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Brief article

Carry on winning: The gamblers' fallacy creates hot hand effects in online gambling

Juemin Xu *, Nigel Harvey

Department of Cognitive, Perceptual and Brain Sciences, University College London, UK

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ABSTRACT

People suffering from the hot-hand fallacy unreasonably expect winning streaks to continue whereas those suffering from the gamblers' fallacy unreasonably expect losing streaks to reverse. We took 565,915 sports bets made by 776 online gamblers in 2010 and analyzed all winning and losing streaks up to a maximum length of six. People who won *were* more likely to win again (apparently because they chose safer odds than before) whereas those who lost were more likely to lose again (apparently because they chose riskier odds than before). However, selection of safer odds after winning and riskier ones after losing indicates that online sports gamblers expected their luck to reverse: they suffered from the gamblers' fallacy. By believing in the gamblers' fallacy, they created their own hot hands.

1. Introduction

The hot-hand fallacy and gamblers' fallacy are assumed to be common among gamblers because it is thought that they believe that outcomes for future bets are predictable from those of previous ones.

1.1. Belief in a hot-hand: "If you have been winning, you are more likely to win again."

The term a "hot hand" was initially used in basketball to describe a basketball player who had been very successful in scoring over a short period. It was believed that such a player had a "hot hand" and that other players should pass the ball to him to score more. This term is now used more generally to describe someone who is winning persistently and can be regarded as "in luck". In gambling scenarios, a player with a genuine hot hand should keep betting and bet more.

There have been extensive discussions about the existence of the hot hand effect. Some researchers have failed to find any evidence of such an effect (Gilovich, Vallone, & Tversky, 1985; Koehler & Conley, 2003; Larkey, Smith, & Kadane, 1989; Wardrop, 1999). Others claim there is evidence of the hot hand effect in games that require considerable physical skill, such as golf, darts, and basketball (Arkes, 2010, 2011; Gilden & Wilson, 1995; Yaari & Eisenmann, 2011).

People gambling on sports outcomes may continue to do so after winning because they believe they have a hot hand. Such a belief may be a fallacy. It is, however, possible that their belief is reasonable. For example, on some occasions, they may realize that their betting strategy is producing profits and that it would be sensible to continue with it. Alternatively, a hot hand could arise from some change in their betting strategy. For example, after winning, they may modify their bets in some way to increase their chances of winning again.

* Corresponding author. Address: Department of Cognitive, Perceptual and Brain Sciences, University College London, Gower Street, London WC1E 6BT, UK. Tel.: +44 (0)2076797570.
E-mail address: juemin.xu@ucl.ac.uk (J. Xu).

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1.2. The gamblers' fallacy: "If you have been losing, you are more likely to win in future."

People gambling on sports outcomes may continue to do so after losing because they believe in the gamblers' fallacy. This is the erroneous belief that deviations from initial expectations are corrected even when outcomes are produced by independent random processes. Thus, people's initial expectations that, in the long run, tosses of a fair coin will result in a 50:50 chance of heads and tails are associated with a belief that deviations from that ratio will be corrected. Hence, if five tosses of a fair coin have produced a sequence of five heads, the chance of tails on the next toss will be judged to be larger than 50%. This is because the coin "ought to" have a 50:50 chance of heads and tails in the long run and, as a result, more tails are "needed" to correct the deviation from that ratio produced by the first five tosses.

1.3. Odds and stake size: A conflict between belief in a hot hand and the gambler's fallacy

Betting strategies are often based on the previous betting results (Oskarsson, Van Boven, McClelland, & Hastie, 2009). The strategies based on a belief in a hot hand and gamblers' fallacy may conflict. For example, when trying to decide what odds to select in the next round, a belief in the gamblers' fallacy would result in betting on higher odds and with more money after losing than after winning. A believer in the hot hand would do the opposite.

2. Method and data

To date, there is little research on real gambling. Our research (1) demonstrates the existence of a hot hand, (2) investigates gamblers' beliefs in a hot hand and the gamblers' fallacy, and (3) explores the causal relationship between a hot hand and the gamblers' fallacy.

2.1. Analysis methods

We used a large online gambling database. First, we counted all the sports betting results to see whether winning was more likely after a streak of winning bets or after a streak of losing ones. Second, we examined the record of those gamblers who has long streaks of wins to see whether they had higher returns; this could be a sign of real skill. Third, we used the odds and the stake size to predict the probability of winning.

