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The rule of three: How the third event signals the emergence of a streak

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Abstract

It is well established that people perceive streaks where they do not exist. However, little is known about what constitutes a streak in the mind of an observer. This paper proposes that the third repeat event in a sequence is pivotal to the subjective belief that a streak is occurring. In five studies, we find direct and indirect evidence that perceived streakiness plateaus with the third repeat outcome in a sequence. The evidence to support this *rule of three* comes from various domains, including: observation of randomly determined probabilistic outcomes, investment decisions in response to performance histories, and basketball shooting percentages.
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Keywords: Streak perception; Streak emergence

"When you win one, you stop a losing streak. When you win two, it's a trend. Three in a row and it's a streak."

–sportswriter Anthony Flum, Boston Daily Free Press, 4/29/2005

"Nobody wants to lose two in a row, and definitely nobody wants to lose three in a row. If you lose three in a row, there will start being a lot of questioning about our losing streak."

–Luol Deng, NBA basketball player

A substantial body of research has established that people perceive streaks in random data (Albert & Bennett, 2001; Albright, 1993; Gilovich, Vallone, & Tversky, 1985). One of the most compelling results from the work on streaks is that people steadfastly maintain beliefs in streaks, even in situations where there is strong evidence to the contrary (Gilovich et al., 1985). The search for streaks in sports has led researchers to analyze data from the domains of professional golfers (Clark, 2003a, 2003b, 2005), sports gambling (Offerman & Sonnemans, 2004), and long distance basketball shootouts (Koehler & Conley, 2003), with the typical result that there is little evidence to support the existence of streaks.[1] Belief in streaks has also been studied in casino gambling (Croson & Sundali, 2005) and in investment decisions (Hirshleifer, 2001; Kahneman & Riepe, 1998). For example, studies have shown that investors will buy assets that have recently increased in an attempt to chase a streak (Johnson, Tellis, & Macinnis, 2005), and that they overweight recent news and rumors when deciding to trade (DiFonzo & Bordia, 1997).

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[1] Statistical existence of streaks has been identified in other domains; for example, Gilden and Wilson (1995) find evidence of streaky performance among putters and dart throwers. The primary concern of this paper is not the actual existence of streaks, but the strong tendency of observers to perceive them to exist.

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Although much work has been done to compare subjective perceptions of streaks against their actual occurrence, little has been done to understand when observers believe a streak has emerged. In other words, at what point does a sequence of events begin to exhibit streakiness? In this article, we propose and test the idea that the third repeat event in a sequence is pivotal to the belief a streak has emerged. Specifically, we propose that the third repeat event in a sequence signals the emergence of a streak. A consequence of this *rule of three* is that three sequential events (one original and two repeat events) should be perceived as streakier than a sequence of two events, and may even be as streaky as a sequence of four or more events.

The rule of three draws support from the importance of the number three in human learning and cognition. Humans perceive the world in three dimensions and are capable of viewing only three basic colors. After three examples of a new word, people can generalize its definition to new objects (Tenenbaum & Xu, 2000), a result consistent with work by Kareev (1995, 2000) on humans' tendency to pick up patterns in small samples. In marketing, three is the optimal number of advertising exposures during a purchase cycle to influence consumer behavior (Belch & Belch, 2001).

The value of repeated outcomes or statements has also been recognized in research on perception and judgment, such as in work on mere exposure effects (Zajonc, 1968) and illusory truth effects (Bacon, 1979; Hasher, Toppino, & Goldstein, 1977). However, whereas much of this work suggests that multiple exposures to a repeated event increase its judged truthfulness, none tested whether three is the optimal number of exposures. Research on perceptions of randomness has frequently documented the tendency of observers to perceive non-randomness in random sequences when outcomes repeat in a way that does not match observers' expectations (see Bar-Hillel & Wagenaar, 1993 for a review). More recent work on how observers perceive randomness in coin flips suggests that likelihood predictions for a repeated next flip first decrease and then increase as streak length increases, with the third event being particularly important as a transition point (Altmann & Burns, 2005).

Based on the importance of three in the human perception of other patterns, we propose that it may play a significant role in streak perception. If it exists, the rule of three would have implications for any situation where beliefs in streaks influence behavior. For example, investors who believe a security is streaking up are likely to purchase it, while investors who believe a security is streaking down are likely to sell it. Opponents of a basketball player who is believed to be streaking hot may divert resources to stop that player from scoring. Gamblers who perceive a streak has emerged may believe it is due to reverse, and so bet against it. Thus, the rule of three could lead to systematic and potentially suboptimal decisions in a variety of settings.

