CrossMark

ORIGINAL PAPER

Betting Decision Under Break-Streak Pattern: Evidence from Casino Gaming

Lawrence Hoc Nang Fong[1] · Amy Siu Ian So[1] · Rob Law[2]

Abstract Cognitive bias is prevalent among gamblers, especially those with gambling problems. Grounded in the heuristics theories, this study contributes to the literature by examining a cognitive bias triggered by the break streak pattern in the casino setting. We postulate that gamblers tend to bet on the latest outcome when there is a break-streak pattern. Moreover, three determinants of the betting decision under break-streak pattern, including the streak length of the alternative outcome, the frequency of the latest outcome, and gender, were identified and examined in this study. A non-participatory observational study was conducted among the Cussec gamblers in a casino in Macao. An analysis of 1229 bets confirms our postulation, particularly when the streak of the alternative outcome is long, the latest outcome is frequent, and the gamblers are females. The findings provide meaningful implications for casino management and public policymakers regarding the minimization of gambling harm.

Keywords Betting decision · Gambler's fallacy · Casino · Streak · Cognitive bias · Macao

✉ Lawrence Hoc Nang Fong
    lawrencefong@umac.mo

    Amy Siu Ian So
    amyso@umac.mo

    Rob Law
    rob.law@polyu.edu.hk

[1] Faculty of Business Administration, University of Macau, Avenida da Universidade, Taipa, Macau SAR, China

[2] School of Hotel and Tourism Management, The Hong Kong Polytechnic University, 17 Science Museum Road, TST East, Kowloon, Hong Kong SAR, China

⌷ Springer

Introduction

Casino gaming is a lucrative business that not only benefits the operators but also stimulates the economy of a locale. A typical example is the Las Vegas Strip (in the United States), which is a renowned gaming destination filled with an array of mega-casino resorts. The casino resorts draw in hundreds of thousands of tourists from different parts of the world, while a large number of employment opportunities are offered to the residents. Following the boom of Asian economies, recent years have witnessed a phenomenal growth of gambling in Asia (Ndubisi et al. 2014).

While casino gaming is currently an important leisure activity, its negative impacts like pathological gambling are evident. Critics cast doubt on the ethical conduct of operating casinos and describe casino gaming as a dirty (Lai et al. 2013) and even a sinful business (Hong and Kacperczyk 2009).

A vast body of research on problem and pathological gambling is documented in the literature. Relevant research can be subsumed under three major streams. The first body of research revolves around the study of the prevalence of problem and pathological gambling (Ferguson et al. 2011; Nowak and Aloe 2014; Welte et al. 2008). The second body of research is related to the treatment of pathological gamblers (Carlbring et al. 2012; Gooding and Tarrier 2009; Toneatto and Ladoceur 2003). The third body of research, which has received the majority of the scholarly attention, focuses on examining the factors driving problem and pathological gambling behavior (Afifi et al. 2010; Johansson et al. 2009; MacLaren et al. 2011; Prentice and Woodside 2013; Raylu and Oei 2002). This is not surprising, as the prevention of problem gambling has been stressed by scholars all over the world (Blaszczynski et al. 2011, 2004), and effective prevention measures require a sophisticated understanding of the predicting factors of problem gambling behaviors.

The factors affecting problem gambling behaviors are largely grounded in cognitive bias—the bias being incurred upon the cognitive processing of information. The bias is salient in the minds of gamblers (Delfabbro 2004), particularly among the problem gamblers (Joukhador et al. 2003; Myrseth et al. 2010; Tang and Wu 2012). While there are a variety of cognitive biases, the representativeness heuristic is one of the most commonly identified biases used by gamblers in making their betting decisions (Griffiths 1994). The heuristic drives people toward the misconception of the randomness of the outcome and thus triggers an erroneous estimation of the probability of the outcome (Kahneman and Tversky 1972).

The heuristic also underpins two opposing fallacies, namely, the gambler's fallacy and hot outcome fallacy (Ayton and Fischer 2004). To illustrate, in a coin tossing exercise, a person who has succumbed to gambler's fallacy would estimate that heads has a higher probability of appearing in the next outcome after three consecutive tails (i.e., a streak of three tails) are witnessed, whereas the person affected by hot outcome fallacy would guess the next outcome to be tails again. To date, there remains a lack of clarity as to the fallacy type that is more common in the gambling context (Fong et al. 2014; Sundali and Croson 2006). However, it is at least understood that the patterns of previous outcomes, echoing the cognitive bias, affect gambling behaviors. This study introduces the break-streak pattern (e.g., heads preceded by a streak of tails or vice versa). Given the break-streak pattern, it is postulated that a person would overestimate the probability of the latest outcome.

As fallacy is particularly salient among problem gamblers (Fortune and Goodie 2012), a responsible casino operation practice should avoid any deliberate manipulation of factors

that trigger the fallacy. A typical manipulation approach is to ask the dealers to keep running the game until an expected pattern emerges, even though there is no player at the table. Given this consideration, if the effect of break-streak pattern on betting decisions does exist, it is imperative to identify the predicting factors so that preventive measures can be executed accordingly. If the break-streak effect is not found, it is still possible that certain factors may suggest that the effect exists. Hence, identifying the predictors is essential.

A recent study suggests that gambler gender and outcome characteristics such as streak length and the frequency of an outcome have an impact on a person's fallacy (Fong et al. 2014). Similarly, this research postulates that the break-streak effect rests upon the streak length of the alternative outcome, the frequency of the latest outcome, and gambler gender.

