

## Are Longshots Only for Losers? A New Look at the Last Race Effect

CRAIG R. M. MCKENZIE<sup>1\*</sup>, SHLOMI SHER<sup>2</sup>, JOHANNES MÜLLER-TREDE<sup>1</sup>, CHARLETTE LIN<sup>3</sup>, MICHAEL J. LIERSCH<sup>4</sup> and ANTHONY GEORGE RAWSTRON<sup>5</sup>

<sup>1</sup>UC San Diego, La Jolla, CA, USA

<sup>2</sup>Pomona College, Claremont, CA, USA

<sup>3</sup>Ohio State University, Columbus, OH, USA

<sup>4</sup>Merrill Lynch, New York City, NY, USA

<sup>5</sup>PUC Rio de Janeiro, Rio de Janeiro, Brazil

### ABSTRACT

There is evidence that betting on longshots increases in the last race of a day of horse racing. Previous accounts have assumed that the phenomenon is driven by bettors who have lost money and are trying to recoup their losses. To test this assumption of “reference dependence,” three laboratory experiments simulated a day at the races: In each of several rounds, participants chose either (i) a gamble with a small probability of a large gain and a large probability of a small loss (the “longshot”) or (ii) a gamble with a moderate chance of a small gain or a small loss (the “favorite”). The first two experiments employed a game played for points, while a third experiment included monetary incentives and stimuli drawn from a real day of racing. These experiments provide a clear demonstration of the last race effect in a laboratory setting. However, the results indicate that the effect is largely reference independent: Participants were more likely to choose the longshot in the last round regardless of whether, and how much, they had won or lost in previous rounds. Winning or losing, bettors prefer to “go out with a bang” at the end of a series of gambles. Copyright © 2015 John Wiley & Sons, Ltd.

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Betting on horse races is popular throughout the world, with over \$100 billion wagered annually (NTRA Wagering Technology Working Group in conjunction with Giuliani Partners LLC, 2003). On a typical day of horse racing, there are eight or nine races, and bettors can bet on horses that are relatively likely to win but pay a small amount if they do (favorites), or on horses that are relatively unlikely to win but pay a large amount if they do (longshots). US horse racing uses a parimutuel betting system, whereby a horse’s posted odds (and hence payoff) are inversely related to the total amount bet on the horse. This has allowed researchers to compare how often horses should win, as implied by the posted odds, with how often they do win. A robust finding is that longshots win less often than implied by their posted odds, and favorites win more often (e.g., Ali, 1977; Asch, Malkiel, & Quandt, 1982; Griffith, 1949; McGlothlin, 1956; Snowberg & Wolfers, 2010).<sup>1</sup> In short, longshots are overbet and favorites are underbet, a phenomenon called the “favorite–longshot bias.” A practical implication of this phenomenon is that betting on favorites has a higher expected return than betting on longshots.

Equally interesting is that there is evidence that betting on longshots in parimutuel markets becomes even more popular at the end of the racing day. Asch et al. (1982) examined the entire 1978 thoroughbred racing season (729 races) at a New

Jersey track and found a larger longshot bias for the last two races of the day (combined) compared with all races. Ali (1977) found the same phenomenon when comparing the last race with the first two, using 20247 harness races at three New York tracks spanning 1970 to 1974. Based on a sample of 286 races at a New York track in 1986, Kopelman and Minkin (1991) found that the posted odds were less favorable for favorites in the last race of the day compared with all earlier races, suggesting that there is less betting on favorites in the last race. Although these studies indicate that betting on longshots is more common at the end of the day, it is not clear whether it increases in the last race only, in the last two races, or gradually increases across all races. Each of these possibilities is consistent with the aforementioned findings. We are aware of just two studies that specifically compared betting in each race: Metzger (1985) discovered increased longshot betting in the last race when she examined 11313 races at US tracks in 1978 (although she found an apparently anomalous effect for the first race, as well), and McGlothlin (1956) found increased longshot betting that was unique to the last race when he examined 9605 races at several US tracks between 1947 and 1953. “The fact that [the data] for the eighth race [are] different from [those] for the first seven races must be explained by a change in betting behavior, and this change is due to the position of the race in the daily program rather than the composition of the races. Horses with high probability of winning, but with accompanying low payoffs, become even more unpopular in the last race.” (McGlothlin, 1956, p. 611) We refer to this phenomenon as “the last race effect.”

Despite these findings, it has recently been claimed that the last race effect does not exist anymore, if it ever did. Snowberg and Wolfers (2010) analyzed 678729 US horse

\*Correspondence to: Craig R. M. McKenzie, Rady School of Management and Department of Psychology, UC San Diego, La Jolla, CA, USA. E-mail: cmckenzie@ucsd.edu

<sup>1</sup>This phenomenon is not limited to horse races using the parimutuel betting system. In the UK, bookmaker-based odds are the norm, and a favorite–longshot bias has also been shown there (Dowie, 1976).

races between 1992 and 2001 and, when comparing the last race with all races combined, found a small but non-significant increase in longshot betting. It is unclear why there is a discrepancy between this study and earlier ones. It could be that the earlier studies were based on samples that were too small (although, taken together, they examined over 42 000 races), and there never was a last race effect. It could also be that over the decades, betting behavior has changed. For example, some bettors may have become aware of the research showing that betting on favorites, especially late in the day, leads to higher expected returns. Indeed, Johnson and Bruce (1993) found that in the UK, off-track bettors—who are likely to be more serious bettors—showed the opposite of the last race effect; they bet more on favorites as the racing day progressed. Earlier studies might have picked up on a natural tendency that, over the years, has been exploited by more experienced bettors and hence largely negated in the aggregate data. This suggests, though, that we should be able to reproduce the effect if we either move away from parimutuel betting or use novice bettors. Thus, one purpose of the laboratory experiments reported here is to examine whether the last race effect is a robust empirical phenomenon in a neutral setting with participants who have not been self-selected. Importantly, this provides a cleaner test of the psychological theories of risk attitudes that have been applied to the last race effect, which we describe later. It may also shed light on why the last race effect occurs in those complex real-world environments in which it has been found.

If the last race effect is real, at least for some gamblers, why would risk preference change in the last race? Previous explanations of the last race effect have assumed that the phenomenon is “reference dependent.” That is, these accounts assume that longshot betting depends on whether bettors see themselves as “ahead” or “behind” when the last race comes around. Perhaps the most common way to explain the increase in longshot betting late in the day has been to appeal to prospect theory (Kahneman & Tversky, 1979; Thaler & Ziemba, 1988). According to the theory, outcomes of a risky prospect are encoded as either losses or gains relative to a reference point, and people are more risk seeking for losses than for gains. In the case of horse racing, a plausible reference point is how much money bettors have when they arrive at the track. Bettors who have lost money are more likely to encode subsequent outcomes as losses. If, in the first race, Bettor A won \$10 and B lost \$10, they may encode the possible outcome of winning \$2 in the second race differently. Bettor A may perceive the outcome as being “up” \$12, whereas B may perceive it as being “down” \$8. Because bettors are assumed to lose more money as the day progresses,<sup>2</sup> and being in the loss domain leads to increased risk seeking, risky longshots are more popular in later races. As Kahneman and Tversky (1979, p. 287) stated, “The well known observation (McGlothlin, 1956) that the tendency to bet on long

shots increases in the course of the betting day provides some support for the hypothesis that failure to adapt to losses or to attain an expected gain induces risk seeking.” Importantly, though, note that prospect theory appears to predict a gradual increase in longshot choices across races because of the gradual increase of bettors who lose money, whereas McGlothlin (1956) found a substantial increase in longshot betting in only the last race. The usual prospect theory account does not explain an increased longshot bias that is specific to the last race.