To reiterate, we hypothesize that belief in the existence of a streak will jump from the second to the third instance and that it will remain relatively flat thereafter. In other words, we expect that two consecutive outcomes will be perceived as less streaky than three outcomes, while four or more consecutive outcomes will not be perceived as streakier than three outcomes. In five studies across a variety of domains we test the rule of three by examining the incremental influence of each successive event on streak perception, beliefs, and behavior.

Study 1: Mentions of streaks on the web

We begin our empirical investigation by collecting some real-world evidence to help us examine whether streaks begin with the third event in a sequence. To do so, we searched Google.com for winning and losing streaks of various lengths (using phrases like "four-game winning streak"). If runs shorter than three in length are seen as being not streak-like, then our searches should yield fewer hits for streaks of length one and two than for streaks of length three, even though three event sequences are less common than single or double event runs. Since three-event runs are more common than four-event runs, and since (according to the rule of three) the third event will signal the onset of a streak, there should be more references to three-event winning and losing streaks than references to streaks of any longer length. In short, the rule of three predicts that a search for winning and losing streaks of various lengths will yield a peak for three-event streaks.

Methods

To test this, we searched for winning streaks and losing streaks for games and matches of lengths one through ten. For example, for three game streaks, we used the following phrases: three-game winning streak, 3-game winning streak, three-game losing streak, and 3-game losing streak.[2] The idea behind searching for both game and match streaks was that matches (e.g., tennis matches) usually occur in the context of a seeded bracket, whereas most games (e.g., basketball, baseball, football) are regular season games in which there is no seeding of teams. The distinction between game and match streaks provides a basis for naturally examining whether baserates influence incidence of mentioning

[2] Search phrases were placed in quotes, so that Google would return only those instances where the exact phrase appeared.

streaks of various length on the web. That is, when contests are seeded (as with tennis tournaments) winning and losing streaks should be more common, with the top seeded players winning most of their matches and the bottom seeded players often losing their first match. We also searched for the phrase "*x* games straight," where *x* was varied from one to ten. The idea here was to determine if any pattern that was observed in the game and match streak data would extend to statements where the word "streak" was not explicitly part of the search string.

Results

Data from the Google searches for run lengths one to ten are presented in Fig. 1 (game streaks), Fig. 2 (match streaks), and Fig. 3 (games straight). All three figures suggest that one event is not seen as much of a streak, as there are very few mentions of one-event streaks for wins or losses in games and matches and almost no mentions of "one straight." There is a jump in all three figures from one to two-event runs. More importantly, there is a substantial jump in incidence in all three figures from two-event runs to three-event runs. This is consistent with the rule of three; specifically, with the idea that runs of length three are more streak-like and so will be referred to as streaks more often than runs of length two. Finally, also consistent with the rule of three, the incidence of hits does not increase for runs greater than three in length.

Figs. 1 and 3 are remarkably similar in shape, but the match data in Fig. 2 differs in two noteworthy ways. First, there is a plateau for runs of length three through five in the match data that does not exist in the game data. This difference is consistent with the claim that runs will be more common in matches than in games. In particular, since many tennis contests are seeded, the drop in likelihood of winning a fourth or fifth match should be smaller than it would be for unseeded games.

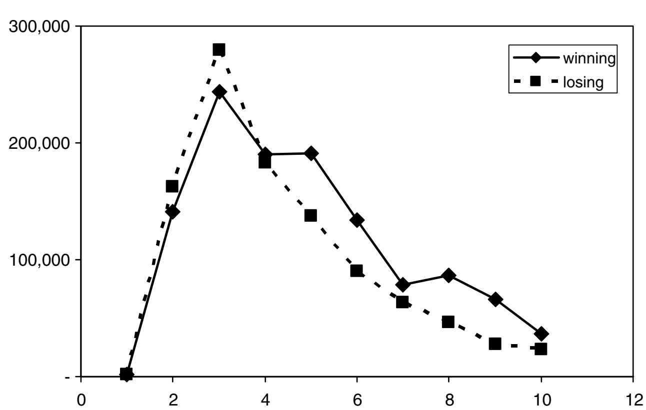

Fig. 1. Incidence of game winning and losing streaks for searches performed on Google.com (Study 1).