In summary, this study contributes to the literature by introducing the effect of break-streak pattern on betting decision and examining the predicting factors. Therefore, the objectives of this study are twofold. The first objective is to examine whether gamblers would bet on the latest outcome under break-streak pattern. The second objective is to examine if the proposed factors have an impact on the betting decisions under break-streak pattern. To achieve these objectives, a non-participatory observation of the gamblers was conducted in a mega-casino in Macao. Cussec (also called Sic Bo), a popular game of chance in the Macao casinos, was selected as the setting for this study.

Literature Review

Cognitive Bias

People are overwhelmed by uncertainty conditions in which they experience stress when making decisions (Choi 1993). This results in a high demand on their cognitive capacity. Given the heavy cognitive burden, people rely on various cognitive cues to reach a decision (Kahneman and Tversky 1996). However, the cues are never as reliable as the decision makers believe, causing systematic errors in the decision-making process—that is, cognitive biases.

Cognitive bias is common in gambling (Joukhador et al. 2003). Gamblers overweigh losses relative to wins (Kahneman and Tversky 1979), so that a win is strongly desired by them. They expend great cognitive effort to process various types of cues, with the objective of obtaining winning outcomes. However, these cues are generally irrelevant to their personal gambling outcome (i.e., a win or loss), and thus cognitive biases result (Kahneman and Tversky 1996).

A variety of cognitive biases have been identified in previous studies. Memory bias is an example whereby gamblers selectively recall their winning experiences (especially the large wins) to maintain their hope of winning and thus their gambling behavior (Babad and Katz 1991).

Temporal telescoping is another type of cognitive bias whereby gamblers believe that they are close to winning temporally (Toneatto 1999). For example, a slot player who obtains a near-win outcome (e.g., double "Seven" intersecting the betting line followed by a third "Seven" proximal to the line) believes that a jackpot will emerge very soon. A gambler who has experienced a series of losses believes that a win is imminent and will occur within the next couple of games. However, it does not necessarily mean that a series of wins drives people to believe losses will occur in the upcoming games. Gamblers may

endorse the "hot hand" bias, in which they believe that they are experiencing a run of good luck and winning will persist in the subsequent games (Croson and Sundali 2005).

Gamblers also endorse attribution bias (Toneatto 1999). They attribute their wins to dispositional factors such as skills and capacities and their losses to situational factors such as luck. Thus, they overestimate their wins because the dispositional factors are under their control from their perspective, and they underestimate their losses because the situational factors are not controllable.

Hindsight bias also affects gambling behavior (Petrocelli and Sherman 2010). Gamblers assess their gambling decisions from the past to provide references for their current gambling decision. A win, from a gambler's perspective, means his/her decision was correct, and thus his/her confidence in gambling increases. Given a loss, a gambler may review his/her gambling experience and conclude that s/he has wagered on the winning number. In other words, the gambler believes that s/he can learn from the losing experience and that gambling performances can be improved. This bias, in turn, enhances his/her confidence in gambling in the future, as s/he will avoid the mistakes made in the past.

Langer (1975), in her seminal work proposing the concept of the illusion of control, revealed that people illusorily perceive that they have a higher chance to win if they compete with a nervous counterpart, choose the lottery ticket by themselves, hold a lottery ticket with familiar symbols, and are cognitively immersed in a gambling task. These are the common cognitive biases of gamblers.

The above cognitive biases indicate that gamblers tend to link independent personal gambling outcomes together to determine the winning formula. This type of bias exists not only in predicting personal outcome (i.e., the win or loss) but also in predicting the outcome of a game (e.g., red and black in Roulette; Sundali and Croson 2006), which will be discussed in the subsequent section.

Heuristics and Fallacy

Cognitive bias is a manifestation of the misconception of randomness (Croson and Sundali 2005; Keren and Lewis 1994). Randomness is the primary mechanism behind an uncertain event. Nevertheless, many individuals make a prediction based on the cues that can lead to systematic error (i.e., deviate from the true probability) (Kahneman and Tversky 1996). This type of probability estimation process is generally called heuristics. Heuristics comprise the availability heuristic and representativeness heuristic. The availability heuristic refers to a person's estimation of the probability of an outcome based on availability—the ease with which the outcome is triggered in his/her mind (Tversky and Kahneman 1973). If the outcome is familiar to an individual, emotionally salient, easy to search, vivid in the mind, or recently observed, the availability heuristic is likely to be triggered (Tversky and Kahneman 1974). The availability heuristic prevails in our lives as it is practically infeasible to ground every decision in probability calculation (Delfabbro 2004; Schwarz et al. 1991).

On the other hand, the representativeness heuristic refers to a person's estimation of the probability of an outcome based on the degree of similarity of the sample to the population (Kahneman and Tversky 1972). People have an assumption regarding the outcome pattern of the population and assume the sample follows the same pattern. For example, in a coin tossing exercise, people estimate a lower probability for a sequence with a small number of alternations (e.g., HHHTTT) than one with more alternations (e.g., HTTHTH). The reason is that people believe the latter better represents the population pattern. While statistical theory posits that heads and tails are equally likely in the population, a sample sequence

with unequal outcome frequencies, for example, five heads and one tail, causes people to believe the sequence has to be balanced by more tails. People then overestimate the probability of tails in the forthcoming outcome.

Availability and representativeness heuristics lay the ground for the fallacy beliefs in the prediction of outcome. Gambler's fallacy and hot outcome fallacy are the two opposing fallacy beliefs underlying outcome prediction. Gambler's fallacy, underpinned by the representativeness heuristic, is the belief in the negative correlation in a series of independent outcomes (Sundali and Croson 2006). For example, in the game of roulette, a person who exhibits gambler's fallacy believes that a streak of red outcomes will be followed by a black outcome so that the sequence can be restored to balance (Ayton and Fischer 2004). In contrast, hot outcome fallacy, underscored by the availability heuristic, refers to the belief in the positive correlation in a series of independent outcomes (Sundali and Croson 2006). Using the roulette example again, a person who exhibits hot outcome fallacy predicts the streak of red outcomes will persist because he/she stresses the latest outcome. Thus, the tendency for gambler's fallacy and hot outcome fallacy rests upon the salience of the representativeness and availability heuristics, respectively.