What, then, might explain a last race effect? One possibility is that those in the loss domain are driving the effect—but only in the last race. Perhaps these bettors are trying to recoup their losses before the day is over, and longshots, especially if bettors do not have much to bet, are the only means to achieve this (Thaler & Ziemba, 1988). Indeed, this account is consistent with prospect theory if it is assumed that bettors are only influenced by their day’s gains or losses just before the last race, rather than before each race. This “recouping losses” account predicts that only those who have lost money will show an increase in longshot betting in the last race.

There is another reference-dependent account. It differs from the “recouping losses” account, though, in that what matters is distance from the reference point rather than whether one is above or below it. The account is motivated by Thaler and Johnson (1990), who presented participants with gambles and found that previous gains or losses influenced choices. These authors suggested that people who had previously lost money wanted to at least break even, while those who had previously won money wanted to avoid falling into the loss domain. Thaler and Johnson were not attempting to explain the last race effect, but the account can potentially explain the effect if one assumes that these motives are unique to, or at least enhanced in, the last race. Generally speaking, in the case of the last race, those who have lost a lot of money need to bet on a longshot in order to win enough to cover their day’s losses. However, those who have lost only a little do not need the longshot to break even; they may prefer favorites because these horses have relatively likely payoffs that are sufficiently large to move these bettors into the gain domain. Similarly, those who have won a large amount can bet a modest amount on a longshot and still avoid the loss domain, while those who have won only a small amount may prefer favorites who are less likely to push them below zero and into the loss domain. This “change in domain” account predicts that those relatively far from the reference point, regardless of gain or loss domain, are driving the last race effect.

Our final proposed account of the effect is reference independent. Perhaps people in general, regardless of whether, or how much, they have won or lost in previous races that day, prefer to bet on longshots in the last race. If people simply prefer to take a relatively large risk to end their day of gambling, this would lead to a last race effect that is independent of the bettor’s reference point.

Because the horse track data do not specify whether bettors have previously won or lost money, those data cannot distinguish between the aforementioned accounts. We conducted three laboratory experiments that simulated a day of

<sup>2</sup>A typical racetrack claims about 18% of each race’s betting pool as a fixed fee (the “track take”) and makes additional money through rounding down payoffs (“breakage”; Busche & Walls, 2001).

horse racing, allowing us to monitor whether, and how deeply, participants were in the gain or loss domain, and whether they preferred to bet on the longshot or the favorite. In this way, we can see whether the last race effect is reproducible in the laboratory and, if so, which of the competing accounts is able to explain it. Experiments 1 and 2 employ a simple repeated-betting game with points. Experiment 1 seeks to reproduce a last race effect in this setting. Experiment 2 manipulates the position of the last race as an independent variable, allowing us to test both the “recouping losses” and “change in domain” accounts of the effect. Experiment 3 replicates the last race effect in an enriched game with monetary incentives and stimuli adapted from a day at the races. Taken together, these experiments provide evidence for a last race effect that is robust and reference independent.

## EXPERIMENT 1

### Method

The participants were 140 University of California, San Diego (UCSD) undergraduate students who received partial course credit (mean age = 20.3 years, 69% female). The experiment took less than 5 minutes and was part of a series of unrelated experiments lasting less than 1 hour.

The experiment was a computer program in the form of a game. Participants were told that the objective of the game was to finish with as many points as possible and that there were eight rounds in the game. On each round, participants chose between two options, each with an expected value of 0:

- A: a 50% chance to win 1 point and a 50% chance to lose 1 point
- B: a 10% chance to win 9 points and a 90% chance to lose 1 point

The first option is the favorite, with a relatively large chance of a small gain. Choosing this option can be thought of as betting one point with even odds. The second option is the longshot: A small chance of a large gain but a large chance of a small loss. Choosing this option is akin to betting one point with 9 to 1 odds. The presentation order of the options was reversed for half of the participants.

The outcome of each choice was determined by a random number generator that corresponded to the stated probabilities, and participants received feedback after each round (although they did not see the outcome of the unchosen gamble). Throughout the game, the current round (e.g., “Round 6 of 8”) and the cumulative score were displayed at the top of the screen. A positive (negative) cumulative score is analogous to being in the gain (loss) domain. To ensure that participants knew when they reached the last round, the last trial was preceded by the message “The next round is the last round!”.

There are four notable aspects of the design. First, we are using gambles with expected values of zero, whereas the favorite–longshot bias at the racetrack implies that longshots have a lower expected value than favorites do (and often both

are negative; Thaler & Ziemba, 1988). Using expected values that are equal results in a more sensitive measure of change in risk attitudes (presumably amplifying any last round effect), and using expected values of zero makes it easier to test whether gain or loss domain influences choices in the last round, because there will be roughly equal proportions of participants in each domain.

Second, because all payoffs were odd numbers (−1, 1, 9), participants’ cumulative scores were odd before even-numbered rounds. This ensured that all participants were either in the gain domain or the loss domain before the last (eighth) round; that is, no one had a score of 0 when choosing in the last round.

Third, the number of participants in the loss domain was expected to decrease across rounds. Winning the longshot one time is sufficient to put (and keep) a participant in the gain domain, and the probability of winning the longshot at least once increases with the number of attempts (e.g., a 10% chance with one attempt and a 19% chance with two attempts). To the extent, then, that participants choose the longshot, the number of participants in the loss domain should decrease across rounds. (The probability of being in the loss domain is constant if the favorite is selected each round.) If so, any increase in longshot choices across rounds—including a “last round effect”—could not be explained in terms of an increasing number of participants in the loss domain.

Finally, although choice of longshot or favorite affects the probability of being in the gain or loss domain in the early rounds, whether participants end up in the gain or loss domain before the last round is largely independent of whether the longshot is chosen often or seldom. After round 1, for example, choosing the longshot leads to a 90% chance of being in the loss domain, whereas choosing the favorite leads to only a 50% chance. These chances even out, however, in the later rounds. Because winning just one longshot (nine points) guarantees being in the gain domain for the remaining rounds, a participant choosing the longshot every round would have to lose every time to end up in the loss domain. Thus, a participant choosing the longshot every round has a 48% chance (.9<sup>7</sup>) of being in the loss domain before the final round, whereas someone choosing the favorite each round has a 50% chance. The probability of being in the loss domain after round 7 is essentially an inverted U-shaped function of how often the longshot is chosen. This means that participants who often choose the longshot are about as likely to be in the loss domain before the last round as those who often choose the favorite.<sup>3</sup> This is important because we want risk preference in rounds 1–7 to be as independent as possible from whether participants are in the gain or loss domain before the last round.

