions (illusion of control fostered by external factors such as luck or superstitions), predicted higher subjective ratings of desire to play after near-miss outcomes. In contrast, perceived lack of self-control predicted persistence on the slot machine task. These data indicate that the motivational impact of near-miss outcomes is related to specific gambling cognitions pertaining to skill acquisition, supporting the idea that gambling near-misses foster the illusion of control.

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Gambling is a widespread activity in the general population. In Switzerland, where the current study was performed, prevalence data indicate that 48.3% of young adults report at least one gambling activity during the past year, and 13.5% gambled weekly (Luder, Berchtold, Akré, Michaud, & Suris, 2010). The 2010 British Gambling Prevalence Survey found that 73% of respondents reported past year gambling (Wardle *et al.*, 2010), a figure that has remained stable over the past decade, despite changes in legislation and increased availability of online gambling. Most of the time, gambling is an unproblematic source of mainstream entertainment (Shaffer, Labrie, LaPlante, Nelson, & Stanton, 2004), but for a subset it becomes dysfunctional, impacting upon daily living (see Raylu & Oei, 2002, for a review), and with a number of features reminiscent of drug addiction.

At least part of the appeal of gambling derives from structural characteristics of the games themselves (Griffiths, 1993), with basic parameters including speed of play and jackpot size. A more subtle and poorly understood feature that nonetheless occurs across all major forms of gambling is the 'near-miss' (or more accurately, near-win). Near-misses occur when an unsuccessful outcome is proximal to a win; the prototypical example on a slot machine is when the payline displays two matching icons on the payline, with the third match stopping just above or below the payline. Despite their objective irrelevance in a game of chance, the manipulation of near-miss frequencies on slot machine games modulates gambling persistence (Côté, Caron, Aubert, Desrochers, & Ladouceur, 2003; Kassinove & Schare, 2001; MacLin, Dixon, Daugherty, & Small, 2007), with maximal play at frequencies around 30%.

Recent brain imaging experiments using simplified slot machine tasks have compared neural responses to near-miss and full-miss outcomes. Near-misses recruited reward-related brain regions (e.g., ventral striatum) that also responded to the monetary wins, even though subjective ratings indicated that the near-misses were experienced as unpleasant (Chase & Clark, 2010; Clark, Lawrence, Astley-Jones, & Gray, 2009). These studies also revealed that participants rated their desire to continue with the game as higher after a near-miss, compared to after a full-miss. These subjective and neural effects of near-misses were observed across groups of non-gamblers (Clark *et al*., 2009) and regular gamblers (Chase & Clark, 2010), as well as in pathological gamblers in an independent study (Habib & Dixon, 2010).

These data establish the pro-motivational effects of near-misses in gambling play, and indicate differential processing of near-miss and full-miss outcomes at both the subjective and neural levels. However, the psychological mechanisms by which near-misses operate to invigorate gambling remain poorly specified. One account highlights the genuine relevance of near-misses in skill-based situations that are common in the real world. In a game such as darts or football, a near-miss gives a useful indication of impending success that may motivate the player to practice further. It is only in games of chance (such as slot machine) that the near-miss gives no information that could be used by a player to increase the future likelihood of winning (Reid, 1986). As evidence for the hypothesis that the invigorating effects of near-misses reflect appraisals of acquired skill, we previously observed that in non-gambling participants, the desire to play again after a near-miss was stronger when the participants made a personal choice in the gamble, compared to no-choice trials that were selected automatically by the computer (Clark *et al*. 2009). If near-misses reflect beliefs about skill, these skills can only be expressed under conditions that permit choice or manual control.

A skill-based account of the near-miss effect is substantiated by a wider cognitive approach to gambling that emphasizes the distorted estimation of the gambler's chances of winning (Ladouceur & Walker, 1996; Toneatto, Blitz-Miller, Calderwood,

Dragonetti, & Tsanos, 1997). These distortions include mistaken beliefs about skill involvement in chance situations (the 'illusion of control', Langer, 1975) as well as failures to appreciate the statistical independence of turns (the 'gambler's fallacy', Oskarsson, Van Boven, McClelland, & Hastie, 2009). Trait susceptibility to gambling cognitions may play a role in the motivational effects of near-miss events (e.g., Chase & Clark, 2010; Clark *et al*., 2009; Griffiths, 1991). For example, brain responses to gambling near-misses in reward-related circuitry (anterior insula) were predicted by scores on the Gambling-Related Cognitions Scale (GRCS; Raylu & Oei, 2004), a measure of the susceptibility to a range of gambling distortions, in a small sample of 15 volunteers.

