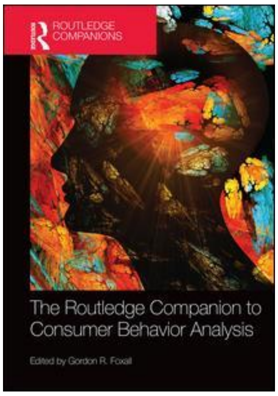

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When loss rewards

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When loss rewards

The near-miss effect in slot-machine gambling

Gordon R. Foxall and Valdimar Sigurdsson

Introduction

It is well established that slot-machine gamblers whose scores closely resemble a winning combination (but which objectively are losses) often seem encouraged thereby to continue playing (Côté et al., 2003; Griffiths, 1994; Reid, 1986; Skinner, 1953). Attempts to explain this "near-miss effect" often implicate neural functioning (e.g., Qi et al., 2011). After all, the same brain regions are recruited in the case of near-misses as are apparent for wins (notably the reward circuits of the midbrain dopaminergic system and the orbitofrontal cortex of the forebrain which they innervate), while losing activates separate neural areas (Chase & Clark, 2010; Habib & Dixon, 2010). This is consistent with a corpus of research findings indicating that pathological gambling (PG) recruits similar neuronal systems as substance addiction.

Another explanation invokes "cognitive distortion" to account for gamblers' apparently judging near-misses as indications that the probability of winning has been increased (Griffiths, 1994). This cognitive approach involves the attribution to gamblers of beliefs about the nature of the game, how it operates, and their own progress as players. Such a judgment might be relevant to the learning of a skill, but is unjustified in the context of games that have probabilistic outcomes. But this "gambler's fallacy" is actually widespread, as is supported by the finding that regular gamblers perceive a greater degree of skill to be involved in slot-machine gambling than do non-regular gamblers and that gamblers' perceived control is related to their gambling persistence (Clark et al., 2009, 2012; Chase & Clark, 2010). An implication is that the treatment of problem gamblers ought to concentrate on the (re-)learning of cognitive judgments by means, inter alia, of cognitive-behavior therapy.

A third explanation attributes gamblers' persistence to environmental factors that would be expected to influence the rate of behavioral performance if it were conceptualized as operant (e.g., Hoon et al., 2008). These include the primary and secondary schedules of reinforcement in effect when slot machines permit near-miss outcomes, and the temporal and spatial positioning of symbols indicating performance outcomes (e.g., prevalence of near-misses). This approach elucidates not only the influence that direct physical situational factors, such as reinforcement schedule(s) and the design configuration of the gambling machine, exert on playing, but also that of gamblers' verbalizations in the course of play that may guide their behavior.

Research on these "self-rules," verbalizations of the apparent contingencies, may inform the search for cognitive distortions that influence gamblers' choices.

None of these approaches, taken alone, provides a comprehensive account of the near-miss phenomenon. To synthesize the disparate results on the near-miss effect, this paper argues that the near-miss phenomenon can be understood if gambling is placed within the context of consumer choice. It conceptualizes gambling as a mode of consumer behavior within a model of economic choice that embraces both routine, everyday buying and the extreme consumption involved in addiction. The empirical research generated by this behaviorist model of consumption indicates that reinforcement includes both the functional or utilitarian benefits of consumer behavior and the symbolic or informational sources of benefit that are recognized in social status and self-esteem. This model, the Behavioral Perspective Model of purchase and consumption (BPM; Foxall, 1990), integrates the neurophysiological, verbal, and contextual elements identified in research on the near-miss phenomenon, showing that the construct of informational or symbolic reinforcement, allied to arousal, provides a key to understanding this otherwise anomalous phenomenon.

Neurophysiology of the near-miss

Classifying PG as an addiction requires more than the observation that it is irrational or compulsive at the behavioral level. It requires a convincing degree of continuity of such gambling with substance addiction. Ross et al. (2008) argue that this is the case and that PG should be considered a genuine addiction on biophysical grounds, indeed the paradigm case. This has been supported by some correlational research that has revealed a relationship between PG and a deficiency of the mesolimbic dopaminergic reward system. Reuter et al. (2005) found a lower activation of the right ventral striatum in PG compared with a control group and a regression analysis revealed a negative correlation between signal changes in the ventral striatum and the severity of gambling behavior as revealed in a questionnaire. Notwithstanding this, more arguments regarding gambling as addiction are needed, especially as the neurophysiological studies tend to deal with correlational issues instead of experimental analysis. Hence, patterns of behavior which may become addictive if reinforced might be identifiable through early identification of their neurophysiological correlates. The widespread assumption that increasingly persistent gambling in the face of near-misses constitutes such a precursor of addiction would be supported if a neurophysiological basis were established for it.