The existing literature indicates that gamblers generally endorse gambler's fallacy in predicting roulette colors (Ayton and Fischer 2004; Croson and Sundali 2005; Wagenaar 1988), horsing racing outcomes (Terrell 1994), and lottery numbers (Clotfelter and Cook 1993). However, a recent study among players of the casino game Cussec indicates that the hot outcome fallacy is more commonly endorsed (Fong et al. 2014). Thus, to date, there is still no conclusion as to whether gambler's fallacy or hot outcome fallacy is more salient. Aside from streaks, there is still a lack of examination of other outcome patterns which can robustly predict the betting decision. In this regard, this study introduces the break-streak pattern.

The break-streak pattern is characterized by an outcome preceded by a streak of alternative outcomes, for example, a roulette outcome pattern in which a black outcome is preceded by a streak of red outcomes. In this situation, the black outcome breaks the streak of red. Given the break-streak pattern, representativeness heuristic drives gamblers' prediction following the latest outcome (i.e., black), as the pattern signals that the balance of streak (i.e., red) starts. Such prediction may hold true across various break-streak lengths. To examine this postulation, the following hypothesis is formulated:

Hypothesis 1 Being exposed to the break-streak pattern, gamblers are more likely to bet on the latest outcome than on the alternative outcome irrespective of the break-streak lengths.

Predicting Factors of the Betting Decision Under Break-Streak Pattern

To gain a fuller understanding of the betting decision under break-streak pattern, identifying the predicting factors is vital. Streak length is a major factor that has an impact on fallacy beliefs (Fong et al. 2014; Tyszka et al. 2008). It is mainly due to people's biases in their interpretation of randomness. They believe that more alternations (i.e., smaller number of streaks) should be exhibited in a series of random events, albeit this is not the reality (Bar-Hillel and Wagenaar 1991; Rapoport and Budescu 1997). As such, a longer streak indicates a stronger necessity to balance the sequence (Huber et al. 2010). Proclivity toward gambler's fallacy grows with the streak length. Following this rationale, streak length is likely to predict the betting decision under break-streak pattern. However, previous research also reveals that gambler's fallacy does not sustain across all streak lengths,

as people suspect the randomness of the outcome-generating process when the streak is too long (Asparouhova et al. 2009; Burns and Corpus 2004; Carlson and Shu 2007). This may not be a concern for the break-streak effect, as the breaking of the streak helps to confirm the existence of the random process, which even strengthens the necessity to balance the sequence. Therefore, the following hypothesis is formulated:

Hypothesis 2 Being exposed to a break-streak pattern, the likelihood of a gambler betting on the latest outcome increases with the streak length of the alternative outcome.

In addition to streak length, the frequency of outcome was also suggested as a determinant of fallacy beliefs. When the probability of an outcome deviates from 50:50, people would cast doubt on the randomness of the process (Blinder and Oppenheimer 2008). People's doubt on the randomness of process eliminates their tendency to balance the previous outcome sequence (Burns and Corpus 2004; Carlson and Shu 2007). They are then more likely to predict frequent outcome to emerge in future events (i.e., following hot outcome fallacy). In a coin tossing exercise, Altmann and Burns (2005) found that participants are more likely to predict heads when heads are more frequently exhibited in the previous records. Similarly, Fong et al. (2014) found that Cussec players overestimate the probability of a more frequent outcome, particularly when that frequent outcome is also the latest outcome. Thus, although the break-streak pattern may drive people toward gambler's fallacy, it is possible that hot outcome fallacy plays a role through outcome frequency effect. Therefore, the following hypothesis is formulated:

Hypothesis 3 Being exposed to a break-streak pattern, the likelihood of a gambler betting on the latest outcome increases with the frequency of that outcome.

Tyszka et al. (2008) called for more research on the effects of personal characteristics on fallacy beliefs. Personal characteristic such as gender have been posited as having an effect on the fallacy belief (Fong et al. 2014). Interestingly, the empirical evidence is scant. A coin tossing study reveals that females are more likely to exhibit misperception of randomness (Dohmen et al. 2009). In another study about lottery betting, fallacy beliefs were only found among males (Suetens and Tyran 2011). In a recent study conducted by Fong et al. (2014), no gender difference was found in the fallacy beliefs of casino players. Based on these studies, the gender effect on fallacy belief remains inconclusive.

Although previous empirical studies failed to provide a concrete conclusion on the gender effect, the literature of intuitive decision making may provide some insights. Using intuition to make decision, people draw selected pieces of information to figure out a pattern which is interpretable (Matzler et al. 2007; Sinclair and Ashkanasy 2005). So, intuitive decision making is not based on rational analysis (Dane and Pratt 2007), though it has been shown to reach better decision and performance in certain domains like managerial decision (Khatri and Ng 2000) and stock investment decision (Seo and Barrett 2007). However, in the prediction of gambling outcome which is purely driven by chance, deviation from rationality would result in fallacy beliefs. Individuals who use intuition to make decision would be more likely to exhibit fallacious behavior. Females have been argued to have better access to intuition because of their strength in encoding and decoding (Sinclair and Ashkanasy 2005). Their likelihood of using intuition to make betting decision may be higher than their male counterparts, especially when betting decisions have to be made in a short-time horizon like those in casino gaming. Following this rationale, fallacy should be more salient among females. As such, the effect of break-streak pattern on betting decision may be more salient among females than males and thus Hypothesis 4 is formulated:

Hypothesis 4 Being exposed to a break-streak pattern, female gamblers are more likely to bet on the latest outcome than male gamblers.