Gambling-related cognitions are often highly idiosyncratic (Delfabbro, 2004), which makes them a complex topic of research. Efforts to classify different types of gambling cognition (e.g., Raylu & Oei, 2004; Toneatto, 1999; Toneatto *et al*., 1997) have made a basic division between distorted cognitions about success, and beliefs about the self in relation to gambling. The primary types of distortion about success are as follows: (1) the belief that one can exert control over gambling outcomes via personal rituals (e.g., lucky numbers, prayers, or superstitious objects); (2) an interpretive bias towards certain outcomes that promote continued play despite losses (e.g., hindsight bias, or relating losses to bad luck); and (3) beliefs in the direct prediction of gambling outcomes, often due to a failure to appreciate the statistical independence of turns ('the gambler's fallacy') (see also Steenbergh, Meyers, May, & Whelan, 2002). These irrational beliefs are not exclusive to regular gamblers, and exist in occasional gamblers and even non-gamblers (Cantinotti, Ladouceur, & Jacques, 2004; Sundali & Croson, 2006). The second type of beliefs, about the self in relation to gambling, comprise: (1) expectations about gambling, such as the positive reinforcement value (e.g., excitement) or negative reinforcement value (e.g., relief of negative mood or boredom) (Jacobs, 1986; Raylu & Oei, 2002); and (2) beliefs about the ability to stop or control gambling (Sharpe, 2002).

The current study sought to examine the relationships between individual differences in the susceptibility to gambling-related cognitions and reactions to near-miss events during a laboratory gambling task. Participants completed a simplified slot machine task used previously to measure subjective (and neural) responses to gambling outcomes (Clark *et al*., 2009). This task resembles a real slot machine and involves monetary reinforcement, which is known to be important in generating physiological arousal in laboratory settings (Ladouceur, Sévigny, Blaszczynski, O'Connor, & Lavoie, 2003; Wulfert, Roland, Hartley, Franco, & Wang, 2005). Two modifications were made from the task used previously. First, a persistence phase was introduced after 30 trials, in order to obtain a *behavioural* index of gambling propensity. Second, given that the effects of near-misses on gambling motivation were restricted to trials with personal choice in previous data (Clark *et al*., 2009), we removed the no-choice trials from the present design, reasoning that persistence may be better assessed with a shorter task. We used the GRCS (Raylu & Oei, 2004) to measure the five types of gambling cognitions outlined above. We controlled for overt levels of disordered gambling using the South Oaks Gambling Screen (SOGS;Lesieur & Blume, 1987), and we assessed social desirability bias given that this may distort self-reported gambling involvement and subjective ratings on gambling tasks (Kuentzel, Henderson, & Melville, 2008).

Two main hypotheses were postulated according to the various subtypes of gambling cognitions measured. First, we hypothesized that distorted cognitions about success and/or skills (i.e., interpretive bias, predictive control, illusion of control) would predict both the motivational effects of near-miss outcomes (i.e., the reported desire to play again after a near-miss) and persistent play in the laboratory task (i.e., the number of

trials played in the extinction phase). Indeed, based on previous works on the effect of near-misses (e.g., Griffiths, 1991), it can be supposed that individuals who think that personal skills or knowledge are involve in gambling will be more likely to consider near-miss outcomes as indicators of imminent success. In contrast, we predicted that although beliefs about the self in relation to gambling (i.e., perceived inability to stop gambling, gambling expectancies) would predict persistent play in the laboratory task, they will not influence the motivational ratings following near-miss outcomes, which would rather depend upon distorted predictions regarding future outcomes promoted by the cognitions about success and/or skills.

Method

Participants and procedure

Participants were volunteers recruited by advertisement. The sample comprised a majority of undergraduate students (68.4%; $N = 54$). The inclusion criterion was being an occasional or regular gambler, and a fluent French speaker. Exclusion criteria were any recent or ongoing depressive episode or anxiety disorder, and any reported neurological disorder. Undergraduate psychology students were excluded, due to possible familiarity with the questionnaire measures. One participant reported receiving treatment for ongoing depression and eating disorder and was excluded after performing the experiment. The sample comprised 84 participants (53 females and 31 males) with an average age of 24.6 years (range 18–62, $SD = 6.20$). The average years of education were 15.6 years (range 9–22, $SD = 2.41$). Participants were tested individually in a quiet laboratory. The protocol was approved by the Geneva psychology research ethics committee and all volunteers provided written informed consent. Participants first completed a demographic sheet and a questionnaire about their gambling activities and frequency of gambling. Participants then performed the slot machine task followed by a short questionnaire about the task. As a final stage, participants completed the three self-report questionnaires, in a randomized order: the SOGS (Lesieur & Blume, 1987), the GRCS (Raylu & Oei, 2004), and the Social Desirability Scale (Tournois, Mesnil, & Kop, 2000). On completion, participants received their winnings from the slot machine task.