Griffiths: psychobiology of the near-miss

In early contributions, Griffiths (1990a, b, c) drew attention to the biological import of research on near-misses, mentioning specifically investigations of a potential neurophysiological substrate in PGs, the role of arousal in gambling, and the role of endorphins. Among the literature he reviewed at that time, Griffiths (1991) mentioned Carlton and Manowitz's (1987) use of electroencephalogram (EEG) measures to determine whether hemispheric dysregulation is related to impulse-control failure. PGs (compared with controls) showed hemispheric activation deficits on verbal and nonverbal tasks similar to those found in some kinds of Attention Deficit/Hyperactivity Disorder involving inattention and impulsivity. In addition, PGs tend to be deficient in serotonin, a neurotransmitter which inhibits control of inattention and impulsivity. In the context of a possible substrate for excessive gambling, Griffiths (1991) also mentioned the work of Roy et al. (1988), who found PGs had "a significantly higher centrally produced fraction of cerebrospinal fluid level of 3-methoxy-4 hydroxyphenolglycol" which is believed to stimulate impulsive behavior and sensation seeking (Griffiths, 1990a, p. 349).

The role of arousal is sufficiently established in excessive gambling for the comment that excitement is the "gambler's drug" to have become a cliché (Brown, 1986, 1987). A prevalent neurophysiological measure is heart rate (HR), which is shown to increase during gambling. Also important from the point of view of relating neurophysiological and cognitive/social research is the finding that physiological measures of arousal correlate well with verbal reports of arousal as a subjective reaction (Mehrabian, 1980). Finally, there was emerging evidence in 1991 that endorphins (endogenous morphine) mimic the effect of opiates and mediate PG. Despite the emerging evidence for a biological basis for PG, however, Griffiths (1990b) concluded emphatically from his own research, based on questionnaire and interview methods, that both neurophysiological and cognitive factors play a part in excessive slot-machine gambling. In particular, persistent gambling entails cognitive bias: illusions of control, biased evaluations, and near-miss as a reinforcer rather than a punisher (see also Reid, 1986). His respondents' sole recreation was fruit (slot) machine playing since nothing else stimulated them in the same way. They played especially when they reported being "depressed" or "feeling down," since the slot-machine gambling changed their mood to a "high" (during gambling), though this was followed by a "low" and, eventually, anger. They mentioned excitement, which was immediate albeit short-lived, as the predominant reinforcer, but winning money was also important. Importantly, PGs differed from non-PGs in experiencing statistically significantly higher levels of excitement during gambling. These results support the findings of others with respect to arousal and endorphins (though the research was not specifically intended to elucidate any biological substrate). Griffiths speculated that arousal, confirmed by his investigation as a major reinforcer, may produce endorphins leading to tolerance which leads to more gambling. Moreover, he suggested that gamblers' representing their near-misses to themselves as near-wins might expand their arousal, which might reinforce play. This is noteworthy as an early indication that cognitive distortion may have a neurophysiological basis.

In recent years, considerable sophistication in the investigation of the neurophysiological basis of the near-miss is apparent in two major research programs: by Clark and colleagues at Cambridge University, and by Dixon and colleagues at Southern Illinois University. Both programs are characterized by a strong interdisciplinary methodology which allows the neurophysiological and cognitive distortion views of the phenomenon to be compared and contrasted. In addition, Dixon's program has made explicit the role of contingencies of reinforcement and behavioral rules in the shaping and maintenance of near-miss effects.

Clark: neurophysiology and cognition

Employing a laboratory simulation of slot-machine gambling,[1] Clark et al. (2009) reported that both outright monetary wins and near-misses activated identical striatal and insular circuitry. Moreover, near-misses were associated with a greater blood oxygenation level-dependent (BOLD) signal in the ventral striatum and anterior insula, something also achieved by outright wins, and near-misses produced additional responses in the meso-limbic reward system (rostral anterior cingulate cortex, midbrain, thalamus) in a similar manner to that found in reinforcer processing. They implicated the tendency of near-misses to recruit the reward circuitry that is the neurophysiological basis of reinforcement as a factor that invigorates gambling propensity despite the objective lack of reward.

Clark et al. (2009) also contribute to the issue of biological versus cognitive/behavioral causation, reporting that activity in the rostral anterior cingulate cortex varies with personal control.

Those gamblers given the opportunity to exercise personal control over arranging the gamble reported near-misses as less pleasant than full-misses but the former nevertheless increased those gamblers' desire to play. Moreover, insular activity for near-misses correlated with both a self-reported and a questionnaire measure of gambling propensity. Clark et al. (2009) also recorded *subjective verbal responses to near-misses* which for gamblers with personal control were less pleasant than full-misses but nevertheless increased the desire to play. This interaction between near-miss and personal control could be detected in fMRI data: "In the rostral portion of the ACC [anterior cingulate cortex], anterior to the genus of the corpus callosum, participant-selected near-misses were associated with a greater BOLD signal than personally-chosen full misses" (Clark et al., 2009, p. 485). The opposite was observed for computer-chosen trials but the result was not statistically significant. Both monetary wins and near-misses recruited the anterior insula. The BOLD signal in this area was associated with two aspects of what Clark et al. call "psychological variables": a positive correlation between insula activity and scores on the Gambling Related Cognitions Scale (GRCS), a measure of susceptibility to cognitive biases (Raylu & Oei, 2004) and a negative correlation between insula activity to near-misses and scores on "How much do you want to continue to play the game?" Only the insula, within the win-related circuit, was predictably associated with these verbal behaviors. By assuming a combined biological/cognitive paradigm, Clark et al. (2009) were able to demonstrate that neural responses associated with near-misses are related to both subjective experience of these events recorded during scanning and a trait-based index of gambling propensity on which problem gamblers exhibit significantly elevated scores.