2.2. Data set

The complete gambling history of 776 gamblers between 1 January 2010 and 31 December 2010 was obtained from an online gambling company. In total, 565,915 bets were placed by these gamblers during the year. Characteristics of the samples are shown in Table 1.

Each gambling record included the following information: game type (e.g., horse racing, football, and cricket), game name (e.g. Huddersfield v West Bromwich), time, stake, type of bet, odds, result, and payoff. Each person was identified by a unique account number. All the bets they placed in the year were arranged in chronological order by the time of settlement, which was precise to the minute. The time when the stake was placed was not available but, according to the gambling house, there is no reason to think that stakes are placed long before the time of settlement. Each account used one currency, which was chosen when the account was opened; no change of currency was allowed during the year.

If there is a hot hand, then, after a winning bet, the probability of winning the next bet should go up. We compared the probability of winning after different run lengths of previous wins (Fig. 1). If the gamblers' fallacy is not a fallacy, the probability of winning should go up after losing several bets. We also compared the probability of winning in this situation.

3. Results and analysis

3.1. The hot hand

To produce the top panel of Fig. 1, we first counted all the bets in GBP; there were 178,947 bets won and 192,359 bets lost. The probability of winning was 0.48.

Second, we took all the 178,947winning bets and counted the number of bets that won again; there were 88,036 bets won. The probability of winning was 0.49. In comparison, following the 192,359 lost bets, the probability of winning was 0.47. The probability of winning in these two situations was significantly different ($Z = 12.10$, $p < .0001$).

Third, we took all the 88,036 bets, which had already won twice and examined the results of bets that followed these bets. There were 50,300 bets won. The probability of winning rose to 0.57. In contrast, the probability of winning did not rise after gambles that did not show a winning streak: it was 0.45. The probability of winning in these two situations was significantly different ($Z = 60.74$, $p < .0001$).

Fourth, we examined the 50,300 bets which had already won three times and checked the result of the bets followed them. We found that 33,871 bets won. The probability of winning went up again to 0.67. In contrast, the bets not having a run of lucky predecessors showed a probability of winning of 0.45. The probability of winning in these two situations was significantly different ($Z = 90.63$, $p < .0001$).

Fifth, we used the same procedure and took all the 33,871 bets which had already won four times. We checked the result of bets followed these bets. There were 24,390 bets that won. The probability of winning went up again to 0.72. In contrast, the bets without a run of previous wins showed a probability of winning of only 0.45. The probability of winning in these two situations was significantly different ($Z = 91.96$, $p < .0001$).

Sixth, we used the same method to check the 24,390 bets which had already won five times in a row. There were 18,190 bets that won, giving a probability of winning of 0.75. After other bets, the probability of winning was 0.46. The probability of winning in these two cases was significantly different ($Z = 86.78$, $p < .0001$).

Table 1
Sample characteristics for sports bets placed in each of three currencies for the year 2010.

	GBP	EUR	USD
Number of bets	371,306	162,077	32,532
Number of gamblers	407	318	51
Mean stake	£145 (1482)	€395 (5555)	$50 (321)
Median stake	£14	€18	$15
Maximum stake	£313,900	€1,492,000	$20,500
Mean number of bets placed by a single account	917	517	641
Median number of bets placed by a single account	171	88	153
Number of horse racing bets	260,550	34,659	8290
Number of soccer bets	69,863	90,415	12,058
Number of greyhound racing bets	28,859	6660	9159