<sup>3</sup>There are outcome-dependent strategies that could influence the probability of being in the gain versus loss domain after round 7 (e.g., “choose the longshot in the first two rounds and, only if both are losses, then choose the favorite in the remaining rounds”), but there are indefinitely many arbitrary strategies, and there are no obvious strategies that would bias our results. Strategies that would cause problems for interpreting our results would have to systematically influence both the probability of being in the gain versus loss domain after round 7 and choice in round 8.

**Results and discussion**

The percentage of participants selecting the longshot in each of the eight rounds is shown in Figure 1. We performed regression analyses to examine how different factors affect the probability of longshot choices. In particular, we report the results of a series of regression models designed to determine whether the last race effect is robust to a variety of reasonable models that include specific regressors. Furthermore, we conducted both ordinary least squares (OLS) and logit analyses, and the results are virtually identical. Because the OLS analyses make fewer assumptions and the results are easier to interpret, we report only the OLS results.

The first model (Model 1 in Table 1) is a simple linear probability model that treats each choice as a separate data point and contrasts the probability of selecting the longshot in the last round with the probability of selecting the longshot in any other round. We found a significant Last Round effect: The probability estimate was 19 percentage points higher in the last round compared with all other rounds. To test for a linear trend in longshot betting across races, Model 2 added Round Number as an independent variable. This analysis revealed a significant increase in longshot choices across rounds. Importantly, the coefficient estimate for Last Round was still significant and indicates an effect of 11 percentage points over and above the general increasing trend in

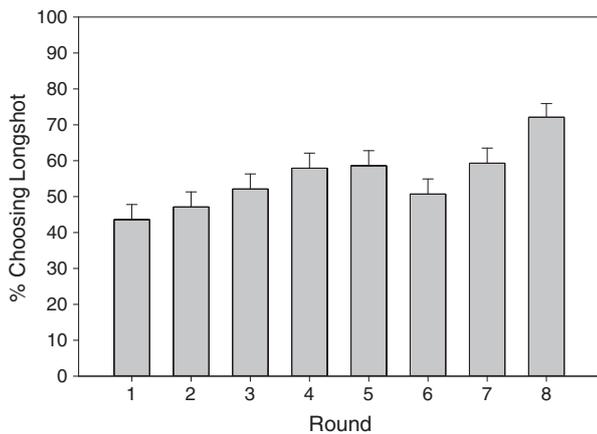


Figure 1. Experiment 1: Percentage of participants selecting the longshot in each round. Standard error bars are shown

Table 1. Regression results for longshot choices in Experiment 1

Independent variable	Model		
	1	2	3
Last round	<b>.19</b> (.04)	<b>.11</b> (.05)	<b>.11</b> (.05)
Round number		<b>.02</b> (.01)	<b>.02</b> (.01)
Intercept	<b>.53</b> (.02)	<b>.44</b> (.04)	<b>.44</b> (.04)

Note:  $N = 1120$  (140 participants  $\times$  8 rounds). Models 1 and 2 are OLS models; Model 3 is a mixed-effects model with participant-level random intercepts and random slopes. Standard errors (SEs) are in parentheses; in Models 1 and 2, SEs are clustered by participants. Coefficients in bold are significant at  $p < .05$ . Model 3 was estimated using the lme4 package in R (Bates, Maechler, Bolker, & Walker, 2014), and the  $p$ -values in Model 3 were computed using the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2014).

longshot choices across rounds. Model 3 differs from the other models in that it introduces random effects for participants (i.e., participant-level random intercepts and random slopes are added to the specification) in order to control for between-participant heterogeneity. The effect of Last Round remains strong. Thus, our results clearly reproduce the last race effect reported by McGlothlin (1956).

Is the last round effect due to those in the loss domain? Figure 2 shows longshot choices separately for participants who, after the penultimate round (round 7), were in either the gain ( $n = 63$ ) or the loss domain ( $n = 77$ ). (Figure 3 shows the distribution of cumulative scores after round 7.) Regardless of domain, participants were more likely to select the longshot in the last round. Figure 2 shows that, more generally, these two groups of participants behaved similarly throughout the experiment. Furthermore, it is worth noting that the number of longshot choices increased across rounds despite the fact that the number of participants in the loss domain decreased (as expected) across rounds; the respective percentages of participants in the loss domain before rounds 2, 4, 6, and 8 (when no participants could have a score of 0) were 66, 61, 56, and 55.

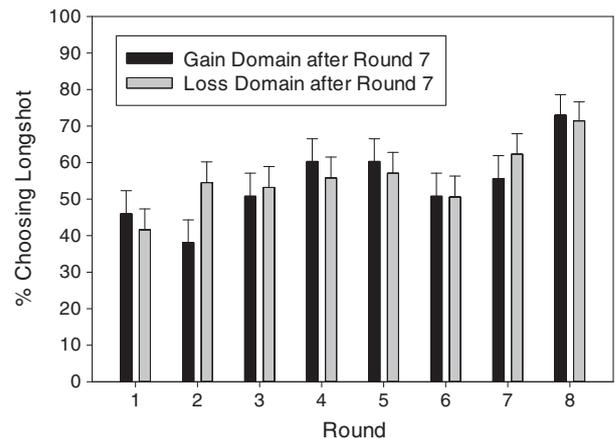


Figure 2. Experiment 1: Percentage of participants selecting the longshot in each round, conditioning on gain versus loss domain after round 7 (i.e., before the last round). Standard error bars are shown

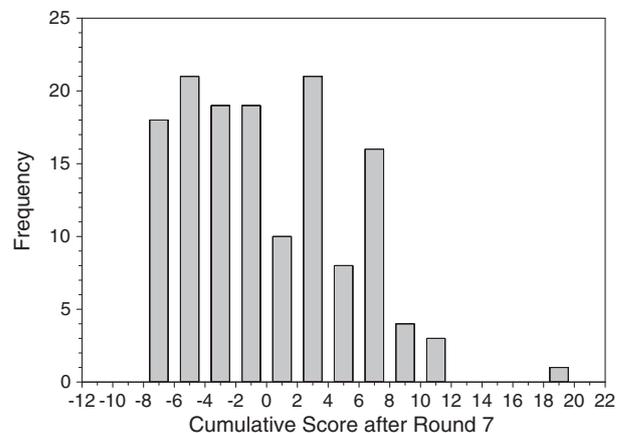


Figure 3. Experiment 1: The distribution of cumulative scores before the last round

Figure 4 provides a more detailed look at this issue. Whereas Figure 2 conditioned on domain after round 7, Figure 4 shows the results conditioning on domain for each round. For example, the data for round 2 indicate whether participants chose the longshot depending on whether they were in the gain or the loss domain after round 1. Note that participants in the loss domain were more likely to choose the longshot in every round except the last one.