Chase and Clark (2010) confirm that near-misses recruit neuro-circuitry associated with the acquisition of behavioral rewards and define PG by reference to its neurobiological commonalities with substance addiction; from the point of view of potential treatment, their work raises the possibility that dopamine- (DA-)induced responses to gambling may be regulated by the impediment of this neurotransmitter.

fMRI scan data were used to compute four contrasts: (1) Between monetary wins minus non-wins; (2) Near-misses minus full-misses; (3) Near-misses minus full-misses depending on computer versus participant selection of left-hand icon; and (4) Win activity for participant-selected versus computer-selected icons. The contrast of all winning with all non-winning outcomes (1) revealed signal change in areas usually associated with reinforcement learning, notably the ventral striatum. The contrast of near-miss with full-miss outcomes (2) indicated that both recruited the same striatal regions, despite the non-win status of both types of outcome. However, neither the contrast of wins for participant-selected minus computer-selected icons (3) nor the interaction contrast for near-miss activity as a function of personal control (4) revealed significant neural recruitment within the chosen ROI mask.

The study combined data from two sources by computing fMRI responses to gambling outcomes by scores on the South Oaks Gambling Screen (SOGS), a verbal test of gambling propensity which enquires of borrowing money, lying, etc. (Lesieur & Blume, 1987). While SOGS scores did not reveal neural correlates of increases or decreases in winning, they were related positively to midbrain responses and negatively to caudate responses to near-miss outcomes. Disordered gamblers showed a more pronounced midbrain response to near-misses than did others, a finding that contradicts previous research.

Clark et al. (2012) present a further study in this series, the aim of which was to trace the capacity of win, near-miss, and full-miss outcomes to generate physiological arousal in laboratory-based gambling simulations. They employed two physiological measures, HR and electrodermal activity (EDA). Both were found to vary with gambling outcomes. Near-misses elicited a greater increase in EDA than full-misses, especially on player-selected icon trials.

Near-misses also evoked a higher level of HR acceleration than alternative outcomes. Overall the results for the neuro-physiological measures indicated that "[n]ear-miss outcomes are capable of eliciting phasic changes in physiological arousal consistent with a state of subjective excitement, despite their objective non-win status" (Clark et al., 2012, p. 123).

The authors also manipulated perceived personal control by means of player (as opposed to computer) icon selection. As in earlier research, near-misses were experienced as less pleasant than outright losses but, in the case of personal icon choice, were followed by a greater verbally reported willingness to continue playing. Against the assertion that laboratory studies of gambling do not produce similar levels of arousal to those encountered in real-time gambling (e.g. Dixon et al., 2010) is evidence that the kinds of result found by Clark et al. (2012) are representative of play on actual video slot machines. Dixon et al. (2010) arranged the contingencies of gambling so that players whose probability of winning was enhanced by increasing the number of gambles made for each spin failed nevertheless to recoup the amounts they had staked. Such "losses disguised as wins" were associated with similar EDA and HR increases to those engendered by wins compared to full-losses.

Dixon: neurophysiology and contingency

Habib and Dixon (2010) were the first researchers to investigate neurophysiological and behavioral differences between pathological and non-pathological gamblers in the context of slot-machine near-misses. Their overriding hypothesis was that pathological gamblers would view near-misses as closely allied to wins while non-pathological gamblers would see them as more akin to the losses which, objectively, they are. This expectation was not borne out at the behavioral level: both types of gambler rated near-misses as close to wins. At the neurophysiological level, however, they identified greater overlap between the win-like elements of near-misses and the win network for pathological gamblers. Moreover, the loss-like aspects of the near-miss and the network activated for full-losses exhibited greater overlap in the case of the non-pathological gamblers.