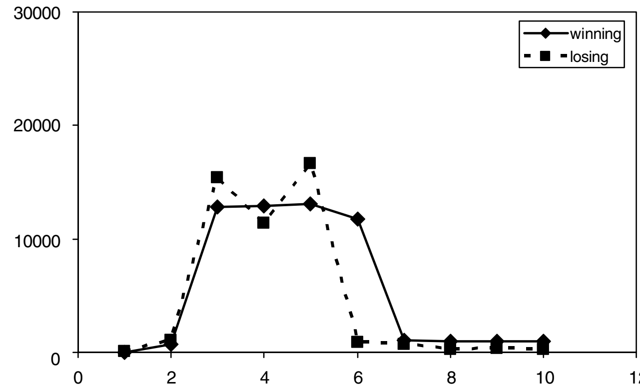

Fig. 2. Incidence of match winning and losing streaks for searches performed on Google.com (Study 1).

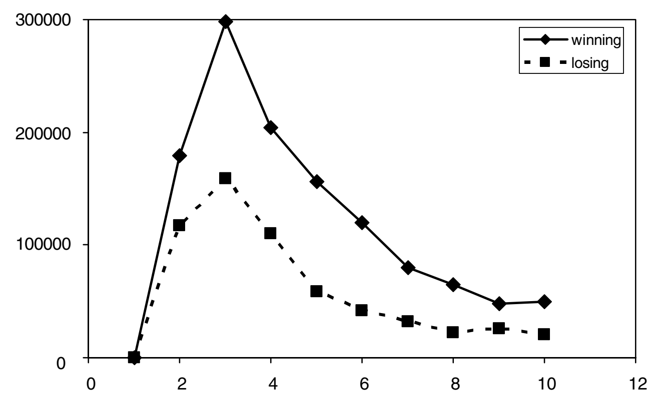

Fig. 3. Incidence of winning and losing games straight for searches performed on Google.com (Study 1).

Thus, the incidence of four match and five match runs relative to the incidence of three match runs is likely to be higher than it is for games, which could explain the plateau in Fig. 2. The second difference is that the jump in streak incidence from runs of length one to two is less substantial for matches than it is for games. This is also consistent with a difference in pairwise parity across the two types of contests. That is, two match runs are likely to be very common in tennis because of the lack of parity in the early contests, and so are unlikely to be seen as streak-like. What is interesting, however, is that there is a prominence of three-run streaks in all three figures. That is, the rule of three seems to dominate baserates.

Discussion

These data indicate that there are more mentions of streaks of run length three for games than of any other run length, and that match runs of length three are as or more common than run lengths of any other length. For both matches and games, three-event streaks are much more incident than two-event streaks, which suggests either that streaks do not begin in earnest until the third successive event or that one-event and two-event streaks are not very impressive. If the latter is true, then we might expect the tradeoff between streak salience (which increases with streak length) and the actual incidence of streaks to continue for streaks of longer lengths. However, if this were the case, we might expect more hits for four-event streaks than for three-event streaks; the data instead shows that three-event streaks are more incident than four-event streaks. Neither of these results is remarkable by itself. That is, three-event streaks are more novel than two-event streaks, so their greater incidence can be justified on grounds of greater salience. Likewise, there are more three-event streaks than there are four-event streaks, so their greater incidence can be justified by there being more of them. What is interesting is that both results exist in the same data, which is inconsistent with either account by itself, but consistent with the notion that streaks begin with the third instance. Though these data do not allow us to say definitively whether streaks begin with the third successive event, they do provide strong initial evidence for the rule of three hypothesis.

These data also suggest that the rule of three might be insensitive to baserates. In other words, baserate neglect may exist in the subjective assessment of streaks in much the same way that it exists in other judgment domains. Of course, these data do not definitively establish baserate neglect in streak perception. As such, we next turn to the laboratory, where we can manipulate baserates, and run lengths, while controlling for actual event incidence.

Study 2: Perceptions of streakiness in a lab study

This study directly measures subjective perception of streakiness for various run lengths of outcomes produced by random event generators. Recall that the rule of three predicts that perceived streakiness will increase monotonically until the third event in the sequence and then will remain steady for each successive event.