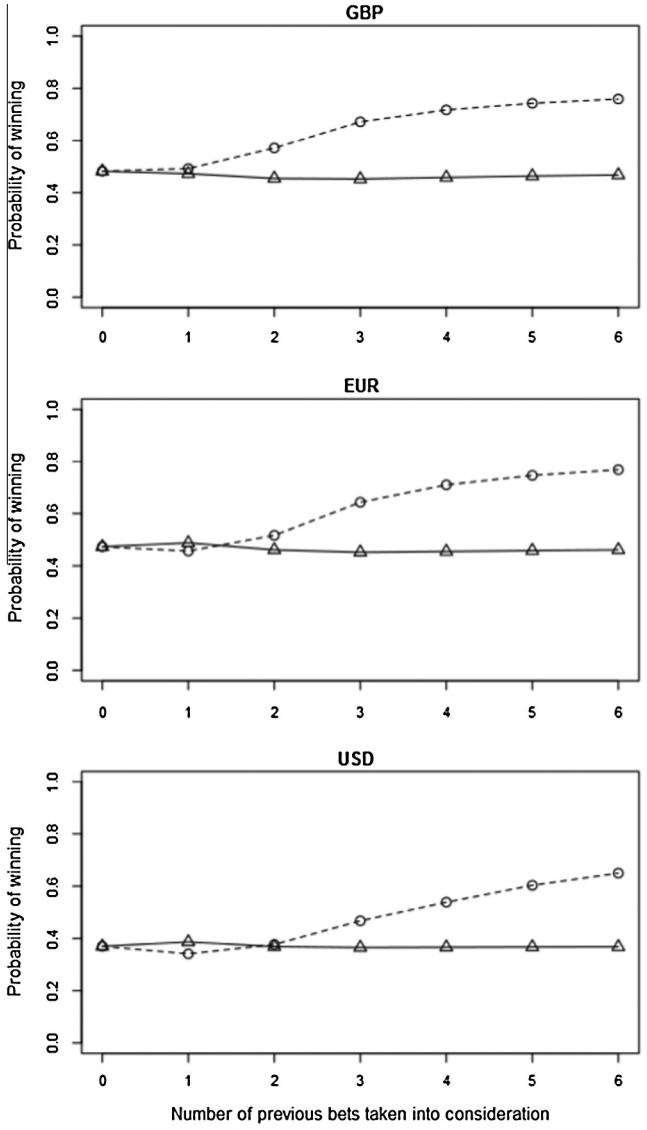

Fig. 1. Probability of winning after obtaining winning streaks of different lengths (o) and after not obtaining winning streaks of those lengths (Δ).

Seventh, we examined the 18,190 bets that had won six times in a row. Following such a lucky streak, the probability of winning was 0.76. However, for the bets that had not won on the immediately preceding

occasion, the probability of winning was only 0.47. These two probabilities of winning were significantly different ($Z = 77.50$, $p < .0001$).

The hot hand also occurred for bets in other currencies (Fig. 1). Regressions (Table 2) show that, after each successive winning bet, the probability of winning increased by 0.05 ($t(5) = 8.90$, $p < .001$) for GBP, by 0.06 for EUR ($t(5) = 8.00$, $p < .001$), and by 0.05 for USD ($t(5) = 8.90$, $p < .001$).

3.2. The gamblers' fallacy

We used the same approach to analyze the gamblers' fallacy. The first step was same as in the analysis of the hot hand. We counted all the bets in GBP; there were 178,947 bets won and 192,359 bets lost. The probability of winning was 0.48 (Fig. 2, top panel).

In the second step, we identified the 192,359 bets that lost and examined results of the bets immediately after them. Of these, 90,764 won and 101,595 lost. The probability of winning was 0.47. After the 178,947 bets that won, the probability of winning was 0.49. The difference between these two probabilities were significant ($Z = 12.01$, $p < 0.001$).

In the third step, we took the 101,595 bets that lost and examined the bets following them. We found that 40,856 bets won and 60,739 bets lost. The probability of winning after having lost twice was 0.40. In contrast, for the bets that did not lose on both of the previous rounds, the probability of winning was 0.51. The difference between these probabilities was significant ($Z = 58.63$, $p < 0.001$).

In the fourth step, we repeated the same procedure. After the 60,739 bets that had lost three times in a row, there were 19,142 winning bets won and losing 41,595 bets ones, giving a probability of winning of 0.32. For other bets, this probability was 0.51 ($Z = 88.26$, $p < 0.001$).

The fifth, sixth and seventh steps were carried out in an analogous way. They showed that the probability of winning after four lost bets was 0.27, after five lost bets was 0.25, and after six lost bets was 0.23.

The pattern was similar for bets in other currencies (Fig. 2). Regressions (Table 2) showed that each successive losing bet decreased the probability of winning 0.05 ($t(5) = 9.71$, $p < .001$) for GBP, by 0.05 for EUR ($t(5) = 9.10$, $p < .001$) and by 0.02 for USD ($t(5) = 7.56$, $p < .001$). This is bad news for those who believe in the gamblers' fallacy.

3.3. Do gamblers with long winning streaks have higher payoffs?

One potential explanation for the appearance of the hot hand is that gamblers with long winning streaks consistently do better than others. To examine this possibility, we compared the mean payoff of these gamblers with the mean payoff of the remaining gamblers.

Among 407 gamblers using GBP, 144 of them had at least six successive wins in a row on at least one occasion. They had a mean loss of £1.0078 ($N = 279,162$, SD = 0.47) for every £1 stake they placed. The remaining 263 gamblers had a mean loss of £1.0077 ($N = 92,144$, SD = 0.38) for every £1 stake they placed. The difference between these two was not significant.