The authors sought to identify brain regions common to pathological and non-pathological gamblers and those exclusive to each of these groups as they experienced the various gambling outcomes: these were termed the win, near-miss, and loss networks. The *win networks* were entirely discrete for the two groups. However, non-pathological gamblers displayed an activation of the right superior temporal gyrus that was peculiar to that group in the case of wins, while for pathological gamblers separate activations in the uncus and posterior cingulated gyrus constituted the win network: Habib and Dixon (2010) note that both of these regions identified for pathological gamblers are located in the extended medial temporal lobe system. It was also possible to define a *loss* network: for losses, activations common to pathological and non-pathological gamblers were apparent in bilateral medial parietal region (precuneus), bilateral middle/superior occipital gyrus, and bilateral superior frontal gyri. A notable difference was observed between the pathological and non-pathological gamblers groups' unique loss networks, however. Non-pathological gamblers demonstrated peculiar activations in a broad network including the medial and bilateral lateral parietal cortices and the medial, bilateral middle frontal, and left inferior frontal gyri. Pathological gamblers evinced a much smaller loss network consisting only of the right lateral parietal cortex. While the authors recorded no more than minimal common activation in the case of near-misses, the results were intriguing for the identification of the neurophysiology of gambling experience. Non-pathological gamblers recruited similar neurology in the case of near-misses to that found for losses: more precisely, they evinced activation in part of the left inferior parietal lobule close to a region that was activated for their loss-win contrasts. The pattern of association among the networks that might be expected on a priori grounds was substantiated in the case of pathological gamblers: *their* near-miss activations had more in common with their wins (win-loss contrasts) located in the uncus in the right anterior medial temporal lobe as well as the right inferior occipital gyrus. These results indicate that non-pathological gamblers are more realistic in judging the status of near-misses, seeing them as losses. Pathological gamblers, by contrast, are disposed to view near-misses as more closely related to wins.

Habib and Dixon (2010) stress not only the greater extent of the win network in pathological gamblers but that in this group this network comprised "emotional regions of the brain" and elements of the midbrain that constitute the reward system. This is especially interesting in that all players taking part received similar monetary rewards for their participation in the experiment but did not receive further compensation for winning. They suggest in interpretation that wins were more pleasant, positive, or rewarding for pathological gamblers, irrespective of monetary gain.

Winstanley et al. (2011) identify more specifically the neurophysiological activity involved in the near-miss by investigating the role of DA during slot-machine gambling, albeit simulated in rats. The construction of research framework in which rats' behavior simulates near-miss activity (Zeeb et al., 2009) facilitated experimental refinement in the further investigation of near-misses' associations with DA-ergic activity in disordered gamblers. For instance, Schultz (2002) had implicated the midbrain DA-ergic system in generating reward prediction errors (RPEs), and Schott et al. (2008) demonstrated that monetary rewards produce BOLD reactions and related striatal DA transmission. More specifically, Chase and Clark (2010) argued that positive RPEs occur as gamblers foresee a win when the right-hand reel slows, negative RPEs when its stopping reveals a no-win. Positive RPEs are especially associated with BOLD signals, suggesting a neural basis for the gamblers' overconfident beliefs. These effects are difficult to demonstrate for in situ human gamblers for technical and ethical reasons. Winstanley et al. (2011) arranged contingencies so that rats' responses determined whether flashing lights were lit/unlit: three illuminated lights constituted a win. Each trial concluded with the opportunity for the rat to select the collection of rewards for wins, also incurring a time penalty for losses, or a new trial. The rats preferred the collect option even if two lights were lit, suggesting an analogy with near-misses in human gambling. "Near-misses" apparently engender a reward expectancy similar to that characteristic of a win.

Qi et al. (2011) measured event-related potentials (ERPs) in an examination of the neural and cognitive correlates of the near-miss effect. As in other research, gamblers rated near-misses less pleasant than full-misses but found them more motivating. P300 amplitude increased from the full-miss condition to that of the near-miss. Further analysis indicated that the initiators of the P300, located in the putamen and orbitofrontal cortex, may be involved, respectively, in motivational evaluation and regret. The authors argue that the near-miss phenomenon may have dual origins in higher motivational level and the incidence of regret resulting from counterfactual thinking.

Summing-up: neurophysiology

Wins activate neural systems related to reward and DA release while no-wins fail to do so. Near-successful behavior is likely to be reinforced during the acquisition of skills, enhancing further improvement. But a gambling near-miss does not affect the probability of a subsequent win. The consequent intellectual challenge is to account for the influence of non-winning gamblers' cognitive responses to near-misses (i.e., their apparently illogical persistence in playing). Further research suggested by the authors may corroborate these findings by investigating, first, whether problem gamblers' generalizations of reward-predictive stimuli (e.g., contextual stimuli present prior to or simultaneously with gambling) correlate with midbrain activity; and second, whether midbrain neurons code adaptively to anticipated reward levels (Chase & Clark, 2010).

One line of critical review of the neurophysiological approach to explaining near-misses involves minutely analyzing the methods employed and proffering advice on improvement. Judging from the commonalities revealed by results from several highly reputable international laboratories and the contrasting methodological positions of the researchers, such recommendations would be incremental at best. An alternative critique contextualizes neurophysiological research by highlighting alternative insights into the near-miss phenomenon and links with the neurophysiological approach. This perspective is more likely to engender the interdisciplinary synthesis that understanding near-misses requires.

Cognitive distortion

A near-miss is not an outcome that *actually* "comes close to being successful" as in Reid's (1986, p. 32) definition: it is an outright failure that *may be interpreted* by the gambler as approximating a win. Explanation of the subsequent patterns of playing in terms of cognitive distortion take as its key variable not the objectively observable similarity of the pattern of symbols achieved to those that denote a win but the interpretation put upon this by the gambler. Its interpretation in terms of "closeness" is an independent variable for those researchers who seek to explain losing gamblers' persistence by invoking it; it is also necessary to view it as a dependent variable, enquiring of its causal origins.