However, the association between longshot choices and being in the loss domain in the early rounds may primarily reflect an effect of choices on domain, rather than an effect of domain on choices. Recall that, especially in the early rounds, choosing the longshot increases the chances of being in the loss domain. To see whether that accounts for the relation in the early rounds, we looked at participants with an identical history of prior choices, some of whom were in the gain domain and some in the loss domain, to see how they chose in the subsequent round. If domain is influencing choice, there should be a difference in subsequent choices. We examined participants who chose the favorite in round 1 because (i) there are many of them ( $n=79$ ) and (ii) the outcome was essentially a coin toss, leading about half (47%) to be in the gain domain and half (53%) to be in the loss domain after round 1. Of those in the gain domain after round 1, 31% chose the longshot in round 2, while 30% of those in the loss domain did so ( $p=1.0$ , Fisher's exact test). Thus, holding choice history constant, but randomly varying domain, reveals no relation between domain and choice in the next round. Furthermore, by round 8, choice is expected to have less influence on domain, so any relation between domain and choice could more easily be attributed to an effect of domain. But as Figure 4 shows, any relation between domain and choice disappears by the last round.

Because choices are affecting whether participants are in the loss domain in early rounds, adding "domain" as a variable in a regression model would violate the conditional independence assumption required for a causal interpretation of the coefficient estimates (because the predictor variable "domain" in a given round would be partly determined by the outcome variable in previous rounds). This violation, which we address in Experiment 2, would therefore render

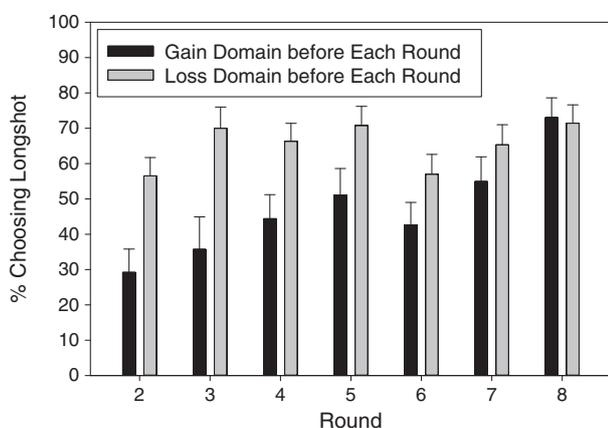


Figure 4. Experiment 1: Percentage of participants selecting the longshot each round, conditioning on gain versus loss domain before each round. Standard error bars are shown

regression results difficult to interpret (cf. Angrist & Pischke, 2009, Chapter 3). Nonetheless, Figures 2 and 4 indicate that the last round effect is not explained by those in the loss domain. Indeed, any effect of domain appears to be the opposite of that predicted by the "recouping losses" account: Those in the gain domain show a bigger last round effect.

In sum, Experiment 1 revealed a robust last round effect. There was an increase in longshot choices that was unique to the last round, which reproduces the finding of McGlothlin (1956). Furthermore, the effect occurred despite a decrease across rounds in the number of participants in the loss domain, which is evidence against the usual prospect theory account. The effect was not due to those in the loss domain just before the last round, either, which is evidence against the "recouping losses" account. Being in the loss domain was generally associated with longshot choices, but this association was strongest in the early rounds and seems best explained by the hypothesis that choices were influencing domain rather than vice versa.

## EXPERIMENT 2

In Experiment 1, we found that participants chose the longshot most often in round 8, which was the last round for all participants. In Experiment 2, we largely replicated the earlier procedure, but we directly manipulated whether round 8 or 10 was the last round. Furthermore, participants did not know which round was the last one until right before it occurred, ensuring that there were no systematic differences between the two conditions for the first seven rounds. With this design, we can treat last round position as an independent variable and examine its effect independently of all aspects of choice history. In light of the results of Experiment 1, we expected that participants would be more likely to choose the longshot in round 8 when it was the last round compared with when it was only the eighth of 10 rounds.

Assuming we replicate the last round effect, this design enables us to cleanly test the "recouping losses" account, that is, whether the effect is primarily due to participants who are in the loss domain before the last round. According to the "recouping losses" account, being in the loss domain should have a particularly strong effect on last round choices compared with choices in other rounds. Consequently, the effect should be stronger for round 8 choices in the 8-round game than for round 8 choices in the 10-round game.

The design also allows us to test whether the last round effect is driven by those whose scores are farther from zero (Thaler & Johnson, 1990). It could be that in our game, those who have cumulative scores of exactly  $-1$  before the last round prefer the favorite because they have a 50% (rather than 10%) chance of getting out of the loss domain, whereas those with cumulative scores less than  $-1$  prefer the longshot because it is their only chance of avoiding the loss domain. Similarly, those with cumulative scores of exactly 1 before the last round might prefer the favorite because there is a 50% (rather than 10%) chance of staying in the gain domain, whereas those with cumulative scores greater than 1 can

choose the longshot without the possibility of ending up in the loss domain. As relatively few participants are exactly one point from zero before the last round (Figure 3), this could account for the domain-independent increase in longshot choices in the last round: Most participants in the loss domain need the longshot to at least break even, and most participants in the gain domain can play the longshot with no risk of falling into the loss domain. However, if this “change in domain” account is to explain the last round effect, then the pattern of results should be stronger for last round choices, holding everything else constant; that is, it should be stronger for round 8 choices in the 8-round game compared with round 8 choices in the 10-round game.

## Method

The participants were 254 UCSD undergraduate students who received partial course credit (mean age = 20.2 years, 72% female). The procedure was identical to that of Experiment 1 except that half of the participants were randomly assigned to a game with 10 rounds ( $n = 128$ ) rather than 8 ( $n = 126$ ). In addition, all participants were told at the start of the experiment that the game consisted of several rounds, and they would be warned when the last round was coming. As in Experiment 1, the last trial was preceded by the message “The next round is the last round!”.

## Results and discussion

Figure 5 shows longshot choices for both games. The number of longshot choices was highest in the last round in both cases. Most important is that there were more round 8 longshot choices in the 8-round game than in the 10-round game (69% vs. 56%;  $\chi^2(1, N = 254) = 4.44, p = .035$ ). Because the participants did not know beforehand how many rounds they would play, there is nothing to distinguish the two conditions after seven rounds, except that the next round was the last round for only the 8-round condition. Holding everything else constant, there are more longshot choices in a given round when that round is the last round compared with when it is not.