Method

Although laboratory experiment has the advantage of controlling for confounding effects, the external validity of the data is questionable. Therefore, practitioners may cast doubt on the robustness of the conclusions drawn from the laboratory study. This study has solicited data by the non-participatory observation of casino gamblers. This covert approach has been criticized for violating the principle of informed consent (Homan 1980). However, it is also argued that the covert method can be used if the data are of high quality (Wells 2004) and overt method would contaminate the phenomenon being researched (ESRC 2015). In this study, if overt observation method is used (i.e., the subjects were well-informed), the Hawthorne effect (the presence of a stranger when data are collected) would negatively affect the data quality. Moreover, the observed subjects in this study are real gamblers and their betting behaviors are not manipulated. Their identities are also un-known. So, it is unlikely for the current study to cause harm to the subjects. More im-portantly, following Denzin's (1968) argument, non-participant observation should be justifiable as long as the researchers, like us, pursue it with scientific purposes in mind.

To mitigate the environmental effects on gambling behavior (Finlay et al. 2010), this study chose only one casino for data collection. The casino is in Macao, which is currently the most lucrative gaming city in the world. Small gaming venues are generally not recommended for non-participatory observations because of the small number of research subjects (i.e., gamblers; Parke 2002). Therefore, this study has pursued the observational work in a Macao mega casino that is frequented by a large number of gamblers. The observations focused on a game called Cussec and lasted for a week, from noon to late evening every day.

Originating from China, Cussec was chosen for this study. It is a type of table game, and one of the most popular casino games in Macao. The game features a random outcome-generating process of shaking three dice in a tumbler. Hence, Cussec is generally known as a game of chance, which is a pre-requisite for examining the fallacy. The total of the three dice (ranging from 3 to 18) dictates the betting outcomes (i.e., win or loss) of a gambler. Among approximately fifty betting options on the Cussec table layout, "Big" and "Small" are most frequently wagered. "Big" represents a total of the three dice ranging from 11 to 17, whereas "Small" represents a dice total between 4 and 10 inclusive. If all dice have the same outcome, "Triple" is the result. Then, any wagers on "Big" or "Small" are considered a loss, and only those gamblers who bet on "Triple" win. While the winning probabilities of "Big" and "Small" are the same, the chance of winning "Triple" is much smaller.

Although Cussec is a game of chance, gamblers tend to believe that the outcome is predictable. Gamblers predict the next outcome by analyzing the previous outcomes listed on a panel screen attached to the Cussec table. Therefore, it is common to observe gam-blers staring at the screen before their wagers (Fong et al. 2014). To testify this phe-nomenon, one of the investigators spent 2 weeks in the casino to observe the betting behavior of the Cussec players. It is found that almost all the players would look at the screen before placing their wagers. Moreover, it is observed that the players always dis-cussed the patterns among themselves before making the betting decisions. On the other hand, based on personal interviews, twenty Cussec players reported that they would read

the patterns before making their betting decisions. A casino director claimed that the screen is for inducing the players to bet. Given these findings, the outcome records on the screen should have an impact on the players' betting behavior and decision.

In the current research, the screen exhibits the last twelve outcome records, with one record per row (see Fig. 1). The latest record is at the top of the screen. There are five column sections including the dice combinations, dice totals, "Big", "Small", and "Triple". For example, as displayed in Fig. 1, the latest outcome record features a dice combination of "335" and thus a total of eleven. As eleven is in the range of "Big", the Chinese character of "Big" is displayed on the screen, whereas the characters of "Small" and "Triple" are not activated. The font colors of the outcome records of "Big", "Small", and "Triple" are in red, yellow, and green, respectively, so that the records can be easily distinguished.

The investigator performed data collection in the Cussec table areas. As the current research is interested in the betting decision under break-streak pattern, the investigator only approached the table at which the break-streak pattern is shown on the panel screen. According to Carlson and Shu (2007), a streak has to comprise three or more consecutive outcomes. An example of the break-streak pattern is displayed in Fig. 1, in which the latest outcome is "Big" preceded by a streak of three "Small" outcomes. Once the break-streak pattern was identified on the screen, the investigator approached the table and stood in a position that afforded a clear view of the screen, the gamblers' faces, and the wagers on the table layout. When the dealer called out "no more bet", the investigator noted the number of bets for "Big" and "Small" on the table layout, the gamblers' genders, and the on-screen outcome records in worksheets with a customized page format for this study. The wagers on "Triple" were not recorded because the probability its occurrence is not equivalent to those of "Big" and "Small". For the same reason, if the latest outcome or the streak contains "Triple", the table is not qualified for the current study. Furthermore, if the screen did not exhibit the twelve outcome records, that table was not qualified for this research. This approach rules out any confounding effect caused by the variation of the length of outcome records.