Several of the studies reviewed here investigated cognitive distortion in addition to the neurophysiological basis of the near-miss. The tendency for slot-machine gamblers to be motivated by near-misses to continue gambling has been shown to depend on the illusion that their selecting the target icon increases their personal control over the outcome of the gamble (Dixon et al., 2007). A feeling of personal control also results from the belief that playing slot machines successfully is a matter of skill and that apparently coming close to winning signals its acquisition. Some tasks are perfected by the acquisition of skill through practice but in the cases of sports performance and accuracy in electronic information processing, for instance, there is a genuine probability that continued performance will enhance expertise. This is not so in gambling where the probability of winning is reset on each trial (Langer, 1975). Slot-machine design nevertheless takes advantage of the illusion of control through skill by affording players the opportunity of "nudging" or "holding" their icons seemingly to influence the generation of a winning line. Moreover, the self-perception of skillfulness is higher among pathological than other gamblers (Griffiths, 1990c). Griffiths (1994) reported that irrational statements about win-propensities are more frequent among more regular than other gamblers, though the incidence of irrational verbalizations was lower in his study of arcade gamblers than earlier research (e.g. Ladouceur et al., 1988) encountered. Griffiths (1994) interpreted his own research, nonetheless, as confirming the general trend of work on cognitive bias. Importantly, he found that regular gamblers were more likely than others to comprehend their behavior in terms of the acquisition of a skill.

Ariyabuddhiphongs and Phengphol (2008) sought to establish the relative importance of near-miss, gambler's fallacy, and entrapment on gambling persistence; entrapment is a variation of the sunk-cost effect in which, having invested so much time and money in a pursuit, the individual feels the costs of quitting are insuperable, hence persists. A model measuring the independent effects of the independent variables on the dependent shows that near-miss alone has a strong and significant effect on behavior; the other two independent variables are weak and non-significant. However, a model that examines the effects of gambler's fallacy and entrapment, mediated by near-miss, on gambling behavior fits the data as closely as the initial model. The overall conclusion is that the strong effect of near-miss on gambling motivation is strengthened by the other two variables.

Wohl and Enzle (2003) revealed that more important in gambling motivation than the incidence or magnitude of a gain or loss is the extent to which the gambler feels lucky. The subjective experience of luck is, in turn, influenced by whether a modest win ($10) is presented as the near-miss of a JACKPOT (delivering $70) or of BANKRUPT. These outcomes are hypothesized as involving upward or downward counterfactual thinking, respectively. As predicted, gamblers who have escaped a near big loss feel luckier than those avoiding a near big gain and are indeed more likely to continue gambling, perhaps as a result of the arousal felt as a result of being lucky. Self-perception of luck in an individual who has narrowly avoided a big loss is greater and this eventuates in continued play. Self-perception of luck is reduced in the player who narrowly misses a large payout and may thereafter doubt their ability to gain the jackpot. Daugherty and MacLin (2007) conducted a follow-up research related to Wohl and Enzle (2003) and found that only participants who experienced near-win situations at a high rate (45% levels) persisted in their gambling behaviors more than the participants in other conditions. Furthermore, Dixon and Schreiber (2004) question the capacity of cognitive distortion to explain the near-miss phenomenon characterizing such bias, from a behavior analytic perspective, as "a hypothetical construct within or characteristic of the individual responsible for an illogical calculation of the reality that explains gambling behavior" (p. 336). They also reject Reid's (1986) conjecture that near-misses constitute reinforcers because they generate arousal in a similar fashion to wins. They broadly endorse Griffiths' (1994) suggestion that near-misses are a sort of feedback that encourages further play, though they are skeptical of his idea that near-misses constitute a reward in themselves. These are all ideas that need to be taken seriously in formulating a general model of near-miss response.

In their own work, Dixon and Schreiber (2004) recorded response latency between plays (trials or spins), and the type of outcome (win, near-miss, or loss). All participants (12 undergraduates knowledgeable of slot-machine use) reported that their near-misses more closely approximated a win than a loss. Moreover, all but one participant estimated higher estimations of a near-miss when the similar symbols on the payout line were adjacent. Dixon and Schreiber (2004) propose tentatively that two adjacent symbols are visually closer to the three required for a win than the separated symbols. Response latencies for eight participants were longer in the case of winning; the four exceptions showed much greater response latency following a near-miss than a full-miss. These results corroborate earlier work by the authors (Dixon & Schreiber, 2004; Schreiber & Dixon, 2001) who suggest that the losing trial is an aversive stimulus from which the gambler seeks to escape quickly (negative reinforcement). This "negative reinforcement and avoidance paradigm" is supported by the longer response latencies shown by three-quarters of the participants after near-misses as opposed to full-misses, raising the possibility that near-misses do reinforce in some way. Schreiber and Dixon (2004) raise the possibility that a near-miss is a verbal event, that gambling is reinforced by the player's saying to him/herself "Wow! Nearly made it!" or similar.