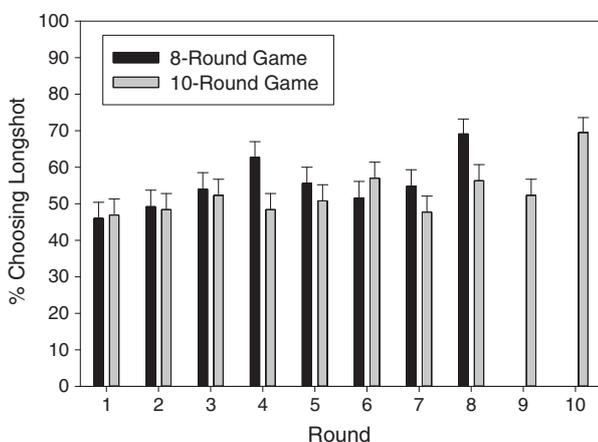


Figure 5. Experiment 2: Percentage of participants selecting the longshot in each round as a function of number of rounds in the game. Standard error bars are shown

In order to examine the last round effect for both sequence lengths (8 and 10 rounds) and make use of choices in all rounds, we performed a series of regressions analogous to those reported for Experiment 1. Table 2 summarizes the results. Model 1 shows that participants were 17 percentage points more likely to choose the longshot in the last round compared with all other rounds. Model 2 reveals that the last round effect was equally strong in the 8-round and 10-round conditions. Model 3 confirms this result in a model with a linear trend (which was not different from zero in either condition). Finally, Model 4 shows that the last round effect remains significant in a mixed linear model that includes individual-specific random effects (for both intercepts and slopes). Overall, we found robust evidence for a last round effect in both the 8-round and 10-round conditions.

As in Experiment 1, the association between longshot choices and being in the loss domain was particularly strong in the early rounds and appears best explained by the fact that choosing the longshot in the early rounds increases the chances of being in the loss domain: Those who selected the favorite in round 1 ( $n = 136$ ) and were effectively randomly assigned to the gain ( $n = 64$ ) or loss domain ( $n = 72$ ) after that round were about equally likely to select the longshot in round 2 (30% vs. 40%, respectively,  $p = .21$ , Fisher’s exact test). When there is a relation between domain and longshot choices (i.e., the early rounds), it seems that choices are influencing domain rather than vice versa.

Despite the dependence between longshot choices and being in the loss domain in the early rounds, the current design allowed us to test the “recouping losses” account in a straightforward manner by comparing round 8 choices between the 8-round and the 10-round conditions. A 2 (Sequence Length: 8 vs. 10 rounds)  $\times$  2 (Loss Domain: cumulative score  $< 0$  vs.  $> 0$ ) log-linear analysis on round 8 choices revealed an effect of Sequence Length, with more longshot choices in the 8-round condition than in the 10-round condition (replicating the effect of last round on choice;  $\chi^2(1, N = 254) = 4.46, p = .035$ ). There was also a marginally significant effect of Loss Domain ( $\chi^2(1, N = 254) = 3.78, p = .052$ ), indicating that collapsing across the two sequence lengths, those in the loss domain were more likely to choose the longshot than those in the gain domain (67% vs. 56%). Importantly, however, we did not find evidence for the interaction between Sequence Length and Loss Domain predicted by the “recouping losses” account ( $\chi^2(1, N = 254) < 1, p = .43$ ). Although the effect was in the predicted direction, loss domain did not have a bigger effect on round 8 longshot choices in the 8-round game (76% vs. 60%) than in the 10-round game (59% vs. 51%). The last round effect can therefore not be attributed to participants who aim to recover their losses by betting on the longshot in the last round.

In order to see whether distance from zero (the “change in domain” account) was driving the last round effect, we examined round 8 choices of those whose scores were within one point of zero and those whose scores were more than one point from zero. (We collapsed across domain because there were too few participants with scores of  $-1$  or  $1$ .) A 2 (Sequence Length: 8 vs. 10 rounds)  $\times$  2 (Distance from

Table 2. Regression results for longshot choices in Experiment 2

Independent variable	Model			
	1	2	3	4
Last round	<b>.17</b> (.03)	<b>.18</b> (.04)	<b>.15</b> (.05)	<b>.15</b> (.05)
Sequence length		.02 (.04)	.01 (.06)	.01 (.05)
Last round * sequence length		-.03 (.06)	-.04 (.07)	-.04 (.07)
Round number			.01 (.01)	.01 (.01)
Round number * sequence length			.00 (.01)	.04 (.09)
Intercept	<b>.52</b> (.02)	<b>.51</b> (.02)	<b>.47</b> (.04)	<b>.47</b> (.03)

Note:  $N = 2288$  (128 participants  $\times$  10 rounds + 126 participants  $\times$  8 rounds). Models 1–3 are OLS models; Model 4 is a mixed-effects model with participant-level random intercepts and random slopes. Standard errors (SEs) are in parentheses; in Models 1–3, SEs are clustered by participants. Coefficients in bold are significant at  $p < .05$ . Model 4 was estimated using the lme4 package in R (Bates et al., 2014); the  $p$ -values for this model were computed using the lmerTest package (Kuznetsova et al., 2014).

Zero: 1 vs.  $>1$ ) log-linear analysis on round 8 choices revealed an effect of Sequence Length, with more longshot choices in the 8-round condition than in the 10-round condition (again showing the effect of last round on choice;  $\chi^2(1, N = 254) = 4.88, p = .027$ ). There was also an effect of Distance from Zero; those more than one point away were more likely to select the longshot (67% vs. 46%;  $\chi^2(1, N = 254) = 7.33, p < .01$ ), which provides a conceptual replication of Thaler and Johnson (1990). However, there was no hint of an interaction ( $\chi^2 < 1$ ). Being more than one point from zero before round 8 was associated with being more likely to select the longshot in that round, but the effect was equally large whether it was the last round (73% vs. 52%) or the eighth of 10 rounds (60% vs. 39%). Thus, the “change in domain” phenomenon does not explain the last round effect, either.<sup>4</sup>

To summarize, we manipulated the last round as an independent variable and found a clear effect of the last round on risk taking. Furthermore, we replicated the last round effect for both 8-round and 10-round games. There is an increase in longshot choices in the last round that does not occur in previous rounds. There was again evidence of a relation between being in the loss domain and selecting the longshot (collapsing across rounds), but as in Experiment 1, this effect appears to be due to the fact that selecting the longshot in the early rounds increases the chances of being in the loss domain. That is, being in the loss domain is not affecting choices; instead, choices are affecting whether a participant is in the loss domain. Importantly, those in the loss domain were not significantly more likely to choose the longshot in the eighth round when it was the last round than when it was not, which fails to support the “recouping losses”

account. Finally, distance from zero did not influence round 8 choices any more in the 8-round game than in the 10-round game, indicating that the “change of domain” account does not explain the last round effect, either. It appears that the last round effect is reference independent: Whether, or how many, points were previously won or lost does not seem to matter.

### EXPERIMENT 3

While Experiments 1 and 2 provide clear evidence of a last round effect, they captured only the most general features of a day at the races. In Experiment 3, we aimed to replicate the effect in a setting with greater ecological realism. We increased realism in two primary ways. First, participants were paid in US dollars on the basis of their performance. Second, for each round, they chose between two horses—one longshot and one favorite—that had actually competed in a previous day of races. Participants saw the horses’ actual names, and each horse’s probability of winning was based on the posted odds from the real race. Thus, participants bet money on a favorite or on a longshot horse over a series of races. As in Experiment 2, we manipulated whether there were 8 or 10 races, allowing us to compare longshot choices in the eighth race. Given the results of the first two experiments, we expected that there would be more longshot choices in race 8 in the 8-race condition than in the 10-race condition. Assuming we again replicate the last round effect, this design, like that of Experiment 2, allows us to test the “recouping losses” and “change in domain” accounts of the effect.