The slot machine task

A modified version of the slot machine task (Clark *et al*. 2009) was used to present three types of gambling outcomes: wins, near-misses, and full-misses. The task was programmed in Microsoft Visual Basic 6, with responses registered on three adjacent keyboard keys. The task display resembles a two-reel slot machine, with the same six icons displayed, in the same order, on the left and right reel, and a horizontal 'payline' across the centre of the screen (see Figure 1). The participant began the task with an endowment of five CHF (Confederation Helvetia Francs), and was briefed that s/he would win and lose money during the task, and that, on completion, the final amount would be delivered in real money. At the beginning of the task, the subject was asked to select six icons to play with, from 16 alternatives arranged in a 4×4 matrix. This feature was included to enhance the participants' level of involvement, and subjects were instructed that the available shapes would vary in the chances of winning during the game. After selecting their icons, the subject played four practice trials, followed by 30 trials with monetary reward available. On each trial, a 2–7 s inter-trial interval was followed by a

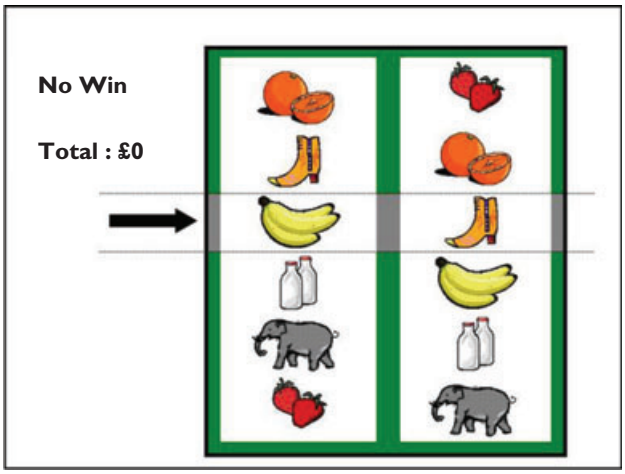

Figure 1. Slot machine task, reprinted from Clark *et al.* (2009) with permission of Elsevier. Note the actual task used in the present experiment used a French translation of all text, with wins in Swiss francs (CHF).

selection phase (duration 5 s), where the participant selected one of the icons on the left-hand reel, by scrolling around the reel with two keys (up or down) and selecting an icon with the third key. During selection, a 0.15 CHF wager was automatically placed on each trial. If the selection was not completed within the 5 s window, a 'too late' message was displayed and the next trial began (the wager was lost). Following selection, the right-hand reel spun for an *anticipation* phase (variable duration 2.8–6 s.), and decelerated to a standstill. In the *outcome* phase (duration 4 s), if the chosen play icon stopped in the payline of the right-hand reel (i.e., the two reels aligned with one another), the participant won one CHF. Trials where the right-hand reel stopped one position from the payline were classified as near-misses, and trials where the right-hand reel stopped more than one position from the payline were classified as full-misses. Outcomes were presented in a fully balanced pseudo-random order to ensure a proportionate number of wins over the 30 trials (1/6, total five), near-misses (2/6, total 10), and full-misses (3/6, total 15).

On each trial, subjective ratings were acquired using on-screen visual analog scales. After the selection phase, subjects rated 'How do you rate your chances of winning?' and after the outcome phase, two further ratings were taken: 'How pleased are you with the result?' and 'How much do you want to continue to play the game?'. Participants indicated their responses on a 21-point scale (scored from −100 to + 100 for pleasantness ratings and from 0 to 100 for desire to play again, and chances of winning ratings) using two keys to move left and right and another key to confirm. No time limit was imposed for the subjective ratings.

At the end of the 30 mandatory trials, participants entered a *persistence* phase in which they could continue to play, or quit the game at any point and collect their winnings. This phase was signalled by appearance of a button reading 'QUIT' in the top right corner of the display. The pay-off structure of the task ensured a marginal profit for participants at the end of the mandatory phase; we reasoned that if participants finished the mandatory phase in debt, they would be unlikely to continue to play further. During the persistence phase, wins were eliminated in order to assess continued responding

in extinction (e.g., Cote *et al*., 2003; Kassinove & Schare, 2001), such that continued play would now lead to reduced winnings and, ultimately, bankruptcy (if wins were maintained in the persistence phase, participants may be expected to continue to play indefinitely). The proportion of full-misses and near-misses in the persistence phase was adjusted to two-third and one-third, respectively, and in all other respects, these trials were identical to the mandatory phase of the task. The number of trials played in the persistence phase was used as an outcome measure.

Gambling-related cognitions scale (GRCS)

The GRCS (Raylu & Oei, 2004) consists of 23 items assessing a variety of gambling-related cognitions that are present in the general population as well as in disordered gambling. Items are scored on a Likert scale from 1 = 'strongly disagree' to 6 = 'strongly agree'. The GRCS has five subscales: (1) interpretive bias (e.g., 'relating my losses to probability makes me continue gambling'; Cronbach's alpha = .80); (2) illusion of control (e.g., 'praying helps me win'; Cronbach's alpha = .72); (3) predictive control (e.g., 'losses when gambling, are bound to be followed by a series of wins'; Cronbach's alpha = .73); (4) gambling-related expectancies (e.g., 'having a gamble helps reduce tension and stress'; Cronbach's alpha = .79); and (5) perceived inability to stop gambling (e.g., 'my desire to gamble is so overpowering'; Cronbach's alpha = .74). For the purposes of this study, the French translation of the GRCS was used (Grall-Bronnec *et al*., 2011), which consists of the 23 original items translated into French using translation and back-translation. The original five-factor structure of the GRCS has been applied successfully to the French GRCS through the use of exploratory and confirmatory factor analyses (see Grall-Bronnec *et al*., 2011).