Dixon et al. (2007) showed that participants in video poker games prefer to gamble on the basis of cards they have chosen personally rather than those that have been selected by computer. A similar effect is apparent in roulette where players prefer self-selected numbers over those chosen by the experimenter (Dixon et al., 1998). However, Weatherly and Flannery-Woehl (2009) counter the view that cognitive fallacies predict slot-machine gambling based on an empirical investigation of the value of such biases in the prediction of gambling behavior.

Fallacious beliefs, assessed by questionnaire, were used to predict financial gambling on video poker and slot machines. Erroneous beliefs were poor predictors of actual gambling; in the single instance in which they predicted gambling behavior, they were associated with less rather than more.

Summing-up: cognitive distortion

Any suggestion that cognitive distortion is the principal influence on gambling persistence requires qualification. First, it is difficult to establish that such beliefs influence behavior since, like other cognitive ascriptions, they are not directly amenable to experimental investigation. They are at best an inference that raises the philosophical question of how cognitive factors produce neurological effects. Second, near-misses are associated with neural changes that are known to be influential in motivating behavior through an established reward mechanism. Although cognitive distortion may be a by-product of the near-miss which, when verbally expressed, predicts further gambling, it is difficult to accord it causal preference over the mesolimbic reward system. Cognitive distortion may well be a result of the arousal engendered by the activation of this system by near-misses, in which case it is itself an effect of past behavior rather than a cause of future play. Hence, any attempt to treat PG by acting directly on biased beliefs is unlikely to succeed. Third, an alternative perspective which considers contextual influences on gambling persistence in the face of near-misses, including those inherent in rule-governed behavior, suggests a means of integrating neurophysiological and behavioral research.

Contingencies of reinforcement

The near-miss phenomenon is puzzling for behaviorists who interpret monetary gains as reinforcers (consequential stimuli that increase the rate of responding) and their absence as punishers (that reduce it). While there are few such behaviorists and even Skinner (1953) interpreted near-misses as reinforcing behavior, knowledge of the effects of reinforcement contingencies on gambling is valuable for three reasons. First, they permit further critical analysis of the neurophysiological approach to explaining near-misses. Second, they suggest theoretical enhancement of the behavior analysis of gambling. Third, they suggest ways in which treatment programs might benefit.

Haw (2009) investigated two aspects of reinforcement contingencies in an experiment in which students were allowed to select one of two machines on which to play. These were the frequency of payouts (wins) and payback rate. Both predicted when individuals changed machines but not overall machine choice. Those participants who did change machines, however, revealed a preference for the machine programmed with the larger payback rate (though not for that providing the greater frequency of wins), indicating a relationship between learning history (prior reinforcement) and machine selection. Haw (2008) reported that the effectiveness of variable ratio and random ratio schedules derives not from the average frequency of wins they engender, as is widely believed, but from the number of early wins and unreinforced trials.

The density of programmed near-misses may be more important in sustaining play than big wins. Kassinove and Schare (2001) used machines programmed to produce near-misses at different rates (15%, 30%, and 45%). Wins of $10 (“big” for the undergraduate participants) were also programmed to occur. Gambling persistence was assessed as the number of trials undertaken during extinction (i.e., when the near-miss and big-win outcomes were no longer available). Near-miss rate was significantly related to persistence (the 30% near-miss contingency produced the greatest persistence) but the big-win contingency was not. A further experiment indicated that when a 0% near-miss outcome was included, the highest level of persistence was produced by the (coincidentally?) greatest density of near-misses (45%).

Ghezzi et al. (2006) examined the effects of win magnitude and near-miss frequency on persistence in a series of three experiments in which near-miss effects took a variety of forms. In Experiment 1, the number of trials played in normal, rewarded, play was maximized when near-misses constituted 66% of outcomes (alternatives were 0%, 33%, and 100%). The second experiment revealed that maximum persistence accompanies medium-sized wins and 0% near-misses. The third showed that a 33% rate of near-misses indicated by adjacent symbols to the right of the payout window secured the most endurance. The experiment conducted by MacLin et al. (2007) required a group of students who gambled recreationally to play slot machines programmed to produce wins on a VR5 schedule. The machines differed, however, in the rate at which they generated near-misses: 15%, 30%, and 45%. In a pre-extinction phase, the 45% contingency generated the greatest level of play. Weatherly et al. (2009) report that female non-pathological gamblers gambling on commercial slot machines which paid out at different rates did not invariably prefer the machine with the highest payout. The authors conclude that neither the programmed nor the obtained reinforcement rate controlled gambling behavior, and argue that behavior analysts should seek to comprehend gambling in terms other than those of "direct, contingency-driven" outcomes. Nastally et al. (2010) report a study of contextual control of slot-machine gamblers' behavior based on different-colored machines (see also Zlomke & Dixon, 2006). Hoon et al. (2008, p. 467) also found that "participants allocated most of their responses to the slot machine that shared formal properties of color with the contextual cue for more than."