### Method

The participants were 224 UCSD undergraduates who were recruited after they had participated in another series of experiments that lasted about 30 minutes (mean age = 20.5 years, 71% female). They were told that the experiment would take only a few minutes and that it would pay an average of \$2, a minimum of \$1, and could pay several dollars.

After agreeing to participate, participants were run individually in separate rooms and took about 5 minutes to

<sup>4</sup>It should be noted that risk preference and variability in outcomes are confounded to some extent (both in this experiment and in the “real world”). Even though  $EV = 0$  for both the longshot and the favorite, selecting the longshot results in more variable outcomes and reduces the likelihood of being within one point of zero after seven rounds. All else being equal, the change-in-domain account predicts that, compared with being within one point of zero, being more than one point away will result in more round 8 longshot choices when round 8 is the last round compared with when it is not. We do not find any evidence for such an interaction in this experiment. It is possible in principle, however, that a causal interaction between distance from zero and sequence length exists but that it is offset by an interaction between sequence length and risk preference in the opposite direction.

complete the computer-based experiment. They were randomly assigned to either the 8-race ( $n = 105$ ) or the 10-race ( $n = 119$ ) condition. The procedure was the same as in Experiments 1 and 2, except for the following differences.

Participants were told that the horses and the probabilities of winning were from an actual day at a horse racing track. The horses, probabilities, and payoffs used in the experiment are shown in Table 3. The data are from a track in New York in 2004 (and are available from the first author). There were 13 races that day, and we used the first 10. For each race, we selected two horses from the real data, one that was the favorite and one that was a moderate longshot. All participants saw the same horses and probabilities for the first eight races; only those in the 10-race condition saw races 9 and 10. We translated posted odds into probabilities because we thought that this would be easier for participants to understand. Each horse had an expected value of approximately zero.

In race 8, the key race for our purposes, we randomized across participants which of the two horse names was associated with the favorite and which was tied to the longshot. In this race, one horse had a 50% chance of winning 1 point (and 50% chance of losing one point) and the other had a 9% chance of winning 10 points (and a 91% chance of losing 1 point; Table 3). Note that these probabilities and payoffs are similar to those used for each round in Experiments 1 and 2.

Because people at the race track know how many races there will be, we told participants whether there would be 8 or 10 races. Before the last race, participants read that “The racing day is coming to an end—the next race is the last race.” After receiving race 8 feedback, all participants were reminded of the horse they bet on and were asked to provide a brief explanation of their choice.

Table 3. Experiment 3: The horses, their probability of winning, and their payoffs

Race	Horse	$p$ (win)	Payoff
1	Lifestyle	.50	1 pt
	Zakocity	.13	8 pts
2	Mogador	.33	2 pts
	Holy Panache	.05	19 pts
3	Grace Course	.20	4 pts
	Taint So	.07	13 pts
4	Moonshine Hall	.33	2 pts
	Halo Homewrecker	.11	8 pts
5	Saintly Action	.33	2 pts
	Elegant Mercedes	.09	10 pts
6	Bear Fan	.50	1 pt
	Kitty Knight	.06	16 pts
7	Speightstown	.33	2 pts
	Key Deputy	.11	8 pts
8	Wonder Again	.50	1 pt
	Intercontinental	.09	10 pts
9	Fire Slam	.25	3 pts
	Smokume	.06	16 pts
10	Stroll	.33	2 pts
	Epicentre	.08	11 pts

Note: In race 8, the two horses' names were randomized across participants with respect to which was the longshot and which was the favorite. In addition, points were translated into money, with 1 point equal to \$0.10.

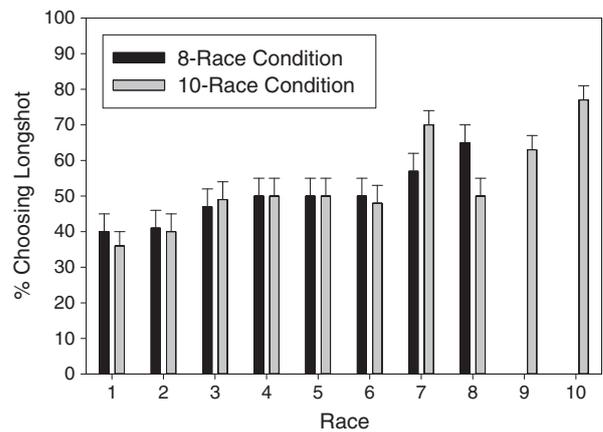


Figure 6. Experiment 3: Percentage of participants selecting the longshot in each round as a function of number of rounds in the game. Standard error bars are shown

Points were translated into money, with each point equal to \$0.10. Participants started the experiment with 20 points (\$2). At the end of the experiment, participants were paid in cash. Please see the Appendix for details regarding the instructions.

## Results and discussion

Participants' mean earnings were \$1.98 and ranged between \$1 and \$4.70. Figure 6 shows the percentage of longshot choices in each race for the 8-race and 10-race conditions. Because each race featured a different combination of probabilities and payoffs (unlike Experiments 1 and 2), and the sequence of races was the same for all participants, differences between races must be interpreted with caution. Nonetheless, note that the greatest number of longshot choices occurs in the last race for each condition. Furthermore, we can make comparisons for the same race across conditions, because participants in the two conditions saw the same first eight races. The crucial prediction was that there would be more longshot choices for race 8 in the 8-race condition than in the 10-race condition, and this was confirmed (65% vs. 50%;  $\chi^2(1, N = 224) = 5.24, p = .022$ ). This replicates the last race effect in a more ecologically valid setting.<sup>5</sup>

To test the “recouping losses” account, we conducted a 2 (Sequence Length: 8 vs. 10 races)  $\times$  2 (Domain: loss vs. gain) log-linear analysis on race 8 choices. There was an effect of Sequence Length, with more longshot choices in the 8-race condition than in the 10-race condition (replicating the effect of last race on choice;  $\chi^2(1, N = 224) = 5.27, p = .021$ ). Unlike in Experiment 2, we found no evidence that those in the loss domain were more likely to choose the longshot than those in the gain domain, collapsing across the 8-race and 10-race

<sup>5</sup>Although we expected a difference in longshot choices between conditions for only race 8, Figure 6 shows that the difference for race 7 is surprisingly large (57% vs. 70%), and it is marginally significant ( $p = .0501$ ). However, in a pilot study ( $N = 273$ ) that was essentially identical to Experiment 3 but without monetary incentives, there was no difference between conditions for race 7 (66% vs. 64% for the 8-race and 10-race conditions, respectively). The longshot is preferred relatively often in race 7 (64% in Experiment 3, 65% in the pilot study), but it seems unlikely that the preference differs as a function of condition.

conditions (57% in both conditions;  $\chi^2 < 1$ ). However, the interaction between Sequence Length and Loss Domain was marginally significant ( $\chi^2(1, N=224)=2.72, p=.10$ ), with those in the loss domain being more likely than those in the gain domain to select the longshot in race 8 if it was the last race (69% vs. 59%) compared with when it was the eighth of 10 races (44% vs. 55%). This finding provides weak evidence in favor of the “recouping losses” account.