We did same analysis for bets made in EUR. Among 318 gamblers using this currency, 111 of them had at least one winning streak of six. They had a mean loss of €1.005 ($N = 105,136$, SD = 0.07) for every €1 of stake. The remaining 207 EUR gamblers had a mean loss of €1.002 ($N = 56,941$, SD = 0.22). The difference between these two returns was significant (t (162,075) = 4.735, $p < 0.0001$). Those who had long winner streaks actually lost more than others.

The results in USD were similar. Seventeen gamblers had at least one winning streak of six and 34 did not. For those who had, the mean loss was \$1.022 ($N = 23,280$, SD = 0.75); for those who had not, it was \$1.029 ($N = 9,252$, SD = 0.35). There was no significant difference between the two (t (32,530) = 0.861, $p = 0.389$). The gamblers who had long winning streaks were not better at winning money than gamblers who did not have them.

3.4. The effects of winning and losing streaks on level of odds selected

To determine whether the gamblers believed in the hot hand or gamblers' fallacy, we examined how the results of their gambling affected the odds of their next bet. Among all GBP gamblers, the mean level of selected odds was 7.72 ($N = 371,306$, SD = 37.73). After a winning bet, lower odds were chosen for the next bet. The mean odds dropped to 6.19 ($N = 178,947$, SD = 35.02). Following two consecutive winning bets, the mean odds decreased to 3.60 ($N = 88,036$, SD = 24.69). People who had won on more consecutive occasions selected less risky odds. This trend continued (Fig. 3, top panel).

Table 2
Regression for length of streaks predicting the probability of winning.

	B	*SE B*	*β*	*t*	*Sig.* (*p*)	*F*	R^2
GBP							
Winning streak	0.475	0.021	0.053 ∗ (0.006)	8.902	<0.001	79.25	0.928
Losing streak	0.489	0.018	−0.047 ∗ (0.004)	9.711	<0.001	94.31	0.940
EUR							
Winning streak	0.439	0.026	0.059 ∗ (0.007)	8.223	<0.001	67.62	0.917
Losing streak	0.508	0.021	−0.053 ∗ (0.006)	9.100	<0.001	82.8	0.932
USD							
Winning streak	0.315	0.025	0.054 ∗ (0.007)	7.996	<0.001	63.93	0.913
Losing streak	0.386	0.010	−0.022 ∗ (0.003)	7.560	<0.001	57.15	0.904

Note: Independent variable is the number of bets taken into consideration.

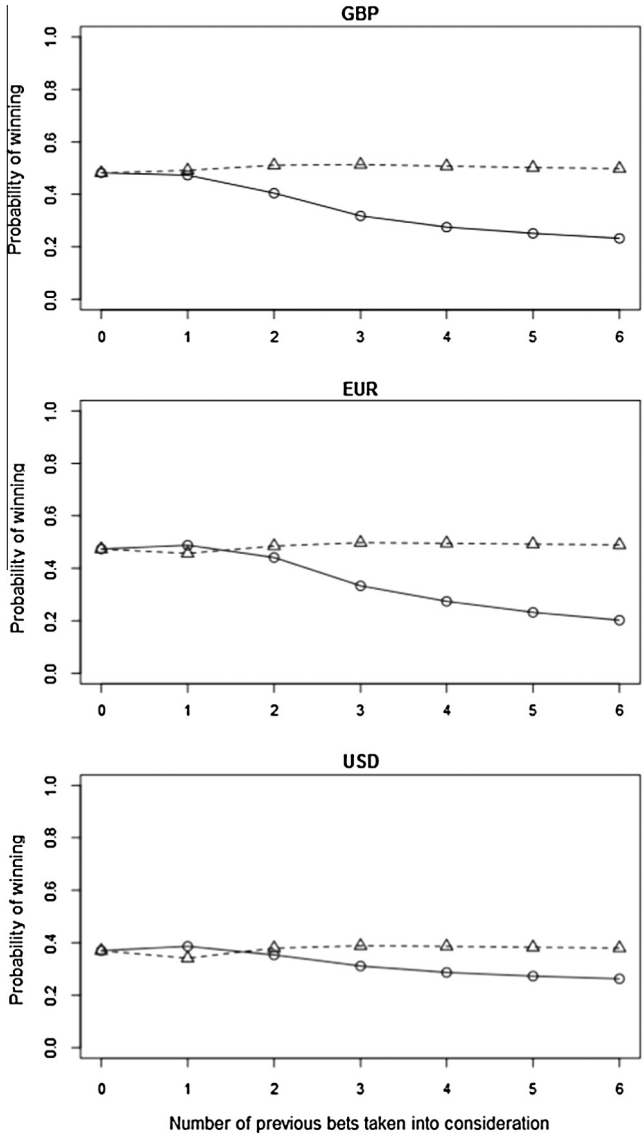

Fig. 2. Probability of winning after obtaining losing streaks of different lengths (o) and after not obtaining losing streaks of those lengths (Δ).