Summing-up: contingencies of reinforcement

The efficacy of contextual factors including reinforcement contingencies derives from their capacity to evoke arousal in gamblers. Arousal may result from a surprise gambling outcome due to changing schedules of reward or symbolic features such as flashing lights and loud noises that accompany not only a large win but a narrow win or even a loss masquerading as a "near-miss." Such symbolic reinforcement undoubtedly has neural correlates (though these have not been investigated in research seeking causes of the near-miss phenomenon) and counterparts in gamblers' verbal behavior that may indicate cognitive distortion. More sophisticated behavior analytic research that takes into consideration gamblers' verbalizations of the contingencies they perceive to be in operation (e.g. Dixon & Delaney, 2006; Nastally, 2010; Wood & Clapham 2006), which is beyond the scope of this review, promises to enhance this avenue of investigation and link it more closely with that concerning cognitive distortion.

Addictive gambling as consumer behavior

A recurring theme in all three research perspectives reviewed is the role of arousal as a consequence of near-misses which resembles that felt during a win and impacts subsequent behavior similarly. A second theme is discussion of the role of slot-machine symbols and audio effects as reinforcers of some kind, a conclusion that has been tentatively accepted, though sometimes without strong conviction, by behaviorists and cognitivists alike. While monetary rewards perhaps remain the primary source of behavioral reinforcement, symbols are a secondary influence on behavioral continuity. This is consonant with a theory of consumer choice which embraces compulsive and addictive behaviors such as problem and pathological gambling (Foxall & Sigurdsson, 2012).

The theory posits that consumer motivation is the outcome of two sources of reinforcement, utilitarian or functional (this would include monetary rewards in gambling) and informational or symbolic (such as the signs of near-misses displayed on slot machines). There is considerable evidence, first, for the role of symbolic reinforcement in maintaining non-compulsive consumer behavior and, second, for the capacity of symbolic reinforcement to engender arousal. Both symbolic reinforcement and arousal are closely related to verbal behavior and rule-governance, both of which assume importance in the explanation of the near-miss effect in terms of contingencies of reinforcement.

According to the BPM, the emotional states are a direct outcome of the reinforcement contingencies (Foxall, 2011; Foxall & Yani-de-Soriano, 2011; Rolls, 2014). During the Primrose Path gambling is governed by informational (mostly social) more than utilitarian (monetary) results, and is often motivated through social drinking and organized gambling in public places. As reinforcing social approval is overtaken by the addictive consequences of monetary and symbolic consequences, the contexts become progressively more closed. Symbolic reinforcement occurs as a consequence of the pathological gambler's conditioning history.

The critical aspect of this history involves a correspondence between the colors, lights, and sound generated by gambling machines in response to so-called near-misses. These effects not only arbitrarily signal a reduction in time to reinforcement (Fantino & Logan, 1979), but are also correlated with aroused happiness to this performance feedback. This can be defined in terms of the facial expression or vocalization sometimes shown by pathological gamblers when "winning" (Dixon et al., 2010; Green & Reid, 1996), or with the use of subjective rating scales (e.g., Foxall & Yani-de-Soriano, 2011; Foxall et al., in press), to provide a means of relating emotional responses to contingencies of reinforcement. With the pathological gambler's sources of motivation to gamble tied to utilitarian as well as to symbolic sources, the situation gets closer to an errorless discrimination contingency as the system does not give as many chances of "mistakes" as one would think. If and how the symbolic feedback increases its reinforcement value and capabilities to arouse positive feelings as gambling progresses needs to be studied more carefully. As the symbolic reinforcement seems to diminish the aversive effects from the normal extinction generated from losses, similar to what happens with errorless discrimination training, it is of value to measure the intensity of aversive emotions generally detected during extinction.

It is well established (Azrin et al., 1966) that animals and humans often show aggressive responses during extinction and as such the arousal, the intensity of the emotion, should be part of the functional analysis. Furthermore, there is evidence that suggests that PG may be maintained by negative reinforcement or an escape function (Miller et al., 2010; Weatherly et al., 2010). This needs to be studied with laboratory methods as well as with field studies, if boredom – a low arousal state – is to be systematically related to gambling behavior. Dixon et al. (2010) showed, for example, that a simulated gambling activity that did not involve monetary outcomes increased happiness levels in elderly individuals. This begs the question how different combinations of utilitarian and informational reinforcement work on operant gambling behavior and classically conditioned emotional responses in normal populations compared to pathological gamblers and how the effectiveness and emotions change during different stages of gambling. The further investigation of PG and other forms of addiction in terms of a broad continuum of consumer choice seems indicated by the foregoing critical review. Equally, an approach to treatment based on changing symbolic reinforcement and verbal behavior is more likely to produce effective results than one that emphasizes cognitive dysfunction and seeks to change beliefs and desires that are not empirically available.