We tested the “change in domain” account by conducting a 2 (Sequence Length: 8 vs. 10 races)  $\times$  2 (Distance from Zero: 1 vs.  $>1$ ) log-linear analysis on race 8 choices. In addition to an effect of Sequence Length (i.e., a last race effect,  $\chi^2(1, N=224)=5.27, p=.021$ ), there was also an effect of Distance from Zero: Those more than one point away were more likely to select the longshot (60% vs. 30%;  $\chi^2(1, N=224)=8.29, p < .01$ ). However, there was no hint of an interaction ( $\chi^2 < 1$ ); that is, distance from zero did not affect longshot choices more when race 8 was the last race (68% vs. 38%) compared with when it was the eighth of 10 races (52% vs. 20%). These findings replicate those of Experiment 2 and provide further evidence that the “change in domain” phenomenon does not explain the last race effect.

Finally, we examined participants’ responses to the question asking them why they chose the horse they did in race 8. Two coders categorized the responses, and any disagreements were resolved through discussion. We first checked whether participants referred to the last race in their justifications. In the 8-race condition, 19% of participants (20/105) explicitly referred to the fact that it was the last race. Of these participants, 80% (16/20) chose the longshot in race 8, whereas only 61% (52/85) of those who did not mention the last race chose the longshot, although the difference is not significant ( $p=.13$ , Fisher’s exact test). If we compare race 8 longshot choices between 8-race condition participants who mentioned the last race (80%) and all 10-race condition participants (50%), the difference is significant ( $p=.015$ ). Thus, participants who explicitly referred to the last race exhibited an increased preference for risk compared with participants who did not explicitly refer to the last race in their justification and with participants for whom it was not the last race.

We also checked race 8 justifications for how often participants referred to domain, that is, whether they were above or below the 20 points (\$2) they were endowed with at the beginning of the experiment. The reference-dependent accounts suggest that participants would be more likely to refer to domain in the 8-race condition (where race 8 was the last race) than in the 10-race condition. Categorizing these responses was more difficult because, for example, participants who chose the longshot might mention losing previous races, but it would be unclear whether they were referring to being in the loss domain per se or to being “due” for a win because of the gambler’s fallacy. Because of this, we conducted analyses using both a “loose” criterion (mention previous outcomes, but do not indicate whether they are above or below the 20 points they started with) and a “strict” criterion (indicate whether they are above or below 20 points) for referring to domain. With the loose criterion, 17% (18/105) of 8-race participants and 13% (15/119) of 10-race participants referred to domain ( $p=.35$ , Fisher’s exact test). With

the strict criterion, the respective results are 12% (13/105) and 9% (11/119;  $p=.52$ ).<sup>6</sup> In short, the justification data are consistent with the choice data and indicate that the last race encourages risk taking that is largely independent of consideration of domain.

## GENERAL DISCUSSION

In three laboratory experiments, we reproduced the horse track phenomenon of increased longshot choices in the last race (or round) reported by McGlothlin (1956; see also Ali, 1977; Asch et al., 1982; Kopelman & Minkin, 1991; Metzger, 1985). This is notable given the recent findings by Snowberg and Wolfers (2010) showing virtually no last race effect when analyzing most US horse races over a 10-year period (1992–2001). As mentioned earlier, perhaps some bettors have become aware that betting on favorites late in the day leads to better expected returns, and this has virtually negated the last race effect at the aggregate level. It is also possible that recreational gamblers are more susceptible than serious gamblers to the last race effect (Johnson & Bruce, 1993), and the earlier studies might have been composed of more recreational gamblers. This change could be due to the legalization of off-track betting in many areas of the USA. (Prior to 1970, off-track betting was legal only in Nevada.) Off-track betting might attract more serious gamblers who are less likely to be affected by the position of the race and, compared with being at a track, probably makes it less salient that a particular race is the last race. We suspect, for example, that bettors at the track are more likely to observe the entire series of races than those betting off track. Whatever the reason for the discrepancy between Snowberg and Wolfers (2010) and earlier studies, our experiments took place in a neutral setting, made the last round salient, and did not involve a self-selecting population of gamblers. Under these conditions, increased preference for risk in the last round of a sequence of gambles is a robust phenomenon.

Reproducing the last race effect allowed us to test different psychological accounts of the phenomenon. We tested two reference-dependent accounts. The first is what we called the “recouping losses” account, which posits that people in the loss domain before the last race are driving the effect because they need the longshot to get out of the loss domain (Thaler & Ziemba, 1988). The data provided mixed evidence at best for this account. Experiment 1 provided weak evidence of the opposite finding: Those in the gain domain showed a stronger last race effect. Experiment 2

<sup>6</sup>The “recouping losses” account suggests that 8-race participants would be more likely to select the longshot when they mention being in the loss domain than when they mention being in the gain domain. The resulting sample sizes are very small, though, even with the “loose” criterion: 83% (10/12) of those mentioning the loss domain chose the longshot, whereas 67% (4/6) of those mentioning the gain domain did so. This result is in the right direction but not significant ( $p=.57$ ). The respective results for the “strict” criterion are 78% (7/9) and 100% (4/4), which is in the direction opposite the “recouping losses” prediction.

revealed essentially no effect of domain on longshot choices in the last round, and Experiment 3 showed a marginally significant effect in favor of the account. Taken together, our data indicate that the last race effect is largely independent of gain/loss domain. However, because only Experiment 3 paid participants (modestly) according to their performance and showed some evidence in favor of the recouping losses account, it does raise the possibility that increasing the stakes (as at the race track) would reveal stronger support for the account.

The second reference-dependent account we tested was that participants who were more than one point from zero in the last race were responsible for the last race effect (the “change in domain” account motivated by Thaler & Johnson, 1990). Most participants in the loss domain are more than one point from zero and need the longshot to break even, and most participants in the gain domain are more than one point from zero and so can play the longshot and stay in that domain. By contrast, the favorite may be preferred by those exactly one point below zero because it increases their chances of breaking even, and preferred by those exactly one point above zero because it increases their chances of staying in the black. We indeed found that participants who were more than one point from zero made more longshot choices in round 8 in Experiments 2 and 3—which provides a conceptual replication of Thaler and Johnson—but this was equally true for both the 8-round and the 10-round conditions and therefore does not explain the last race effect (but see footnote 4). Thus, the last race effect appears to be independent not only of whether participants have gained or lost points, but also of how many points they have gained or lost. We conclude that the last race effect is largely reference independent.