Method

Each participant ($n = 78$) saw four sequences of different lengths that were generated by four different event generators. The event generators were (a) the flipping of a fair coin, (b) the rolling of a fair six-sided die, (c) the drawing of a red card from a standard 52-card deck, (d) the drawing of a red poker chip from a bag containing 120 chips (20 of each of six different colors). These four generators create natural variation in the baserate of an event (e.g., 50% for the coin and the deck of cards; 16.6% for the die and the poker chips), and whether sampling occurred with replacement (die and coin) or without replacement (deck of cards and poker chips).

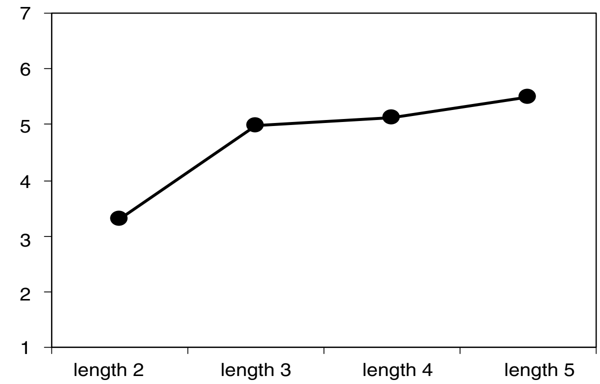

Fig. 4. Perceived streakiness for various run lengths in Study 2.

Each participant rated the streakiness of four of the sixteen possible sequences that were created by crossing the four generator types by four different streak lengths (e.g., two-run, three-run, four-run, or five-run sequence). Each generator-specific sequence repeated the same event for the specified length; for example, a three-run length of coin flips would take the form of three successive head flips while proving no other information about outcomes before or after that run. Order of the four sequences was randomized, with the sole constraint that no participant saw the same generator type or streak length twice. After viewing each sequence, participants answered the following question, "To what extent would you describe the sequence above as a streak?" Responses were collected using a 7-point scale, with endpoints 1 = "not a streak at all" and 7 = "very much a streak." We did not define the word "streak" for participants because we were interested in learning how they (on average) define it for themselves (e.g., does three repeat events constitute as much of a streak as four repeat events?).

Results

We first tested for an effect of generator on streak perceptions. Finding no such effect ($p > .15$), we then tested for effects of baserate and sampling type. Here too, neither baserate (50% versus 16.6%) nor sampling type (replacement versus no replacement) influenced perceived streakiness, nor was there a significant interaction effect (all $p > .15$).[3] As such, we examine the effect of sequence length on streakiness by combining the data from all four generators. These data are presented in Fig. 4.

As expected, perceived streakiness increases from a two-run sequence ($M = 3.30$, $SD = 1.47$) to a three-run sequence ($M = 4.97$, $SD = 1.41$), $t(152) = 7.20$, $p < .001$,

[3] All p-values in this paper are the result of two-tailed significance tests.

$d = 1.17$. Equally important, perceived streakiness plateaus after three successive repeat events. That is, the four-run sequence is not more streaky ($M = 5.12$, $SD = 1.58$) than the three-run sequence, $t(154) = 0.60$, $p > .15$, $d = .10$, nor is the five-run sequence more streaky than the three-run sequence ($M = 5.49$, $SD = 1.57$), $t(156) = 1.47$, $p = .14$, $d = .24$.

Discussion

These data indicate that the most substantial increase in perceived streakiness occurs between sequences of two and sequences of three events. That is, two-run sequences are not seen as very streaky, while sequences of three runs or longer are perceived as roughly equally streaky. This pattern obtained for sampling with and without replacement, for different base rate probabilities, and across different types of sequence generators (e.g., coin flips versus draws of poker chips). The fact that we get similar patterns for environments with different underlying likelihoods is consistent with the data from Study 1 and with the more general finding that individuals tend to be insensitive to the actual probabilities of the outcomes they are observing (Rottenstreich & Kivetz, 2006).

The lack of an effect of baserate on perceived streakiness also rules out the possibility that participants mapped joint probability into perceived streakiness. That is, if a sequence of events was deemed to be streaky when the joint probability of the events fell below a predetermined level (say .125) then it should be the case that two events in the low baserate condition (.17) would be as streaky as three events in the high baserate condition (.5). This follows from the fact that two events in the low baserate condition have a joint probability of .029, which is lower than the joint probability of three events in the higher baserate condition (.125). Since perceived streakiness did not differ across baserates, this explanation for the data pattern can be dismissed.