Conceptualizing gambling and addiction as consumer behavior emphasizes the continuity between routine purchasing decisions (e.g., food brand choices) which exhibit a stochastic selection of alternatives (Ehrenberg, 1988) and extreme modes of consumption marked by compulsion. The analysis of factors influencing the more amenable modes of consumption, the routine choices, suggests how more extreme behaviors may be defined and studied. The routine and extreme consumer behaviors just mentioned are polar extremes on a continuum that also includes credit buying, environmental despoliation, and compulsive purchasing. All of these are influenced by a similar array of genetic, neurobiological, economic, contextual, and cultural factors (Foxall, 2010; Heyman, 2009), though these differ in salience according to the nature of the behavior in question. The location of a particular consumer behavior on the continuum is a measure of the impulsivity/self-control shown by the consumer. Although addiction has been shown to follow the matching law (Herrnstein, 1997), it is only recently that routine consumer behaviors have been shown to exhibit this process (e.g., Foxall et al., 2007) which underlies temporal discounting. Indeed, consumer behaviors are marked by temporal discounting regardless of their positioning on the continuum, albeit to differing extents. Findings generated by a model of consumer behavior for the more routine behaviors may therefore generate understanding of more impulsive forms of choice.

For instance, research inspired by BPM identifies two sources of reinforcement that are germane to the shaping and maintenance of economic behaviors: utilitarian (functional) and informational (symbolic/social), which act in tandem to affect consumer choices that reflect different underlying patterns of consumer valuations of the products chosen, measured in terms of differing elasticities of demand and levels of essential value (Foxall et al., in press; Yan et al., 2012a, b). The relevance of this to the present discussion lies in the verbal nature of informational reinforcement which reflects social norms of performance (in terms, for example, of social status and esteem). Symbolic reinforcement of this kind has been reliably related to emotional feelings of arousal in eight studies of consumer response to a wide range of consumption environments (Foxall et al., in press), a finding that is highly relevant to the results for near-miss gambling discussed in this chapter.

The import of interpreting these results in terms of informational reinforcement is that the outcomes of near-misses are in themselves as reinforcing as monetary gains; moreover, the efficacy of these symbolic reinforcers is enhanced by the arrangement of the paraphernalia of gambling, namely the ways in which slot machines respond to play-outcomes that are actually losses in a similar fashion to those that are outright wins. We can now understand why the sights and sounds generated by gambling machines in response to so-called near-misses are as effective in promoting further gambling as the financial gains that follow unmistakable successes. It is perfectly comprehensible why the cognitive mediation of these rewards by gamblers results in their reporting that they are feeling lucky and want to continue playing. It is not a matter of loss being rewarding: a near-miss is as much a successful outcome in view of the symbolic meaning it has acquired in the course of a gambling history as it would be if every near-miss were marked by the receipt of money. The application of the consumer behavior model to gambling confirms what has been suspected: that the potency of slot-machine gambling as a potential contributor to personal and social disruption is not as likely to be meliorated by the manipulation of schedules of reinforcement that govern the payout rate to gamblers as by the control of the symbolic reinforcers that influence arousal and thereby promote continued playing.

Conclusions

The assiduity with which casino managers and machine manufacturers seek to incorporate features that reward failure as well as success provides eloquent testimony to their practical value. The scale of gambling problems encourages critical reviewers to move beyond the minutiae of proliferating findings to the synthesis of salient results into applicable models for research and treatment. This is a time for bold conclusions rather than prescriptions for further penetration of well-worn paths. The consumer behavior framework outlined here is capable of integrating the biological, economic, social, and situational influences on gambling behavior that are known to be closely connected with the incidence of the near-miss effect.

Further research

Additional evidence is required of the role of experience in determining structural differences between pathological and non-pathological gamblers. There is certainly plenty of evidence that experience changes brain structures in laboratory enrichment studies, and in the study of London taxi cab drivers, so why not gamblers?

Various addictions, both drug-dependent and non-drug problematic behaviors, such as PG seem to share similar neurobiological foundations (Martin & Petry, 2005). With increased experience, the vulnerable individual develops increased sensitization, or inverse tolerance, a neuroadaptive response that is to a large degree dependent on context and learning (Berridge & Robinson, 2003). This alters neuronal circuitry involved in the normal processes of motivational operations and reinforcement. PG is characterized by changed reinforcement contingencies, the incapacity to experience or be motivated by reinforcers usually working in the local environment. This is due to reduced sensitivity to endogenous brain dopamine, and a striking responsiveness to cues that are associated with gambling, both inside the skin (e.g. anxiety or depressive symptoms) and in the environment. What is missing, though, in the literature are longitudinal studies looking at the long-term effects of gambling on brain chemistry.

Note

1 "The Slot Machine Task." One of six icons having been selected on the left-hand reel (by the participant or by computer), spinning the right-hand reel reveals one or other of the icons. If left- and right-hand icons match, the participant receives a small cash prize. A mismatch between the icons of one vertical position is a "near-miss"; other mismatches, "full-misses." Following initial icon selection, participants rate their chances of winning by responding to the question "How do you rate your chances of winning?" Following the outcome, participants state how much they want to continue to play on the question "How much do you want to continue to play the game?"

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