South Oaks Gambling Screen (SOGS)

The SOGS (Lesieur & Blume, 1987) is a 16-item questionnaire based on the symptoms of pathological gambling in the third edition of the Diagnostic and Statistical Manual of mental disorder (DSM-III; American Psychiatric Association, 1980). We administered the French version of the SOGS (Lejoyeux, 1999). The SOGS assesses core symptoms and negative consequences of gambling (e.g., borrowing money, family conflict), with items scored 0 (no) or 1 (yes). The SOGS has been cross-validated against a DSM semi-structured interview, in both community participants (e.g., Cox, Enns, & Michaud, 2004) and treated patients with pathological gambling (e.g., Strong, Lesieur, Breen, Stinchfield, & Lejuez, 2004). The internal consistency of the SOGS was high (Cronbach's alpha = .88). SOGS ≥ 1 is often considered as a potential sign of risky gambling, whereas SOGS >4 indicates problem gambling (e.g., Kassinove & Schare, 2001).

Social Desirability Scale (DS-36)

The DS-36 (Tournois *et al*., 2000) is a 36-item French questionnaire designed to assess two facet of the construct: (1) auto-deception, that is, the tendency to give favourable but honest self-descriptions, and (2) hetero-deception, that is, the tendency to give an excessively favourable self-description to others. All items are scored on a Likert scale from 0 = 'totally false' to 6 = 'totally true'. The current analysis used only the hetero-deception subscale, as we held no study hypotheses for auto-deception, and the tendency to manage impressions has been shown to influence self-report descriptions of gambling

behaviour in both college students and problem gamblers (Kuentzel *et al.*, 2008). The internal reliability (Cronbach's alpha) was .74 for the hetero-deception subscale.

Statistical analyses

One-way repeated measures ANOVAs were conducted to compare subjective ratings from the mandatory phase of the slot machine task, to the three gambling outcomes (win, near-miss, full-miss). Pearson correlations were used to evaluate relationships between variables. Pearson-point biserial correlations were used to evaluate the effects of gender (female = 1; male = 2). As our sample is composed of gamblers from the community, scores on the SOGS were skewed and we recoded SOGS scores in dichotomous scores (SOGS $< 1 = 1$; SOGS $\geq 1 = 2$), in order to also model SOGS associations using Pearson's point-biserial correlations. The correlations were considered statistically significant at $p < .05$, corrected for multiple comparisons by using the Benjamini and Hochberg's false discovery rate procedure (Benjamini & Hochberg, 1995).

Linear multiple regressions analyses were performed to examine the contributions of the various types of gambling-related cognitions, dichotomized SOGS score, and social desirability, upon the 'continue to play' ratings, and gambling persistence in the slot machine task. Pairwise treatment of missing data was applied on all analyses.

Results

Variation in gambling behaviour

The sample comprised both regular and occasional gamblers: 32.1% ($N = 27$) played at least once a week, whereas the remaining 67.9% were occasional gamblers playing at least once a month ($N = 57$). The forms of gambling practiced were: scratch-cards (96.2%); lotteries (83.3%); poker (non-internet based; 70.5%); slot machines (59%); online poker (19.2%); sport betting (15.4%); and roulette (6.4%).[1] The mean number of different gambling activities was 3.50 ($SD = 1.09$). Maximum expenditures in a single gambling session varied from five CHF to 2,000 CHF ($M = 99.11$, $SD = 257.93$).[2] The scores on the SOGS ranged from 0 to 7 ($M = 0.50$, $SD = 1.04$), although data were highly skewed with 56 participants (66.6%) scoring 0, and 28 participants (33.3%) scoring between 1 and 7.

Results for the slot machine task

Two participants were excluded as performance outliers (these participants displayed rapid icon selection latencies, choice of the same icon for the 30 mandatory trials, and zero persistence). Three ANOVAs were computed on the remaining 82 participants, to investigate the subjective effects of the gambling outcomes. First, on the 'pleased with outcome' rating ($M_{\text{win}} = 62.9$, $SD_{\text{win}} = 35.9$; $M_{\text{near-miss}} = -57.0$, $SD_{\text{near-miss}} = 34.6$; $M_{\text{full-miss}} = -57.2$, $SD_{\text{full-miss}} = 35.3$), the effect of outcome was significant,

[1] *Given that our task was a slot machine simulation, and only 59% of the sample reported playing slot machines, we computed Pearson-point biserial correlations to evaluate whether slot-machine players reacted differently to non-players on the task. This further analysis revealed that slot-machine player status had no influence on either subjective ratings or persistence in the simplified slot machine task.*

[2] *The Swiss Franc (CHF) to pound sterling (GPB) conversion rate was approximately 1–0.65 in 2010 during data collection.*