Separate from the last race effect, we found evidence in Experiment 1 for an increase in longshot choices across rounds. On the surface, this might appear to be consistent with prospect theory, which predicts such an increase at the horse track because the number of people in the loss domain increases after each race, and those in the loss domain are more likely to choose the longshot. Importantly, though, the number of players in the loss domain decreased across rounds in our experiments. Clearly, an increase in the number of people in the loss domain is not necessary for there to be an increase in longshot choices (including the last race effect). Indeed, according to the usual logic behind the prospect theory predictions regarding race track betting, longshot choices in our experiments should have decreased across rounds and should have been lowest in the last round. This was clearly not the case.

Also of interest is that despite finding only weak evidence for the “recouping losses” account, we did find that participants in the loss domain were more likely to choose the longshot, at least in the early rounds. However, this appears to be due to the nature of our design: Participants are more likely to be in the loss domain in the early rounds to the extent that they select the longshot. Analysis of participants with identical betting histories but different outcomes supported the conclusion that longshot betting led to losses (in early rounds), but losses did not cause longshot betting.

Using laboratory experiments to study the last race effect allowed us to control expected value and the position of the last race, and to monitor individual choices, outcomes, and the extent to which participants were in the gain or loss domain. This, in turn, enabled us to conclude that the last race effect is robust and is not reference dependent. Of course, our laboratory experiments differ from a day of betting at a horse racing track in numerous ways. We increased ecological validity in Experiment 3 by paying participants according to their performance and by using stimuli (horse names and posted probabilities) drawn from a real day at a race track. We still found clear evidence of a last race effect. Nonetheless, numerous differences remain between our experiments and a day at the track: Bettors at the track can bet as much as they wish on a race, or not bet at all, whereas our participants bet the same amount on each race; real-world bettors have access to a variety of information (e.g., track conditions), not just posted odds and payoffs; a series of horse races takes hours, whereas our experiments lasted a few minutes; at the race track, one learns how all horses perform, not just the chosen horse; the stakes are larger at the race track; and so on. However, none of these differences seems to be critical for a last race effect: Even in our stripped-down Experiments 1 and 2, in which participants sat in front of a computer for a few minutes and gambled for points, there was a clear last race effect.

Indeed, a similar phenomenon has been observed in a very different context (Xing, Wen, Sun, Cai, & Fung, 2014). In an investment decision-making task, undergraduates were initially given money to invest (i.e., bet) over a series of trials. Each trial consisted of a decision to take a particular risk or not and, if so, how much to invest. Participants who were told in advance which trial was the last one were more likely to invest, and invested more money, on that trial than participants who were not told. Notably, the effect occurred even when the investment had negative expected value. A preference for increased risk at the end of a series of trials may be strong and widespread.

Our primary goal in this article was to test whether the last race effect is reference dependent or independent, and the data from our laboratory experiments suggest that the effect is reference independent. This finding is important in light of longstanding speculation that the last race effect is reference dependent (McGlothlin, 1956; Ali, 1977; Asch et al., 1982; Kahneman & Tversky, 1979; Thaler & Ziemba, 1988). Why, though, does preference for risk increase in the last round of a series of gambles? If previous wins or losses are not the cause, what is? We suspect that there is a general proclivity to end a series of related events with the most fun, interesting, or exciting event (see, e.g., Loewenstein & Prelec, 1993). Looking beyond risky decision making, fireworks displays end with a grand finale; the last movement in a musical composition tends to be dramatic and fast paced; awards ceremonies save the most prestigious awards for last; concerts end with the most anticipated musical artist. In the case of horse racing, betting on a longshot not only has the possibility of a very good outcome, but it also has the accompanying anticipation of the good outcome. It is something to look forward to, perhaps even savor. By

contrast, betting on the favorite in the last race is anticlimactic; there would be little anticipation of the modest outcome, and even winning the modest amount may be unsatisfying. People may want a day of gambling, like an evening of fireworks, to go out with a bang.

## APPENDIX

Following are the full instructions for Experiment 3.

Screen 1:

This study simulates a day at a horse racing track. You will have the opportunity to bet on different horses, and win or lose points depending on their performance.

The data that you encounter in this study, including the horses' names and their chances of winning, are taken from the records of a real day at an actual racetrack.

Screen 2:

You will bet on a number of different races. A typical horse race usually features several horses, but for each bet, you will see two horses selected from this larger field.

For each horse, you will be told how likely it is that this horse will win. You will also be told how many points you'd get if you bet on this horse and it wins. In general, a bet on a horse that is less likely to win pays out more if the horse does win.

Screen 3:

You begin the study with 20 points. In each race, you have to bet on one of the two horses.

If your horse loses, you lose 1 point.

If your horse wins, you win the number of points indicated on the screen.

Screen 4:

For example, you might be given a choice between the following two horses:

Frou-frou: a 33% chance to win 2 points

Gladiator: an 8% chance to win 12 points

So if you bet on Gladiator, you have a small chance of winning many points. And if you bet on Frou-frou, you have a larger chance of winning a smaller number of points.

In either case, if the horse you bet on loses, you lose 1 point.

Screen 5:

At the end of the study, your point balance will be converted to money, and you will be paid. Each point is worth 10 cents, so your starting balance of 20 points is worth \$2.

Screen 6:

There will be [eight/ten] races in total, and we will notify you just before the last race occurs so you know when the racing day is about to end.

The races will begin on the next screen.

Screen 7:

This is race 1 of 8. You currently have 20 points.

Please select a horse to bet on.

Zakocity: a 13% chance to win 8 points

Lifestyle: a 50% chance to win 1 point

End of instruction screens.

Participants clicked on a radio button to select a horse and were then told the outcome, e.g.,

“You bet on Lifestyle, offering a 50% chance to win 1 point, and your horse lost.

You have lost 1 point(s), and now have 19 points.”

Before the last race (race 8 in one condition, race 10 in the other), participants read, “The racing day is coming to an end—the next race is the last race.”

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*Authors' biographies:*

**Craig R. M. McKenzie** received his PhD in Psychology from the University of Chicago and is now a professor in the Rady School of Management and in the Department of Psychology at the University of California, San Diego. His research interests include decision making, inference, rationality, and creativity.

**Shlomi Sher** received his PhD in Psychology from Princeton University and is now an assistant professor in the Department of Psychology at Pomona College. His research interests include decision making, rationality, and consciousness.

**Johannes Müller-Trede** received his PhD in economics from Universitat Pompeu Fabra in Barcelona and is currently a post-doctoral researcher in the Rady School of Management at the University of California, San Diego. He is interested in the performance, the psychology, and the rationality of people's judgments and their decision making.

**Charlette Lin** is a graduate student in the Department of Psychology at the Ohio State University. Her current work involves mathematical modeling of decision-making, visual attention, and memory.

**Michael Liersch** is managing director, head of Behavioral Finance and Goals-based Development at Merrill Lynch Wealth Management. He has been a visiting professor at NYU's Stern School of Business and earned his PhD in Cognitive Psychology from the University of California, San Diego. His recent research is focused on how investors make decisions that sustain wealth.

**Anthony George Rawstron** graduated in Psychology at the Pontifícia Universidade Católica, Rio de Janeiro (Brazil), and received his diploma in Economics from the University of Cologne (Germany). He is currently working as a therapist in Rio de Janeiro.