The possibility exists that participants in this study applied a semantic heuristic that a streak requires at least three events. If so, then the third event would not alter beliefs and so will not induce a change in behavior. However, if the third event signals the emergence of a streak, then we should observe behavioral changes consistent with this change in beliefs. Study 3 tested this proposition.

Study 3: Investing in a risky prospect

Our focus in Study 3 is on measuring strategic behavioral changes that are consistent with belief in the rule of three. Participants in this study decided how much money to invest in a hypothetical derivative after seeing recent performance. By measuring investment levels after n consecutive closes up, we can examine strategic reactions to various sequences of repeated events.

Method

Participants were 47 undergraduate students who received extra credit for participating in this study. Each was given a questionnaire describing a hypothetical investment opportunity. They were told to imagine that they had inherited \$100,000 under the stipulation that they invest all of it in a combination of an oil industry derivative and bonds, with at least ten percent invested in each. After reading a description of the derivative, and learning of a single day's performance ("up 1% over the previous day"), participants made their investment decision. The specific question to which they responded was "How would you allocate the \$100,000?" Participants then turned the page of the stimulus packet and learned that the derivative had closed up 1% on the second day. They were then allowed to revise their allocation without cost. This was repeated for six days, yielding a within-participant allocation record for a sequence of six 1% increases in the derivative's value.[4]

Results

The average allocation to the derivative for each streak length is shown in Fig. 5. Our primary interest is in the level of investment in the derivative for each successive day. We examined the effect of streak length on allocation to the derivative by comparing allocation proportions for each sequence length to the next longest sequence length. We find that the proportion invested in the derivative increases, though not reliably, from the one-run sequence ($M_1 = .505$, $SD = .308$) to the two-run sequence ($M_2 = .537$, $SD = .308$), $t(46) = 1.41$, $p > .15$, $d = .42$. As predicted by the rule of three, there is a significant increase in allocation to the derivative when the sequence length changes from a run of two to a run of three ($M_3 = .582$, $SD = .312$), $t(46) = 1.97$, $p < .05$, $d = .58$. However, allocation to the derivative

[4] In an attempt to contrast the rule of three in environment where outcomes are expected to be streaky versus not streaky, we also manipulated whether the derivative had been engineered to be streaky or not streaky. This was done by giving participants additional information about how the derivative was constructed. Manipulation checks confirmed that the subjects understood the implications of this distinction prior to making their allocation decisions. Analysis of the data revealed no effect of this manipulation on allocations; participants in both conditions still looked for and bet on streaks in the price sequences. This is consistent with prior research on individuals looking for streaks even in investments they know follow a random walk (Bloomfield & Hales, 2004). Since the effect of run length on allocation to the derivative was replicated for both conditions of expected streakiness, we combined across these two conditions and present the analyses for the combined sample.

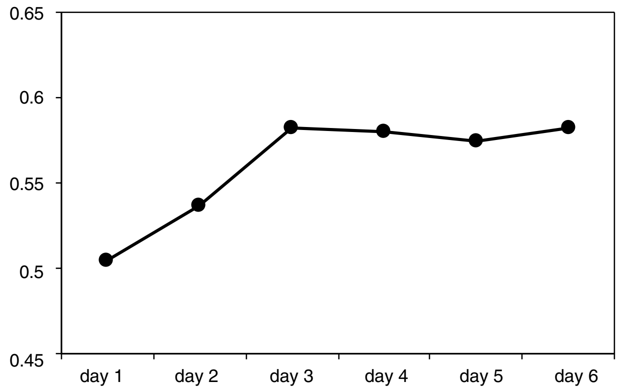

Fig. 5. Proportion of $100,000 allocated to the derivative by run length in Study 3.

remains flat thereafter ($M_4 = .580$, $SD_4 = .323$; $M_5 = .575$, $SD_5 = .313$; $M_6 = .582$, $SD_6 = .317$).

Discussion

This study reveals that investment allocations respond to three consecutive observations, a finding that suggests strongly that the rule of three can influence behavior. However, we have not directly demonstrated that the behavioral change was driven by a change in underlying beliefs. That is, Studies 1 and 2 provide evidence for the rule of three in streak perceptions, and Study 3 establishes an effect on behavior, but none of these studies establishes an effect on beliefs. To fill this void, we replicated Study 3 and collected retrospective thought listings, which we coded for evidence that investment allocations were driven by beliefs about streaky performance.