$F(2, 162) = 314.38$, $p < .001$, $\eta^2 = .80$. *Post hoc* comparisons showed that participants were more pleased after wins compared to both near-misses $t(81) = 17.84$, $p < .001$, and full-misses, $t(81) = 17.75$, $p < .001$, with no difference between pleasantness ratings of near-miss and full-miss outcomes, $t(81) = 0.17$, $p = .87$. Second, on the 'continue to play' rating ($M_{win} = 51.4$, $SD_{win} = 23.6$; $M_{near-miss} = 40.8$, $SD_{near-miss} = 18.8$; $M_{full-miss} = 36.2$, $SD_{full-miss} = 19.6$), the effect of outcome was also significant, $F(2, 162) = 52.69$, $p < .001$, $\eta^2 = .39$. Participants reported more desire to play again after a win than after either a near-miss or a full-miss, $t(81) = 7.23$, $p < .001$, and reported a stronger desire to play again after a near-miss than after a full-miss, $t(81) = 7.53$, $p < .001$. Thus, despite reporting that near-misses and full-misses were similarly unpleasant, participants displayed increased motivation to play again after a near-miss compared to a full-miss. Third, the ratings of 'chances of winning' taken after icon selection ($M_{win} = 36.5$, $SD_{win} = 20.9$; $M_{near-miss} = 38.0$, $SD_{near-miss} = 18.9$; $M_{full-miss} = 36.7$, $SD_{full-miss} = 19.4$) were analysed in relation to the prior outcome (i.e., the rating following a win, a near-miss, and a full-miss). No significant effect of prior outcome type was observed, $F(2, 162) = 1.13$, $p = .33$, $\eta^2 = .01$. The number of trials played in the persistence phase varied from 0 to 43 ($M = 4.0$, $SD = 7.6$). Two other participants who were outliers on the persistence phase (43 and 37 trials) were excluded from further analysis.[3] In the remaining 80 participants, the number of persistence trials ranged from 0 to 25 ($M = 3.2$, $SD = 5.1$), and 33 participants (41.3%) stopped playing immediately upon entering the extinction phase. In the participants who played at least one trial in extinction, the mean persistence score was 5.4 ($SD = 5.8$). Persistence in the extinction phase was not significantly related to 'pleased with outcome' ratings, but was positively correlated with the 'continue to play' ratings following all outcome types, lending support to the validity of the persistence index (see Table 1).

Relationships between gambling-related cognitions and the slot machine task

Correlational and multiple regression analyses were computed to test our predictions concerning the influence of trait gambling cognitions. First, we explored the univariate relationships between GRCS, the subjective ratings and persistence measure on the slot machine task, the level of disordered gambling (SOGS), and social desirability bias (DS-36) (see Table 1).[4] Several significant relationships were observed between the types of gambling-related cognitions and the variables of the slot machine task. In general, all five GRCS subscales were positively related with 'continue to play' ratings after wins, near-misses, and full-misses, as well as with persistence on the task. The SOGS was positively correlated with 'pleased with outcome' ratings after a win.

The univariate correlations indicate that both the 'continue to play' ratings and persistence on the slot machine task were multi-determined, as reflected by significant relationships with both gambling-related cognitions and the magnitude of pleasure following win outcomes. In addition, we could not exclude the possibility that social desirability bias had an impact on participants' responses on the task. Multiple regression

[3] *We have also computed the analyses without removing these two participants and the results remained similar.*

[4] *Correlations concerning demographics (age, gender, years of education) are not reported in the results. Some demographic associations were however observed: males had higher scores on two subscales of the GRCS, namely gambling expectancies; perceived inability to stop gambling), and they played more trials in persistence, compared to females. Older participants had higher scores on the 'gambling expectancies' subscale of the GRCS. Level of education was unrelated to gambling variables.*

Table 1. Pearson correlations between subjective ratings in the slot machine task, gambling cognitions, problem gambling, and social desirability

	Again-W	Again-NM	Again-FM	Persistence			
Pleasure-W	.44*	.34*	.26	.12			
Pleasure-NM	.03	.17	.25	.15			
Pleasure-FM	.04	.17	.26	.16			
Persistence	.36*	.49*	.48*	-			
	SOGS	GRCS-IB	GRCS-IC	GRCS-PC	GRCS-GE	GRCS-IS	DS36-HD
Pleasure-W	.33*	.28	.11	.23	.13	.13	.08
Pleasure-NM	−.12	.01	−.01	−.10	.04	.02	.02
Pleasure-FM	−.15	−.03	.01	−.13	.01	−.02	.06
Again-W	.21	.30*	.23	.26	.25	.28	.12
Again-NM	.24	.43*	.31*	.36*	.36*	.25	.26
Again-FM	.23	.37*	.27	.32*	.31*	.22	.29
Persistence	.10	.38*	.38*	.42*	.39*	.56*	−.02

*Comparisons significant at $p < .05$, corrected for multiple comparisons using the false discovery rate procedure.