After a losing bet, the opposite was found. People who had lost on more consecutive occasions selected riskier odds. After six lost bets in a row, the mean odds went up to 17.07 (N = 22,694, SD = 50.62). In comparison, after winning six times in a row, the figure for mean odds was 0.85 (N = 18,252, SD = 9.82). From the odds that they selected, we can infer that gamblers believed in the gamblers' fallacy but not in the hot hand.

The gambling results were affected by the gamblers' choice of odds. One point of odds increase reduced the probability of winning by 0.035 (SD = 0.003, $t(36)$ = 13.403, $p < .001$).

3.5. The effects of winning and losing streaks on stake size

Among all GBP gamblers, the median stake was £14 (N = 371,306, Interquartile Rang = 4.80–53.29). After winning once, the median stake went up to £18.47 (N = 178,947, Interquartile Range = 5.04–66.00). After winning twice in a row, the median stake rose to £20.45 (N = 88,036, Interquartile Range = 8.00–80.00) (Fig. 4, top panel).

For the losing side, the opposite was found. People who had lost on more consecutive occasions decreased stakes. After losing once, the median stake went down to £10.89 (N = 192,359, Interquartile Range = 4.00–44.16). In comparison, after losing twice in a row, the median stake dropped to £10.00 (N = 101,595, Interquartile Range = 3.33–30.00). These trends continued (Fig. 4, top panel).

Gamblers increased stake size after winning and decreased stake size after losing. This could be the result of more money available after winning and less money available after losing.

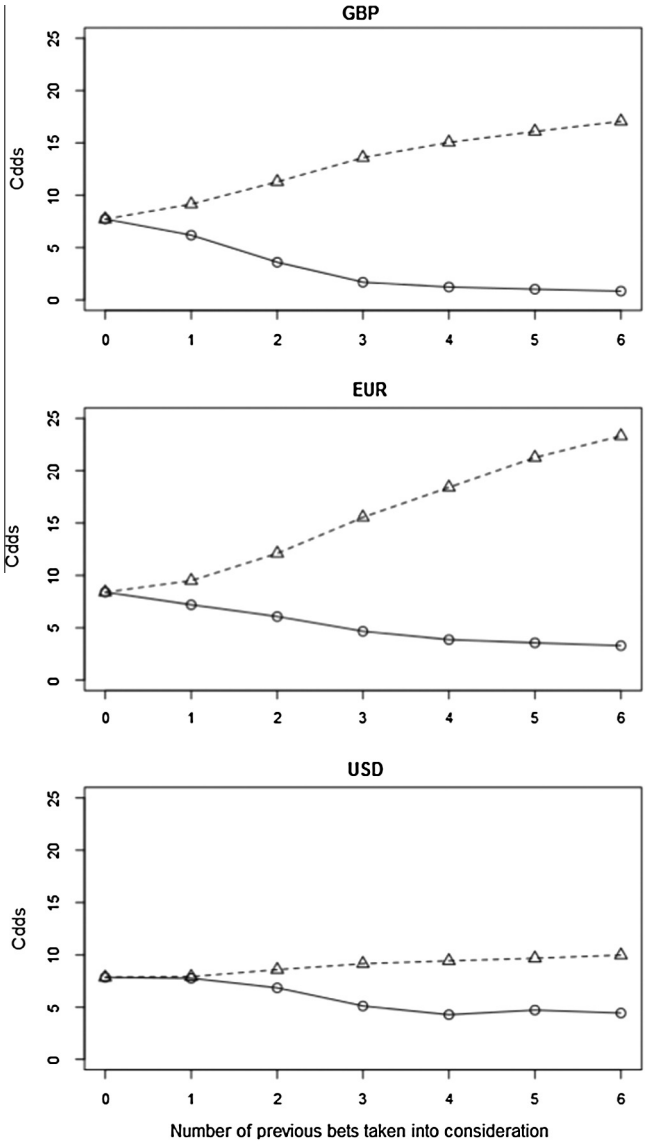

Fig. 3. Mean preferred odds after winning (o) and losing (Δ) streaks of different lengths.