Study 4: Replication and examination of beliefs

This study was designed to replicate Study 3 using a between participant design. Participants were 41 undergraduate students, each of which was assigned to a run length of two, three, or four 1% increases in the derivative's value. After learning the recent history of the derivative, each participant made a single allocation decision between the derivative and bonds. After doing so, participants read the following instructions: "Take a moment to reflect on what you were thinking when you made the allocation decision above. Please write down any thoughts you had about the derivative's likely performance in the near future." Participants' thought listings were coded by two independent raters as either referencing a *belief about the derivative being on a streak* or referencing some *other* issue (e.g., having balanced portfolio). The correlation across raters was .88, and the two discrepancies were resolved through discussion.

Results and discussion

As expected, run length had a significant effect on allocation to the derivative ($F(2,48) = 7.18$, $p < .01$). Subsequent planned contrasts, using Tukey's test for multiple pairwise comparisons, revealed a significant increase in allocation when moving from the two-run sequence ($M = .311$) to the three-run sequence ($M = .556$, $p < .03$). However, the slight increase in allocation from the three-run to the four-run sequence ($M = .659$) was not significant ($p > .50$). These results replicate the findings in Study 3.

More importantly, analysis of the retrospective thought listings revealed that participants in the three-run condition were more likely than those in the two-run condition to decide allocation on the basis of beliefs about the derivative being on a streak. Specifically, 39% of participants in the three-run condition mentioned the streakiness of the derivative as a factor in their decision, whereas only 7% of participants in the two-run condition noted this ($z = 2.13$, $p < .05$). Those in the two-run condition mentioned factors such as balancing their portfolio, avoiding risk, or knowledge about the industry as determinants of their allocation decision. A large minority of participants in the four-run condition (39%) also noted the current streak of the derivative as a factor in their decision, a proportion that equaled the three-run condition. In sum, these data indicate that beliefs of streakiness change in a manner consistent with the rule of three.

Study 5: Strategic reactions in basketball

We next examined whether reactions to a sequence of three events would occur in a noisy and competitive environment such as basketball. As reported by Gilovich et al. (1985), most basketball players and coaches believe that any player can get on a hot streak or a cold streak. They also believe that basketball strategies should adjust for such streaks. For example, Gilovich et al. report that 84% of college basketball fans agreed with the statement, "It is important to pass the ball to someone who has made several shots in a row." Whereas Gilovich et al. focus on whether players actually exhibit streaky shooting (i.e., the "hot hand"), our focus is on whether there is evidence of a change in strategy after three makes or three misses in a row. In other words, is there evidence that players change their playing style in reaction to shot history in a manner that is consistent with the rule of three?

We reasoned that if three represents the emergence of a streak, then after a player makes three shots in a row he, his coach, his teammates, and his opponents should perceive him to be on a "hot" streak. Accordingly, he should take riskier shots, be given the ball in riskier settings, and be guarded more tightly by the defense after making three shots in a row than after making one or two shots in a row. The consequence of these strategic reactions is that the fourth shot taken (after three makes in a row) should be made less often than any random shot. Symmetrically, a player who missed three shots in a row should be perceived to be on a "cold" streak, is likely to shoot only easy shots and to have less defensive resources committed to him. As such, he should be more likely to make his next shot, relative to any given shot.

Method

To test the above we reexamine Gilovich et al.'s (1985) basketball shooting data for the 1980–1981 Philadelphia 76ers basketball team and for shots taken by college basketball players during a controlled shooting session. For both sets of data, we analyze the probability that a shot is made, conditional on the history of the last few shots. If the rule of three operates in the 76ers data, which comes from actual games, then strategic reactions should influence shooting percentages as outlined above. Namely, players and coaches should respond accordingly, causing the probability of making a shot after three makes (misses) to drop below (exceed) the baseline probability of making any given shot. Since strategic reaction to one or two makes or misses should be less extreme, the probability of making a shot after one or two makes or one or two misses should not significantly differ from the probability of making any given shot. Finally, since strategic forces cannot operate when players shoot without defense from a preset distance, there should be no such evidence for the rule of three in Gilovich et al.'s controlled shooting data of college basketball players.

