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interlocking explanations of cause and effect between disciplines

On Streaks

Perception, Probability, and Skill

Long streaks are, and must be, a matter of extraordinary luck imposed on great skill.
Stephen Jay Gould
The Streak of Streaks [1]

Anyone can theoretically roll 12 sevens in a row.

Bill Gross
Barron's [2]

Finding the Hot Shot

Humans are natural pattern seekers. One well-known example is the hot hand in basketball. A player who makes a few baskets in a row is considered to have a hot hand, which implies that he has a higher-than-normal chance of sinking his next shot. Research shows that sports fans, and the athletes themselves, believe in the hot hand phenomenon.

There's only one problem: The hot hand doesn't exist. Scientists studied a season's worth of shooting statistics of the Philadelphia 76ers and free-throw records of the Boston Celtics and found no evidence for the hot hand. Players did make successive shots, of course, but those streaks were completely consistent with probabilities. Streaks and slumps lie within the domain of chance. [3]

We see patterns where none exist because we're wired to expect that the characteristics of chance show up not just in a total sequence, but also in small parts of the sequence. Psychologists Amos Tversky and Daniel Kahneman call this "belief in the law of small numbers."

For example, if you show someone a short section of a long coin toss series, he will expect to see a 50/50 mix between heads and tails even though a short section will generally deviate systematically from chance. Even a short sequence of repeated heads is enough to convince most people (falsely) that the longer sequence is not random. That's the reason we believe in hot hands. [4]

The main point here, though, is not that humans are poor at relating probabilities to sequences of outcomes. The more important issue is that streaks inform us about probabilities. In human endeavors, unlike a fair coin toss, the probabilities of success or failure are not the same for each individual. Long success streaks happen to the most skillful in a field precisely because their general chance of success is higher than average.

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Streaks and Skill

Here's an illustration of the link between streaks and skill. Let's say you have two basketball players, Sally Swish and Allen Airball. Sally, the more skilled of the two, makes 60% of her shot attempts. Allen only makes 30% of his. What are the probabilities of each player making five shots in a row? For Sally, the likelihood is $(0.6)^5$, or 7.8%. That means that Sally will get 5 in a row about every 13 sequences. Allen's chances are only $(0.3)^5$, or 0.24%. So Allen's only going to hit 5 straight once every 412 sequences. Without violating any probability principle, Sally is going have a lot more streaks than Allen. [5]

Consistent with this thesis, Wilt Chamberlin drained 18 consecutive shots on February 24, 1967, to earn the NBA record for the longest field-goal streak in a game. Chamberlin made 54% of his field-goal attempts over his career, placing him among the game's top 20 in shooting accuracy.

The one streak in sports, however, that defies the probabilities is Joe DiMaggio's 56-game hitting streak in 1941. (The closest streak is 44 games, 80% of DiMaggio's record, by Pete Rose and Wee Willie Keeler.) Ed Purcell, a Nobel laureate in physics, combed baseball's streak and slump record and concluded that everything that has happened in baseball was within the realm of probability—except DiMaggio's streak. [6]

Granted, DiMaggio was a great hitter—his lifetime batting average is the 27th best in baseball history—but the likelihood of his streak was less than a one-in-a-million, even for him. [7] For this reason, most statistically oriented baseball fans believe that DiMaggio's streak is the record least likely to be broken. [8]

Baseball hitting streaks are another good way to test the notion that we should associate long streaks with skill (as well as luck). In major league baseball history, 39 players have staked hitting streaks of 30 or more games. The average lifetime batting average of these players is .311. To put that in perspective, a .311 lifetime average would place a hitter among the top 100 in the history of the game.

Also, the five players with the most 20-game hitting streaks in history—Pete Rose, Ty Cobb, Tris Speaker, Heinie Manush, and Chuck Klein—have a combined lifetime batting average of .333. Over time, the batting average in baseball has hovered around .260. [9]

Toss Out the Coin Toss

Most finance professionals attribute money manager streaks (consecutive years of benchmark outperformance) to luck. For example, finance teachers enthusiastically invoke a coin tossing metaphor to demonstrate market efficiency. [10] The basic idea is that if you start with a sufficiently large sample of money managers, the probabilities tell you a priori that some will have a streak of outperformance. Start with a group of say 1,000 funds, assume a 50/50 chance of beating the market, and roughly 30 funds will outperform five years in a row—$(0.5)^5$ x 1,000.