We examined EUR and USD bets. Findings for selected odds were similar (Fig. 3) but those for stake size were less robust (Fig. 4), perhaps because of the reduced sample size.

4. Discussion

We found evidence for the hot hand but not for the gamblers' fallacy. Gamblers were more likely to win after winning and to lose after losing.

After winning, gamblers selected safer odds. After losing, they selected riskier odds. After winning or losing, they expected the trend to reverse: they believed the gamblers' fallacy. However, by believing in the gamblers' fallacy, people created their own luck. The result is ironic: Winners worried their good luck was not going to continue, so they selected safer odds. By doing so, they became more likely to win. The losers expected the luck to turn, so they took riskier odds. However, this made them even more likely to lose. The gamblers' fallacy created the hot hand.

Ayton and Fischer (2004) found that people believed in the gamblers' fallacy for natural events over which they had no control. Our gamblers displayed the gamblers' fallacy for actions (i.e. bets) that they took themselves. This may indicate that they did not believe that bets were under their control. Fong, Law, and Lam (2013) reported Chinese gamblers believed their luck would continue. Does this mean they felt they had more control over their bets? By believing their luck would continue, did they help to bring it to an end?

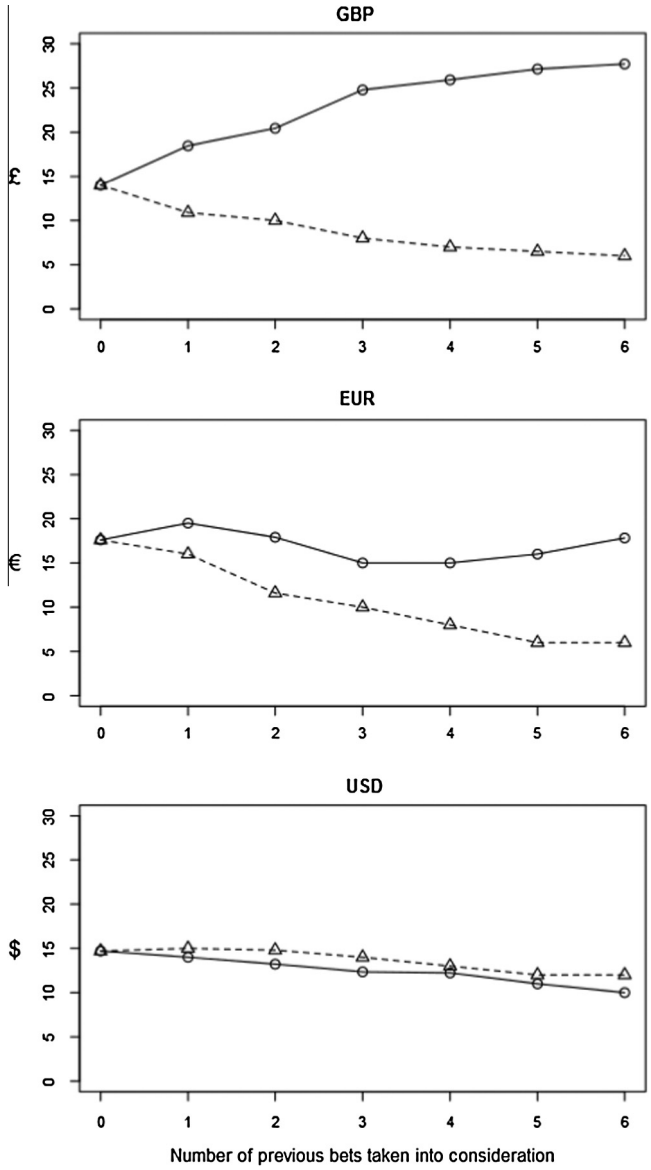

Fig. 4. Median stake size after winning (o) and losing (Δ) streaks of different lengths.

5. Implications

There are likely to be other domains (e.g., financial trading) where people reduce their preference for risk in the wake of chance success and thereby give the impression of a hot hand. Furthermore, they may attribute their successes to skill rather than chance (Langer, 1975) and may not be aware of their change in risk preference. In such circumstances, they may develop the illusion that they are becoming better at the task and able to persuade others that this is so. In the financial domain, this would have clear implications for people's selection of investment strategies.

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