Note. Pleasure-W, pleasure ratings after a win in the slot machine task; Pleasure-NM, pleasure ratings after a near-miss in the slot machine task; Pleasure-FM, pleasure ratings after a full-miss in the slot machine task; Again-W, desire to play again ratings after a win in the slot machine task; Again-NM, desire to play again ratings after a near-miss in the slot machine task; Again-FM, desire to play again ratings after a full-miss in the slot machine task; Persistence, number of trials played during the extinction phase of the slot machine task; SOGS, South Oaks gambling screen (1 = SOGS ≥ 1; 0 = SOGS < 1); DS36-HD, Social Desirability scale – hetero-deception; GRCS-IB, gambling-related cognitions scale – interpretive bias; GRCS-IC, gambling-related cognitions scale – illusion of control; GRCS-PC, gambling-related cognitions scale – predictive control; GRCS-GE, gambling-related cognitions scale – gambling-related expectancies; GRCS-IS, gambling-related cognitions scale – perceived inability to stop gambling.

was thus used to examine the specific contributions of the various types of gambling-related cognitions to the 'continue to play' ratings following each type of outcome, and overall gambling persistence, while controlling symptoms of disordered gambling, the pleasure provoked by win outcomes, and social desirability. Eight independent predictors were entered in the four initial regression analyses: SOGS (scored dichotomously), the pleasure ratings associated with wins on the slot machine task, the hetero-deception facet of the DS-36, and the five subscales of the GRCS. In running the initial linear regressions, multicollinearity was evidenced (i.e., a strong link between two predictors of the regression, indicated by a variance inflation factor >2.5 and tolerance score <.30, see e.g., Allison, 1999), and appeared to be attributable to a strong correlation between the 'interpretive bias' and 'predictive control' subscales of the GRCS ($r = .78$). Indeed, there is clear thematic overlap between these subscales. Accordingly, we regrouped these subscales in a single factor that we labelled 'interpretive and predictive control', and reran the regression analyses (with seven independent predictors instead of eight). Inspection of residuals and multicollinearity effects showed that the conditions of application for regression analyses were respected.

These regression models indicated several key effects (see Table 2): (1) the 'continue to play' rating after a win was only significantly predicted by the pleasure associated with winning; (2) the 'continue to play' rating after a near-miss was significantly predicted

Table 2. Standardized and non-standardized regression coefficient for the multiple regression analyses

Dependent variable	Independent predictors	*B*	*SE B*	*t*	β	*p*
Desire to play again	SOGS	−2.15	5.81	−0.37	−.04	.713
After wins	Pleasure experienced after wins	0.25	0.07	3.51	.38	.000
	Hetero-deception (DS-36)	5.49	4.03	1.36	.15	.177
	Predictive and Interpretive control/bias (GRCS)	2.89	0.75	0.75	.11	.456
	Illusion of control (GRCS-IC)	0.89	2.79	0.32	.04	.751
	Gambling expectancies (GRCS-GE)	0.42	3.06	0.14	.02	.892
	Perceived loss of control (GRCS-IS)	7.23	5.41	1.34	.19	.186
Desire to play again	SOGS	−1.87	4.41	−0.42	−.05	.673
After near-misses	Pleasure experienced after wins	0.12	0.05	2.16	.23	.034
	Hetero-deception (DS-36)	9.05	3.06	2.96	.31	.004
	Predictive and Interpretive control/bias (GRCS)	4.39	2.19	2.00	.27	.049
	Illusion of control (GRCS)	0.70	2.12	0.33	.04	.743
	Gambling expectancies (GRCS)	3.21	2.32	1.38	.19	.171
	Perceived loss of control (GRCS)	0.87	4.11	0.21	.03	.833
Desire to play again	SOGS	−0.57	4.83	−0.12	−.01	.907
After full-misses	Pleasure experienced after wins	0.08	0.06	1.27	.14	.209
	Hetero-deception (DS-36)	10.34	3.35	3.09	.33	.003
	Predictive and Interpretive control/bias (GRCS)	4.28	2.40	1.78	.25	.079
	Illusion of control (GRCS)	0.44	2.32	0.19	.02	.851
	Gambling expectancies (GRCS)	2.60	2.55	1.02	.15	.311
	Perceived loss of control (GRCS)	1.51	4.50	0.33	.05	.739
Persistence in the	SOGS	−1.62	1.17	−1.38	−.15	.173
Slot machine task	Pleasure experienced after wins	0.00	0.01	0.20	.02	.838
	Hetero-deception (DS-36)	1.04	0.82	1.28	.13	.203
	Predictive and Interpretive control/bias (GRCS)	1.13	0.58	1.95	.25	.056
	Illusion of control (GRCS)	0.27	0.56	0.48	.06	.631
	Gambling expectancies (GRCS)	−0.29	0.62	−0.46	−.06	.644
	Perceived loss of control (GRCS)	4.23	1.09	3.88	.52	.000

by the GRCS 'interpretive and predictive control' composite scale, by the pleasure associated with winning, and by social desirability bias (DS-36); (3) the 'continue to play' rating after a full-miss was only significantly predicted by social desirability bias (DS-36); and (4) persistence was only significantly predicted by perceived inability to stop gambling (GRCS).

Our *a priori* hypotheses were thus partially verified. First, we found that distorted cognitions about the role of personal skills in games of chance predict the motivational effects of near-miss outcomes, although this finding was restricted to the cognitions related to interpretive bias and predictive control. In addition, a marginal relationship exists between this type of gambling-related cognitions and persistence in the slot machine task ($p = .056$). Second, beliefs about the self in relation to gambling are differentially linked to persistent play: perceived lack of control predicted persistent play, but gambling expectancies did not.