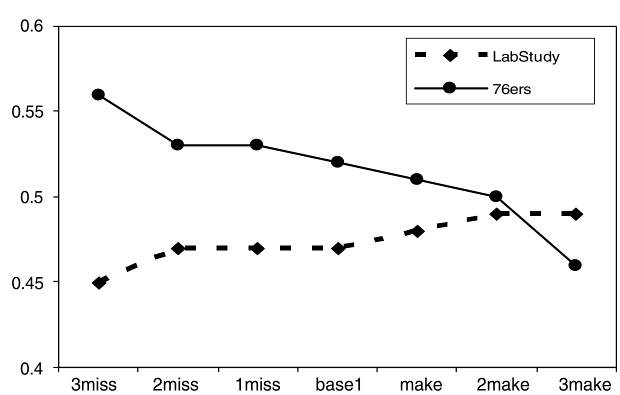

Fig. 6. Shooting percentages for the 1980–1981 Philadelphia 76ers during actual games and for Cornell University varsity basketball players in a controlled shooting experiment, conditional on recent shot history.

Results

We first examined the shooting percentages for the 1980–1981 76ers, conditional on recent shot history (see Fig. 6). We first note that the probability of making any given shot (on average across players) was .52. We also note that there was a decline in shooting percentage as a function of past success. This relationship was confirmed via binary logistic regression that revealed a positive coefficient of shot history on the likelihood the next shot was made ($\beta = .11$, $z = 6.44$, $p < .001$).

We next compared each conditional probability to the probability of making any given shot. As expected, the likelihood of making a shot after one make (.51) or two makes (.50) or after one miss (.53) or two misses (.53) did not differ from the probability of making any given shot (all $p > .20$). However, the probability of making a shot after three prior makes (.46) was significantly lower than the baseline probability ($z = 2.15$, $p < .05$), and the probability of making a shot after three successive misses (.56) was higher than the baseline, though not reliably so ($z = 1.32$, $p = .19$).[5] Finally, it is worth noting that there was directional evidence to support the rule of three in the shooting percentages of every player on the team (i.e., for every player the probability of making a shot after three makes was directionally lower than the probability of making a shot after three misses).

If these differences in shooting percentages derived from strategic reactions to perceived streaks, they should not exist when strategic responses are not possible. In other words, shot history should not matter to anyone who is shooting in an environment where defense cannot adjust and where the shooter cannot vary the difficulty of the shot. To test this we examined Gilovich et al.'s (1985) data from Cornell University basketball players who took shots in a controlled environment from a preset distance.

As expected, there was no relationship between shot success history and the likelihood the next shot was made. These data appear as the dashed line in Fig. 6. If anything, there was a positive relationship between shot history and the probability of making the next shot (i.e., the hot hand), which Gilovich et al. argued was not statistically significant. Thus, this data allows us to verify the pattern predicted from the rule of three: when taking shots in an environment where strategic reaction to a sequence of three is possible, likelihoods change

[5] The fact that the difference in probability is significant for a sequence of three hits but not three misses is not surprising when we consider the psychology of the opposing defensive players; a perceived streak of hits is likely to be more salient than a streak of misses as the former has greater consequence to defenders. We also note that this difference in reaction between hits and misses mirrors our team-level findings in Study 1 that game winning streaks are reported more often than game losing streaks.

after three makes or misses. This pattern does not exist when players are shooting in isolation from a fixed distance, where reaction to a perceived streak is impossible.

General discussion

This article proposed and tested the idea that the third repeat event in a sequence is pivotal to the subjective belief that a streak has emerged. Data from five studies supports this rule of three by showing that incremental reaction to an additional repeat event plateaus after the third event. We find evidence for the rule of three in references to winning and losing streaks on the web (Study 1), as well as in the perceived streakiness ratings of sequences outcomes generated by random event generators such as coins and dice (Study 2). We also find evidence for the rule of three in hypothetical investment decisions, given recent performance histories of different lengths (Study 3). In Study 4, participants in replication of Study 3 were more likely to base their investment decisions on beliefs about the trend of the derivative after seeing three or four daily closes, relative to seeing just two daily closes. Finally, a reexamination of the data collected by Gilovich et al. (1985) suggests that the rule of three governs strategic reactions to player performance on the basketball court. Collectively, these data provide strong initial support for the rule of three in streak perception.