When the investigator completed the noting tasks, he moved to the next qualified table and repeated the data collection procedure. In total, 1367 bets were recorded. The data were encoded based on the latest outcome. Among the four variables in this study, two of them are nominal variables including the betting decision (BET: Bet on the opposite of latest outcome = 0, Bet on the latest outcome = 1) and gender (GENDER: Male = 0, Female = 1), whereas the remaining two are continuous variables including the streak length of the alternative outcome (i.e., the second latest outcome) (STRK_LEN) and the frequency level of the latest outcome relative to the alternative outcome (FREQ_LAT). Inasmuch as the total number of outcome records on the screen is twelve and the break-streak pattern is characterized by the latest outcome preceded by a streak of alternative outcomes, the STRK_LEN variable cannot be out of the range of three through eleven. The values in the FREQ_LAT variable are in percentages, derived from the following formula, wherein A denotes the number of records of the latest outcome on the screen and B denotes the number of records of alternative outcomes on the screen:

$$A \times 100/(A + B)$$

This data transformation is necessary as the number of records of the latest outcome cannot reflect the frequency level relative to the alternative outcome. For instance, in Fig. 1, there are 6 records of the latest outcome (i.e., Big), 5 records of the alternative

Fig. 1 The screen layout of the cussec outcome
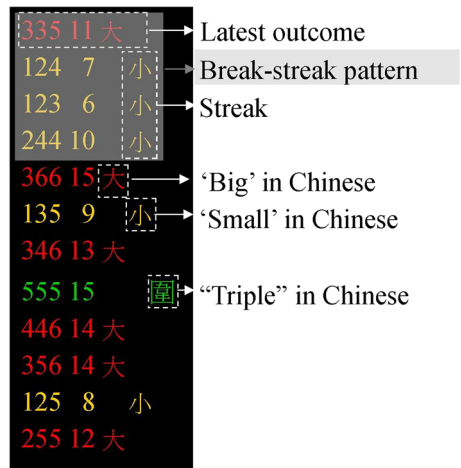
outcome (i.e., Small), and 1 record of "Triple" on the screen. Based on the frequency count, the latest outcome (i.e., Big) occupies half of the records (6 out of 12). However, as the betting decision is between "Big" and "Small", the "Triple" record has to be excluded. Thus the frequency level of the latest outcome should be greater than half (6 over $11 = .545$). Therefore, the data transformation is essential.

Before proceeding to the data analysis, the data set was initially cleaned by identifying the univariate outliers in the continuous variables. Given the large sample size, z values >4 or <-4 are considered outliers (Mertler and Vannatta 2010). The z values of STRK_LEN ranged from $-.843$ to 3.336, whilst the z values of FREQ_LAT ranged from -2.432 to 2.461. Thus, no univariate outlier was found.

While the dependent variable (BET) is a categorical variable, logistic regression was employed to test hypotheses 2 through 4. The independent variables are STRK_LEN, FREQ_LAT, and GENDER. Multivariate outliers have to be identified. Ninety-five cases were excluded as their z-values were not within the range of -2 and 2 (Field 2009). Therefore, 1272 bets (or cases) were retained.

Logistic regression was performed again to locate the influential cases. The results indicate that the leverage values of forty-three cases were greater than thrice the average

Table 1 Results of the binomial analyses

Length of break-streak	Bet on latest outcome (%)
Three ($n = 485$)	81***
Four ($n = 269$)	87***
Five ($n = 179$)	87***
Six ($n = 132$)	83***
Seven ($n = 103$)	90***
Eight ($n = 19$)	84**
Nine ($n = 22$)	91***
Ten ($n = 13$)	100***
Eleven ($n = 7$)	100*
Overall ($n = 1229$)	85***

* $p < .05$; ** $p < .01$; *** $p < .001$

values −.0094—although the absolute values of DFBeta and the values of Cook's Distance were satisfactory (<1) (Field 2009). Therefore, forty-three influential cases were further trimmed, and the remaining number of bets became 1229.

Results

Among the 1229 bets, 829 of them (67.5 %) were made by male gamblers. Hypothesis 1 is to examine if Cussec gamblers were more likely to bet on the latest outcome than the alternative outcome given a break-streak pattern. Binominal analysis with a baseline of 50 % was used to test the hypothesis. Only the variable BET was included. Binomial analyses were performed for all the data and the data within various break-streak lengths. As shown in Table 1, results indicate that the proportion of bets in the latest outcome is significantly >50 % (*proportion* = 85 %, $p < .001$). Same results were found for all the break-streak lengths (*proportions* ranging from 81 to 100 %, $p < .05$) Therefore, Hypothesis 1 is confirmed.

As mentioned previously, logistic regression was employed to test hypotheses 2 through 4. The assumptions of the logistic regression including the linearity of the logit for continuous predictors and multicollinearity issues were assessed. The interactions between log STRK_LEN and STRK_LEN and between log FREQ_LAT and FREQ_LAT were not statistically significant ($p > .05$). Therefore, the assumption of linearity has not been violated. In addition, the assumption of multicollinearity has not been violated as the VIF values of the predictors (ranging from 1.012 to 1.449) were below 5, the absolute correlations between independent variables (ranging from .04 to .454) were below .7, and the highest condition index (14.181) was below 30 (Dormann et al. 2013).

Given the exploratory nature of this study (the first attempt to research the determinants of the break-streak effect), the stepwise (backward) approach was adopted. Table 2 displays the results of the logistic regression analysis. The model correctly classifies 84.9 % of the cases. With the precondition of a break-streak pattern, betting on the latest outcome is more likely to occur given a longer streak of alternative outcomes (STRK_LEN: $B = .540$, $p < .001$), a higher frequency level of the latest outcome relative to the alternative outcome (FREQ_LAT: $B = .112$, $p < .001$), and a female gambler (GENDER: $B = 2.097$, $p < .001$). Therefore, hypotheses 2 to 4 are all confirmed. In other words, all of these factors predict the betting decision under break-streak pattern.