Discussion

The aim of the study was to examine whether gambling-related cognitions influence behaviour and subjective feelings in a laboratory slot machine task. Near-misses were compared against full-miss outcomes that were objectively equivalent (i.e., both outcomes constituted non-wins with loss of wager). Although near-misses and full-misses were evaluated as similarly unpleasant on a 'pleased with outcome' rating, the near-misses were associated with higher ratings of 'continue to play' compared to full-misses, consistent with previous work conducted with this task (Clark *et al.*, 2009). In the present study, a persistence phase was included to assess continued play in extinction, as a behavioural index of gambling propensity. Persistent play was correlated with higher subjective ratings of 'continue to play' following all types of outcome. The two major findings of the study are that: (1) individual differences in gambling cognitions related to interpretive bias and predictive control predicted higher 'continue to play' ratings after near-miss outcomes; and (2) perceived inability to stop gambling predicted persistent play.

In the current study, we found that the 'interpretive bias' and 'predictive control' factors of the GRCS were strongly related and may be considered more parsimoniously within a single factor of 'skill-oriented cognitions' (i.e., beliefs that skills or knowledge may be acquired to increase the likelihood of winning, e.g., 'a series of losses will provide me with a learning experience that will help me win later'). Indeed, the high correlation between these subscales resulted in multicollinearity problems that violated assumptions for multiple regression. These skill-oriented cognitions, along with the pleasure evoked by wins, and trait social desirability bias, all predicted the desire to play again after near-misses on the slot machine task. Other aspects of gambling-related cognitions – notably, the 'illusion of control' factor of the GRCS – did not predict the desire to play after near-misses, although it is important to recognize that this subscale predominantly emphasizes ritual-oriented cognitions (i.e., beliefs that superstitions or rituals influence winning, e.g., 'praying helps me win'). The desire to play after a win was better predicted by the subjective pleasure associated with that win, and the desire to play after a full-miss was only predicted by social desirability. Thus, it seems that one may usefully distinguish between illusory control fostered by internal factors such as game-related skills and knowledge from illusory control fostered by external factors such as luck, superstitions, and rituals (ritual-oriented cognitions) (Steenbergh *et al.*, 2002). Our data indicate that the motivational effects of the near-miss outcomes (i.e., the degree of desire to play

again after this type of outcome) are specifically aligned with skill-oriented cognitions activated during gambling.

The link between the near-miss and skill-oriented cognitions is consistent with the broader hypothesis that near-miss outcomes are directly appraised as evidence of skill acquisition (see Griffiths, 1991; Reid, 1986). This appraisal is in fact valid in most games of skill (e.g., archery, soccer), where near-misses provide a signal of imminent success, but this is an erroneous interpretation under conditions of pure chance. By providing a false signal of skill acquisition, near-misses foster the desire to play again. In accordance with our first hypothesis, the data demonstrate that distortions related to perceived skill involvement in the game predict the motivational impact of near-miss outcomes (i.e., the self-reported desire to play again ratings). A marginal relationship ($p = .056$) was observed between skill-oriented cognitions and persistent play in the slot machine task, suggesting that this type of cognitions may influence behavioural measures of persistence as well as subjective ratings of motivation. It should be mentioned here that interpretive bias and predictive control also played a minor role in the desire to play again following full-misses, as reflected by the non-significant trend in the regression analysis ($p = .079$). Thus, certain skill-oriented cognitions promote the desire to play again after loss outcomes in general (full-misses and near-misses), and this mechanism may be especially true for beliefs about probabilities and randomness (e.g., a failure to appreciate the statistical independence of turns). Accordingly, examination of such effects in a task presenting longer sequential effects (e.g., a succession of full-miss outcomes) may be worthwhile.

In contrast, we saw no association between gambling cognitions pertaining to rituals and superstitions (the GRCS 'illusion of control' subscale) and subjective ratings following near-miss experiences. We would argue that the 'illusion of control' as originally defined by Langer (1975) (see also Thompson, Armstrong, & Thomas, 1998) comprises a wider range of erroneous cognitions than those reflected in the GRCS subscale, and should include skill- and knowledge-related cognitions besides thoughts about gambling rituals and superstitions. That said, the dissociation between these two GRCS components in predicting the reactions to near-misses also suggests that it may be unhelpful to view the illusion of control as a unitary construct. We note that the ritual-oriented cognitions factor does not thoroughly interrogate beliefs in personal luck, which Wohl and Enzle (2003) link to near experiences on a wheel of fortune task: participants who tended to feel lucky increased their bet size after near outcomes. The effects in that experiment were driven primarily by near-losses rather than near-wins, and only one item on the GRCS (item 9, loading on the 'illusion of control' subscale) clearly targets personal luck. As a final point, skill-oriented and ritual-oriented beliefs are not mutually exclusive (see e.g., Lesieur, 1977, p. 31–34), and many gamblers may invoke both types of distortion (in the present dataset, a moderate correlation was observed between 'interpretive and predictive control' and 'illusion of control', $r = .55$, $p < .001$).