There is nothing wrong with this logic as far as it goes. The problem is that not all fund managers are of equal skill—the money management industry has its versions of Sally Swish and Allen Airball. So attributing *any* fund streak to chance misses the point that skilled participants are the most likely to post a streak.

The streak that has garnered the most attention in the mutual fund world is that of Legg Mason's Bill Miller, whose Value Trust fund has managed to outperform the S&P 500 for each of the past 12 years. * No other fund has ever outperformed the market for a dozen consecutive years in the last 40 years. What are the odds of that?

Some pundits are perfectly satisfied to chalk up Miller's record to chance. For example, Gregory Baer and Gary Gensler write: "While we are happy for Legg Mason and its manager, Bill Miller, we view that outcome as roughly in line with random chance and as an indictment of active management." [11] More incredible is the comment (quoted at top) by well-regarded bond manager Bill Gross, who "snarled" that Miller's performance is equivalent to rolling 12 sevens in a row with a pair of dice. We can only hope that Gross, who has a great track record and familiarity with gambling, was misquoted: The odds of rolling 12 sevens in a row are approximately 1-in-2.2 billion.

We can look at Miller's streak two ways. The first assumes that a constant percentage of funds outperform the market each year. We can then select a percentage and calculate the probability of one fund outperforming each and every year. (See Exhibit 1.) For example, if you assume that mutual fund performance is essentially a coin toss—half of all funds beat the market and half underperform—the odds of one fund beating the market for 12 consecutive years is 1-in-4,096. Given that there were only 900 comparable mutual funds at the beginning of Miller's streak, his performance looks impressive.

*An analyst involved in the preparation of this report has a financial interest in shares of the Legg Mason Value Trust fund.

Exhibit 1: Probability That One Fund Will Outperform Each Year

		Percent of funds that outperform the market			
# of years		30%	40%	50%	60%
1	1 in	3	3	2	2
2	1 in	11	6	4	3
3	1 in	37	16	8	5
4	1 in	123	39	16	8
5	1 in	412	98	32	13
6	1 in	1,372	244	64	21
7	1 in	4,572	610	128	36
8	1 in	15,242	1,526	256	60
9	1 in	50,805	3,815	512	99
10	1 in	169,351	9,537	1,024	165
11	1 in	564,503	23,842	2,048	276
12	1 in	1,881,676	59,605	4,096	459
13	1 in	6,272,255	149,012	8,192	766
14	1 in	20,907,516	372,529	16,384	1,276
15	1 in	69,691,719	931,323	32,768	2,127

Source: CSFB.

The problem with this analysis, though, is that outperforming the market is not a 50/50 proposition for the average mutual fund. In fact, the average percentage of outperformance over the past 12 years was 44%. (We calculate this by dividing the cumulative number of funds that outperformed by the sum of all funds per year.) If we assume a 44% ratio, the probability of one fund outperforming for a dozen years is roughly 1-in-18,000. [12]

The second way of looking at Miller's streak is to look at the actual percentages of funds that beat the market in each year. This allows us to determine the cumulative probability given what actually happened. This calculation shows that the probability of beating the market 12 years in row was about 1-in-477,000. A quick glance at the numbers shows why the odds are so low. Two years, 1995 and 1997, create the camel-through-the-needle's-eye probability, as only about 10% of all funds beat the market in each of those two years.

Exhibit 2: Percentage of Funds That Beat the S&P 500, 1991–2002

Year	Funds	Percent that beat S&P 500
1991	889	47.7 %
1992	1,018	50.9
1993	1,289	72.0
1994	1,733	24.0
1995	2,325	12.6
1996	2,894	20.7
1997	3,761	7.9
1998	4,831	26.1
1999	5,873	51.4
2000	6,966	62.2
2001	8,460	49.7
2002	9,749	58.7

Source: Lipper.