Table 2 Results of the logistic regression analysis

	B (SE)	95 % CI for odds ratio		
		Lower	Odds ratio (Exp B)	Upper
Constant	−5.342* (.593)			
STRK_LEN	.540* (.069)	1.498	1.716	1.965
FREQ_LAT	.112* (.010)	1.096	1.118	1.141
GENDER	2.097* (.314)	4.399	8.138	15.054

Dependent variable = BET; R^2 = .241 (Hosmer and Lemshow), .186 (Cox and Snell), .324 (Nagelkerke); Model $\chi^2(3)$ = 252.99, $p < .001$; * $p < .001$

The odds ratios denote the effect size of the predictors. The results indicate that GENDER (*Exp B* = 8.138) is the strongest predictor of the betting decision, followed by STRK_LEN (*Exp B* = 1.716), and FREQ_LAT (*Exp B* = 1.118). Therefore, the odds of betting on the latest outcome under break-streak pattern are 8.138 times higher among female gamblers than for their male counterparts, 1.716 times higher for the long streak than for the short streak of the alternative outcome, and 1.118 times higher when the latest outcome is more frequent than when it is less frequent relative to the alternative outcome.

Discussion and Conclusion

This research introduces the effect of break-streak pattern on betting decisions and aims to confirm it among gamblers of a casino game called Cussec. The results indicate that the effect prevails as most Cussec gamblers bet on the latest outcome when that outcome is preceded by a streak of alternative outcomes. The findings imply the salience of representativeness heuristic or more specifically gambler's fallacy, which underpins the thought that the streak of alternative outcomes has to be restored to balance. Previous research on the streak effect fails to draw a coherent conclusion on whether gambler's fallacy or hot outcome fallacy is more salient (Ayton and Fischer 2004; Croson and Sundali 2005; Fong et al. 2014; Wagenaar 1988). A possible reason is that the streak itself is not a reliable cue for people to predict the outcome. In contrast, the break-streak pattern signals that the balance of outcome sequence starts, which strengthens the gamblers' belief that the latest outcome will repeat itself. Therefore, under the break-streak pattern, gambler's fallacy, instead of hot outcome fallacy, drives the betting decision.

An additional major objective of this study is to identify the predictors of the break-streak effect. Three predictors, including the streak length of the alternative outcome (i.e., the second-to-last outcome), the frequency level of the latest outcome relative to the alternative outcome, and gender, were identified, and their relationships with the break-streak effect are confirmed. It was found that the longer streak length of the alternative outcomes results in a higher tendency toward the break-streak effect. As the representativeness heuristic signals to the gamblers that they have to restore the sequence to balance, a longer streak prompts a stronger need to achieve the balance. According to Carlson and Shu (2007), people cast doubt on the degree of randomness in the outcome-generating process in the case of a very long streak. This argument provides further support for the relationship between streak length and the break-streak effect. The breaking of a long streak helps alleviate gamblers' doubt about the randomness of outcome, which in turn strengthens their belief that the forthcoming outcomes have to restore the sequence to balance.

Similar to Fong et al.'s (2014) study in which the frequency of the latest outcome strengthens fallacy beliefs, this study also corroborated the relationship between outcome frequency and the break-streak effect. Availability heuristic enlivens the frequent outcome in gamblers' minds and drives them to bet on that outcome (i.e., hot outcome fallacy). Although the frequency effect is significant, it is less important than the effect of the streak length of the alternative outcome (based on their odds ratios; i.e., gambler's fallacy). The frequency effect is even less important than the gender effect in this study.

Gender is the most significant predictor of the break-streak effect. This study reveals that female gamblers are more likely to bet on the latest outcome under break-streak pattern than their male counterparts. The findings echo those of Dohmen et al. (2009) that

females are more vulnerable to the misperception of randomness. This is not surprising as females are more likely to use intuition to make decision (Sinclair and Ashkanasy 2005).

To conclude, this study adds to the literature by proposing the break-streak pattern underpinned by the representativeness heuristics. Moreover, the predictors of the break-streak effect are identified and confirmed. While the break-streak effect is manifested in the prediction of the outcomes of a game, it is unknown whether the effect will be found in the prediction of personal outcome (i.e., a win or loss). Future research may attempt to address this gap.

This research provides meaningful insights for the casinos as to the responsible operation of their businesses, especially in terms of minimizing the harm from gambling. Inasmuch as the break-streak pattern enhances gambler confidence in betting decisions, the pattern may induce a more pronounced gambling intention as well as the amount of gambling. A responsible casino operator may therefore consider not deliberately creating this type of pattern. For instance, if there is no gambler at a Cussec table, the casino manager should not ask the dealer to run the game until the break-streak pattern emerges. While this study concludes that female gamblers are less able to recognize randomness, responsible gambling educational work for females is vital. Stakeholders in the casino industry such as the casino operators, government, problem gambling prevention organizations, and treatment centers have unavoidable responsibilities in terms of the educational work.

This study has several limitations. First, as the data collection was conducted in a Macao casino where a majority of gamblers are Chinese (Lam 2009), generalization of the findings to include gamblers of other ethnicities has to be cautious. Future research may replicate this study among non-Chinese subjects. Second, this research presumes that all gamblers read the panel screens before making their betting decisions. However, it is possible that some gamblers wagered without referencing the pattern on the screen. Moreover, other factors that the gamblers attended to are unknown. These issues can be addressed by a follow-up controlled laboratory study. More importantly, a laboratory setting can help rule out the effect caused by the casino environment and allow researchers to delve into the underlying cognitive process of gamblers when they are exposed to the break-streak pattern, and to explore other predicting factors (e.g., problem gambling severity, trait impulsivity, smoking habit, memory, and culture) of betting decision. In addition, betting decisions under break-streak can be compared to those under no break-streak patterns in the laboratory setting in order to provide convergent evidence of the break-streak effect. As the observational data do not allow isolation of the outcome frequency effect (driven by the hot outcome fallacy), future laboratory research needs to control this effect in order to reach a concrete conclusion on the break-streak effect. Finally, as the relationships between the predictors and the break-streak effect have been individually confirmed, future studies may include the investigation of the interactions among the predictors to disentangle the predicting effects.