The rule of three has implications for any situation where beliefs in streaks tend to influence behavior. For example, consider the case of predicting which team is likely to win an upcoming game. If the rule of three operates in team competitions, as our Google search data suggest, then gamblers will tend to bet for (against) teams that have won (lost) their last three games. If so, the odds, which adjust to account for the amount of money bet on each team, will be too far in favor of the team that has won three games in a row. In other words, a team that has won three games in a row will be overpriced. In the face of this bias, a savvy gambler (who is aware of the rule of three) might do well to bet against teams that have won three games in a row and bet for teams that have lost three games in a row. The extension to predicting the success of any entity (a student, a firm, a security) follows naturally, with similar opportunities to take advantage of the misevaluation of those entities that have had three successive failures or successes.[6]

In general, to predict how people will behave in reaction to a perceived streak requires two components. First, it is necessary to know what constitutes a streak in the mind of the observer. Second, it is necessary to understand the observer's theory about the event generator. We believe the rule of three provides a clear answer to the first question. Namely, the third instance is the event at which people believe a streak has emerged. Though this may not be a universal property of subjective experience it seems to be remarkably robust across a wide range of domains. The second question is, in many ways, more complex. Certainly, there are generators for which most people hold the same theory (e.g., the majority of people believe that basketball players can get hot or cold). However, there are other generators for which there may be no consensus as to the basic theory (e.g., can a coin or a deck of cards get hot?). Such differences in expectations for generator randomness may help explain the distinction between beliefs in a "hot hand" versus a "gambler's fallacy." Adding to the complexity of heterogeneity in theories across individuals is the possibility that any given person's theory about a generator may be partly a function of recently witnessed events. For example, after witnessing ten heads in a row from a fair coin, even the most rational person is likely to wonder whether something non-random is at work.

Our empirical exploration has been constrained to likelihood judgments (i.e., how likely a player is to make their next shot) and to the downstream consequences of these judgments (i.e., the direction of resources toward or away from a player). The effect of the rule of three on judgment, and its likely extension to prediction, may have other implications within social and organizational contexts. For example, an individual observing the behavior or outcomes of other individuals in a team may make stronger inferences about the characteristics or abilities of those individuals after seeing three consecutive similar events. Such inferences about team member abilities are the primary driver of behavior for the NBA basketball players in Study 5. If inferences about team members are occurring on the basketball court after seeing three repeated outcomes, consider how the same effect may apply for managers responsible for judging performance and assigning new tasks for subordinates. An employee with three positive outcomes, whether based on skill or pure chance, is likely to be rewarded, while an employee with three negative outcomes finds himself permanently tagged as an underperformer. The rule of three also may also extend to other domains of social inference, such as trusting other individuals based on past moves within certain social dilemmas and trusting games (Dawes, McTavish, & Shaklee, 1977), and creation of category stereotypes based on repeated interactions with out-group members (Allport, 1954). The effects of the rule of three on social inference offer

[6] In contrast to situations where perception of streaks that do not actually exist can be suboptimal, there are circumstances where streak perception can be highly adaptive. For example, Burns (2004) suggests that chasing a streak is adaptive when the streak signals an event generator with higher average probability of success than other options (e.g., a basketball player with a higher base rate than his teammates).

a potentially rich vein for future research, with high prescriptive value for practicing managers.

The importance of three in the domains of judgment and prediction mirrors its status in domains as diverse as religion (the Holy Trinity), mythology (the Three Fates), literature (three daughters of King Lear), architecture, law, and persuasion. Three is important in construction, where it is the smallest number of points that can provide a stable foundation to a structure (e.g., three legged stools and tripods). In voting, three is the smallest group that allows a difference of opinions but no ties, a structure that has led to three-judge appellate courts and three branches of government in the US. It seems that the number three, in many of these domains, is the minimal number of points that is seen as sufficiently stable, offering an optimal balance between strength and efficiency.

The value of the number three in providing a strong but efficient level of support could form the basis for a theory in which the rule of three is extended beyond streak perception to other forms of perception. For example, experts on presentation styles suggest that three is the most efficient number of arguments to make a strong case. If so, then we might expect to find three arguments are more convincing than two arguments, but not less convincing than four arguments. If people have an intuitive awareness of such a rule, it might be quite common for communicators to use three instances to make a point (e.g., three studies in a paper, three independent sources to verify a claim, three analyses to test a hypothesis). Indeed, the power of three for persuasion is employed by comedians, ministers (for their sermons), and salespeople. Whether for streak perception, prediction, or persuasion, the number three may possess special significance for human judgment. Along these lines, we admit an initial urge to detail three studies in this paper, and footnote the others.

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