Streaks and Luck

In money management, the magnitude of market outperformance (adjusted for risk) is the true bottom line. But streaks are intriguing because they are exceptionless—no bad years are allowed. Further, as the streak lengthens, the tension and pressure mount.

Was Miller lucky along the way? Without a doubt. But as Stephen Jay Gould says, long streaks are extraordinary luck imposed on great skill. [13] Good investors have better probabilities of beating the market, hence longer streaks.

Let's be clear. This discussion is neither a prediction of Miller's future performance nor an endorsement of his fund. The central message is that across domains, long streaks typically indicate skill. And since humans have a hard time relating to all but the easiest probabilities, we often fail to see the significance of streaks.

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[1] Stephen Jay Gould, "The Streak of Streaks," *The New York Times Review of Books*, August 18, 1988. See http://www.nybooks.com/articles/4337.

[2] Jonathan R. Laing, "A Truly Amazing Run: But, with dangers ahead, can Bill Gross keep outracing the market?" *Barron's,* March 17, 2003.

[3] Thomas Gilovich, Robert Valone, and Amos Tversky, "The Hot Hand in Basketball: On the Misperception of Random Sequences," *Cognitive Psychology,* 17*,* 1985, 295-314.

[4] Amos Tversky and Daniel Kahneman, "Belief in the Law of Small Numbers," *Psychological Bulletin,* 76*,* 1971, 105-110.
For an illustration, see http://wetzel.psych.rhodes.edu/random/mainbody.html.

[5] Adapted from Gould's "The Streak of Streaks."

[6] Gould.

[7] Here's the math. DiMaggio had 7,671 plate appearances in 1,736 career games, or 4.42 plate appearances per game. He also had 2,214 career hits, for a 0.289 hit-per-plate appearance average. With a 0.289 hit per appearance average, DiMaggio would be expected to get a hit in 0.778 percent of his games. So the probability of getting a hit in 56 straight games is $(0.778)^{56}$, or 1-in-1.279 million. See http://espn.go.com/mlb/s/2002/0107/1307254.html.
For DiMaggio's career statistics, see http://mlb.mlb.com/NASApp/mlb/mlb/stats_historical/mlb_individual_stats_player.jsp?playerID=113376&HS=True.

[8] Amazingly, DiMaggio's 56-game streak wasn't his longest. As a teenager in the Pacific Coast League, DiMaggio had a 61-game streak. Of note, too, is immediately after DiMaggio's 56-game streak was broken, he went on to a 16-game hitting streak. So he got a hit in 72 of 73 games during the course of the 1941 season.

[9] Stephen Jay Gould, *Triumph and Tragedy in Mudville* (New York: W.W. Norton & Company, 2003), 151-172.

[10] Here's a sample of some references (there are too many to list exhaustively): Burton G. Malkiel, *A Random Walk Down Wall Street* (New York: W.W. Norton & Company, 2003), 191; Nassim Taleb, *Fooled By Randomness* (New York: Texere, 2001), 128-131; Gregory Baer and Gary Gensler, *The Great Mutual Fund Trap* (New York: Broadway Books, 2002), 16-17; Peter L. Bernstein, *Capital Ideas* (New York: Free Press, 1992), 141-143.

[11] Gregory Baer and Gary Gensler, *The Great Mutual Fund Trap* (New York: Broadway Books, 2002), 17. Baer and Gensler only consider the streak's first 10 years (even though the book came out after the 11th year was complete). The difference between 10- and 12-year streaks is significant.

[12] Miller also ran a second fund, Opportunity Trust, which has a different composition but beat the market for each of the past three years. The probability of beating the market 15 years consecutively (assuming a 44% fund outperformance rate) is 1-in-207,000.

[13] While the Value Trust streak is Miller's longest, it is not his only streak. In the six years ended 1993, Miller's Special Investment Trust beat the market every year.

Additional Disclosures

An analyst involved in the preparation of this report has a financial interest in shares of the Legg Mason Value Trust fund.

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