References

Afifi, T. O., Cox, B. J., Martens, P. J., Sareen, J., & Enns, M. W. (2010). Demographic and social variables associated with problem gambling among men and women in Canada. *Psychiatry Research, 178*(2), 395–400.

Altmann, E. M., & Burns, B. D. (2005). Streak biases in decision making: Data and a memory model. *Cognitive Systems Research, 6*(1), 5–16.

Asparouhova, E., Hertzel, M., & Lemmon, M. (2009). Inference from streaks in random outcomes: Experimental evidence on beliefs in regime shifting and the law of small numbers. *Management Science, 55*(11), 1766–1782.

Ayton, P., & Fischer, I. (2004). The hot hand fallacy and the gambler's fallacy: Two faces of subjective randomness? *Memory and Cognition, 32*(8), 1369–1378.

Babad, E., & Katz, Y. (1991). Wishful thinking—Against all odds. *Journal of Applied Social Psychology, 21*(23), 1921–1938.

Bar-Hillel, M., & Wagenaar, W. A. (1991). The perception of randomness. *Advances in Applied Mathematics, 12*(4), 428–454.

Blaszczynski, A., Collins, P., Fong, D., Ladouceur, R., Nower, L., Shaffer, H. J., et al. (2011). Responsible gambling: General principles and minimal requirements. *Journal of Gambling Studies, 27*(4), 565–573.

Blaszczynski, A., Ladouceur, R., & Shaffer, H. J. (2004). A science-based framework for responsible gambling: The Reno Model. *Journal of Gambling Studies, 20*(3), 307–317.

Blinder, D. S., & Oppenheimer, D. M. (2008). Beliefs about what types of mechanisms produce random sequences. *Journal of Behavioral Decision Making, 21*(4), 414–427.

Burns, B. D., & Corpus, B. (2004). Randomness and inductions from streaks: "Gambler's fallacy" versus "hot hand". *Psychonomic Bulletin & Review, 11*(1), 179–184.

Carlbring, P., Degerman, N., Jonsson, J., & Andersson, G. (2012). Internet-based treatment of pathological gambling with a three-year follow-up. *Cognitive Behaviour Therapy, 41*(4), 321–334.

Carlson, K. A., & Shu, S. B. (2007). The rule of three: How the third event signals the emergence of a streak. *Organizational Behavior and Human Decision Processes, 104*(1), 113–121.

Choi, Y. B. (1993). *Paradigms and conventions: Uncertainty, decision making, and entrepreneurship.* Ann Arbor, MI: The University of Michigan Press.

Clotfelter, C. T., & Cook, P. J. (1993). Notes: The "gambler's fallacy" in lottery play. *Management Science, 39*(12), 1521–1525.

Croson, R., & Sundali, J. (2005). The gambler's fallacy and the hot hand: Empirical data from casinos. *Journal of Risk and Uncertainty, 30*(3), 195–209.

Dane, E., & Pratt, M. G. (2007). Exploring intuition and its role in managerial decision making. *Academy of Management Review, 32*(1), 33–54.

Delfabbro, P. (2004). The stubborn logic of regular gamblers: Obstacles and dilemmas in cognitive gambling research. *Journal of Gambling Studies, 20*(1), 1–21.

Denzin, N. K. (1968). On the ethics of disguised observation. *Social Problems, 15*(4), 502–504.

Dohmen, T., Falk, A., Huffman, D., Marklein, F., & Sunde, U. (2009). Biased probability judgment: Evidence of incidence and relationship to economic outcomes from a representative sample. *Journal of Economic Behavior & Organization, 72*(3), 903–915.

Dormann, C. F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., & Lautenbach, S. (2013). Collinearity: A review of methods to deal with it and a simulation study evaluating their performance. *Ecography, 36*(1), 27–46.

ESRC. (2015). ESRC framework for research ethics: Updated January 2015. http://www.esrc.ac.uk/_images/framework-for-research-ethics_tcm8-33470.pdf.

Ferguson, C. J., Coulson, M., & Barnett, J. (2011). A meta-analysis of pathological gaming prevalence and comorbidity with mental health, academic and social problems. *Journal of Psychiatric Research, 45*(12), 1573–1578.

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). Los Angeles, CA: Sage.

Finlay, K., Marmurek, H. H. C., Kanetkar, V., & Londerville, J. (2010). Casino décor effects on gambling emotions and intentions. *Environment and Behavior, 42*(4), 524–545.

Fong, L. H. N., Law, R., & Lam, D. (2014). An examination of factors driving Chinese gamblers' fallacy bias. *Journal of Gambling Studies, 30*(3), 757–770.

Fortune, E. E., & Goodie, A. S. (2012). Cognitive distortions as a component and treatment focus of pathological gambling: A review. *Psychology of Addictive Behaviors, 26*(2), 298–310.

Gooding, P., & Tarrier, N. (2009). A systematic review and meta-analysis of cognitive-behavioural interventions to reduce problem gambling: Hedging our bets? *Behaviour Research and Therapy, 47*(7), 592–607.

Griffiths, M. D. (1994). The role of cognitive bias and skill in fruit machine gambling. *British Journal of Psychology, 85*(3), 351–369.

Homan, R. (1980). The ethics of covert methods. *British Journal of Sociology, 31*(1), 46–59.

Hong, H., & Kacperczyk, M. (2009). The price of sin: The effects of social norms on markets. *Journal of Financial Economics, 93*(1), 15–36.

Huber, J., Kirchler, M., & Stöckl, T. (2010). The hot hand belief and the gambler's fallacy in investment decisions under risk. *Theory and Decision, 68*(4), 445–462.