We also hypothesized that certain beliefs about the self in relation to gambling would predict persistent play. In this regard, another important finding of the study was that trait-related individual differences in the perceived inability to stop gambling (GRCS subscale) (e.g., 'I am not strong enough to stop gambling') predicted the number of trials played on the slot machine task in a free-choice phase under conditions of extinction. In contrast, perceived lack of control did not predict subjective ratings of desire to play, following any outcome type. This dissociation underscores the necessity to distinguish between the motivational impact of an outcome on the subjective desire to play again,

from actual persistent play as a behavioural corollary. More precisely, inhibitory control will be necessary when a gambler who experiences a strong desire to play again (e.g., after a near-miss outcome) tries to stop playing. Individuals with weak inhibitory function will thus probably have more difficulty to voluntarily stop gambling in these situations than those with more efficient inhibitory control. This hypothesis is in accordance with data showing inhibition functions to be impaired in problem gamblers (e.g., Goudriaan, Oosterlaan, de Beurs, & Van den Brink, 2006; Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009) as well as in other putative behavioural addictions (e.g., compulsive buying, overuse of the internet) (e.g., Billieux, Gay, Rochat, & Van der Linden, 2010; Sun *et al.*, 2009.)

We confirmed the need to control for social desirability biases, and more specifically hetero-deception proneness, when assessing self-reported gambling behaviours. While these biases are well recognized in questionnaire-based research (see Dunning, Heath, & Suls, 2004), they are rarely assessed in studies of gambling (e.g., Kuentzel *et al.*, 2008). In our data, social desirability influenced subjective ratings in the slot machine task, but was unrelated to the behavioural index of persistent playing. In addition, social desirability was the only predictor of the desire to play again after loss outcomes. At a more global level, the fact that gambling-related cognitions still predicted the desire to play again after near-misses outcomes, while controlling for participant's social desirability bias, increased the validity of our findings.

Several limitations should be noted. Our two-reel slot machine simulation was greatly simplified compared to commercial gaming machines, imposing some limits to external validity. Our task was initially designed for event-related neuroimaging and psychophysiology (Clark *et al.*, 2009; Clark, Crooks, Clarke, Aitken, & Dunn, 2011), where a two-reel task with a single stop allows clearer modelling of outcome-related physiological activity. A further advantage of a two-reel task is to limit the number of different types of near-miss that could be delivered, as any differences between XXO, XOX, and OXX near-misses have not been thoroughly characterized in extant research. There are also wider issues about the feasibility of studying gambling in the psychological laboratory versus naturalistic settings (Gainsbury & Blaszczynski, 2011), and we note our design included trial-by-trial monetary reinforcement, which appears to be an important prerequisite for excitement and arousal (Ladouceur *et al.*, 2003; Wulfert *et al.*, 2005). Indeed, our observations that individual differences in gambling-related cognitions predicted the motivational effects of near-misses and persistent play on a simulation task provide a clear indication that fundamental aspects of gambling behaviour can be modelled in the laboratory.

A second caveat applies to our sample, who were recreational gamblers playing at least monthly, but with an overall low rate of gambling problems: only 10% of the sample had a SOGS score of 2 or more. Although pathological gambling is currently diagnosed by endorsing five from 10 listed criteria, substantial gambling harms are evident in regular gamblers who do not meet this arbitrary threshold (Toce-Gerstein, Gerstein, & Volberg, 2003). Moreover, gambling cognitions such as those measured on the GRCS are prevalent even in non-gamblers, but scores increase with gambling involvement, and pathological gamblers score very high on the GRCS (Michalczuk, Bowden-Jones, Verdejo-Garcia, & Clark, 2011). A final point worth making is that treatment programs for pathological gambling are likely to directly attenuate the gambling cognitions that we are studying (Breen, Kruedelbach, & Walker, 2001). Recreational gamblers, therefore, serve as a useful population for studying the transitional processes that cause regular play to become excessive and problematic. Nevertheless, further examinations of the links

between near-miss outcomes and gambling-related cognitions in clinical populations are clearly required. For example, gambling expectancies (the motivation to gamble to relief negative affect or to promote positive affect) are thought to play a central role in pathological gambling (e.g., Jacobs, 1986), and may have predictive utility in clinical groups that can not be seen in recreational gamblers.

In conclusion, this study assessed the relationships between gambling-related cognitions, and behavioural and subjective measures of gambling propensity including the near-miss effect. Skill-oriented cognitions predicted the subjective effects of near-misses on the desire to play. In contrast, persistent play on the simulated gambling task was predicted by specific gambling-related cognitions about perceived poor self-control. Enhanced understanding of the psychological mechanisms underlying the motivational effects of gambling near-misses will have important implications for gambling legislation (e.g., restrictions on near-miss events in electronic machines; Harrigan, 2008; Parke & Griffiths, 2004), and the characterization of individual differences in these effects may inform our understanding of disordered gambling (Ladouceur, Sylvain, Boutin, & Doucet, 2002).

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