Johansson, A., Grant, J., Kim, S., Odlaug, B., & Götestam, K. G. (2009). Risk factors for problematic gambling: A critical literature review. *Journal of Gambling Studies, 25*(1), 67–92.

Joukhador, J., Maccallum, F., & Blaszczynski, A. (2003). Differences in cognitive distortions between problem and social gamblers. *Psychological Reports, 92*(3c), 1203–1214.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology, 3*(3), 430–454.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263–292.

Kahneman, D., & Tversky, A. (1996). On the reality of cognitive illusions. *Psychological Review, 103*(3), 582–591.

Keren, G., & Lewis, C. (1994). The two fallacies of gamblers: Type I and type II. *Organizational Behavior and Human Decision Processes, 60*(1), 75–89.

Khatri, N., & Ng, H. A. (2000). The role of intuition in strategic decision making. *Human Relations, 53*(1), 57–86.

Lai, J. Y. M., Chan, K. W., & Lam, L. W. (2013). Defining who you are not: The roles of moral dirtiness and occupational and organizational disidentification in affecting casino employee turnover intention. *Journal of Business Research, 66*(9), 1659–1666.

Lam, D. (2009). *The world of Chinese gambling*. Norwood: Peacock Publications.

Langer, E. J. (1975). The illusion of control. *Journal of Personality and Social Psychology, 32*(2), 311–328.

MacLaren, V. V., Fugelsang, J. A., Harrigan, K. A., & Dixon, M. J. (2011). The personality of pathological gamblers: A meta-analysis. *Clinical Psychology Review, 31*(6), 1057–1067.

Matzler, K., Bailom, F., & Mooradian, T. A. (2007). Intuitive decision making. *MIT Sloan Management Review, 49*(1), 13–15.

Mertler, C. A., & Vannatta, R. A. (2010). *Advanced and multivariate statistical methods* (4th ed.). Glendale, CA: Pyrczak Publishing.

Myrseth, H., Brunborg, G., & Eidem, M. (2010). Differences in cognitive distortions between pathological and non-pathological gamblers with preferences for chance or skill games. *Journal of Gambling Studies, 26*(4), 561–569.

Ndubisi, N. O., Nataraajan, R., & Chew, J. (2014). Ethical ideologies, perceived gambling value, and gambling commitment: An Asian perspective. *Journal of Business Research, 67*(2), 128–135.

Nowak, D., & Aloe, A. (2014). The prevalence of pathological gambling among college students: A meta-analytic synthesis, 2005–2013. *Journal of Gambling Studies, 30*(4), 819–843.

Parke, J. (2002). Slot machine gamblers—Why are they so hard to study? *Journal of Gambling Issues,* (6), 1–11. http://jgi.camh.net/doi/full/10.4309/jgi.2002.6.7.

Petrocelli, J. V., & Sherman, S. J. (2010). Event detail and confidence in gambling: The role of counter-factual thought reactions. *Journal of Experimental Social Psychology, 46*(1), 61–72.

Prentice, C., & Woodside, A. G. (2013). Problem gamblers' harsh gaze on casino services. *Psychology and Marketing, 30*(12), 1108–1123.

Rapoport, A., & Budescu, D. V. (1997). Randomization in individual choice behavior. *Psychological Review, 104*(3), 603–617.

Raylu, N., & Oei, T. P. S. (2002). Pathological gambling: A comprehensive review. *Clinical Psychology Review, 22*(7), 1009–1061.

Schwarz, N., Bless, H., Strack, F., Klumpp, G., Rittenauer-Schatka, H., & Simons, A. (1991). Ease of retrieval as information: Another look at the availability heuristic. *Journal of Personality and Social Psychology, 61*(2), 195–202.

Seo, M. G., & Barrett, L. F. (2007). Being emotional during decision making—Good or bad? An empirical investigation. *Academy of Management Journal, 50*(4), 923–940.

Sinclair, M., & Ashkanasy, N. M. (2005). Intuition: Myth or a decision-making tool? *Management Learning, 36*(3), 353–370.

Suetens, S., & Tyran, J.-R. (2011). The gambler's fallacy and gender. *CentER Discussion Paper No. 2011-011.* http://ssrn.com/paper=1759997.

Sundali, J., & Croson, R. (2006). Biases in casino betting: The hot hand and the gambler's fallacy. *Judgment and Decision Making, 1*(1), 1–12.

Tang, C. S. K., & Wu, A. M. S. (2012). Gambling-related cognitive biases and pathological gambling among youths, young adults, and mature adults in Chinese societies. *Journal of Gambling Studies, 28*(1), 139–154.

Terrell, D. (1994). A test of the gambler's fallacy: Evidence from pari-mutuel games. *Journal of Risk and Uncertainty, 8*(3), 309–317.

Toneatto, T. (1999). Cognitive psychopathology of problem gambling. *Substance Use and Misuse, 34*(11), 1593–1604.

Toneatto, T., & Ladoceur, R. (2003). Treatment of pathological gambling: A critical review of the literature. *Psychology of Addictive Behaviors, 17*(4), 284–292.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5*(2), 207–232.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*(4157), 1124–1130.

Tyszka, T., Zielonka, P., Dacey, R., & Sawicki, P. (2008). Perception of randomness and predicting uncertain events. *Thinking & Reasoning, 14*(1), 83–110.

Wagenaar, W. A. (1988). *Paradoxes of gambling behavior*. London: Lawrence Erlbaum Associates.

Wells, H. M. (2004). Is there a place for covert research methods in criminology? *Graduate Journal of Social Science, 1*(1), 1–19.

Welte, J., Barnes, G., Tidwell, M. C., & Hoffman, J. (2008). The prevalence of problem gambling among US adolescents and young adults: Results from a national survey. *Journal of Gambling Studies, 24*(2), 119–133.