The Hot Hand

Do statistics support the existence of hot streaks in sports?

A common strategy in basketball is to pass the ball to the player who is currently on a roll, the person who has made all of his recent shots—the one with the "hot hand." According to the hot hand belief, of the five players on the court, the best player to take the next shot is the player who has successfully made most of his previous attempts. Many players, coaches, and fans insist that short streaks of success are common, and indeed, the data support their beliefs: streaks do occur rather frequently. But, the question of more importance here is this: Will a current hot streak accurately predict future success?

With the game on the line, would you rather have the person who is a 60 percent average shooter but who has missed her last four shots in a row take the shot, or the 40 percent average shooter who has made her last four in a row? There are three schools of thought on the issue, each with a different prediction about why one shooter would be preferred over the other.

The hot hand school of thought suggests that the 40 percent shooter who has made her last four in a row is "in the zone"—that mysterious (and mythical to some) mind–body place where confidence is high and performance is maximized. The answer to our little dilemma is simple from the hot hand perspective: regardless of who is the better shooter on average, give it to the person who is on a roll, the one with the hot hand.

The law of averages school of thought suggests just the opposite solution. The 60 percent shooter is normally successful on 6 out every 10 shots, whereas the 40 percent shooter normally hits only 4 out of every 10 shots. Because the 60 percent shooter has missed her last 4 shots, then the law of averages suggests that she will score on her next 6 shots (because she averages 6 out of 10, and has missed her last 4 shots, making the next 6 in a row will get her back to her average). At the very least, the law of averages suggests that she is certainly due to make a basket on her next shot. By the same reasoning, the 40 percent average shooter, having successfully made her last 4 in a row, is likely to miss her next 6 shots, or at the very least, she is due for a miss on her next shot. Therefore, the law of averages school of thought suggests giving the ball to the person who is most due to make a shot (or not give it to someone who is most due to miss), based on recent history combined with average success.

The statistical independence school of thought suggests that both of the preceding theories are wrong because of a fundamental flaw in logic. But

first, let's consider some simple facts underlying this school of thought. Take a coin that is perfectly balanced and can be tossed without bias. That is to say, the probability of it landing with either the head or tail showing is equal (a probability of 50 percent, or $p = 0.50$). Tossing that coin repeatedly results in something called sequential independence. That is, the occurrence of a head or a tail on one coin toss will have no influence whatsoever on whether a head or a tail will show on the next toss. But streaks do occur in coin tossing. If you were to make a thousand tosses of a coin, you would likely find that a large number of streaks occurred, perhaps as many as 10 heads (or tails) in a row. But these are just chance occurrence streaks that are impossible to predict in advance, and they certainly do not change the likelihood that a head or tail will appear on the next coin toss.

Failure to understand this concept of sequential independence is the root cause of the gambler's fallacy—the mistaken belief that a long streak of repeat occurrences of independent events is more likely to be followed by a different event than another repetition of the same event. For example, a long run of reds on a casino's roulette wheel often will see an increase in the number of people placing bets on black because they believe that black is overdue. But, a fair roulette wheel, like a coin, has no memory; it doesn't know or care what happened on the previous spin, and every new spin is a completely independent event. The gambler's fallacy lies in attributing a sequential dependency probability value to a chance occurrence.

But basketball shooting is not a roulette wheel. To err is human, but to succeed is human as well. If the hot hand really does exist, then the implications for motor control theory are very important, because it suggests that our central nervous system exhibits periods of perceptual–motor behavior that is streaky. So, does the hot hand really exist?

The world of basketball hot hand believers was shaken when Thomas Gilovich and his colleagues published an influential paper in 1985. Gilovich and his colleagues examined performance data from several NBA teams in the early 1980s and found no evidence to support the existence of a hot hand. Indeed, the researchers found that short streaks of success were no more likely to occur than would be expected by chance alone. Sequential dependencies, in which a previous event influenced the outcome of a subsequent event, were absent in both the jump shot and free throw basketball data that they examined. It is important to note that they did not suggest that performance success was random, or that streaks of successful shots in a row did not occur. Rather, their claim was simply that the occurrence of a streak was no more likely than what might be expected by chance, much like the coin tossing occurrence of 10 heads in a row might be unpredictable yet still quite possible.

As expected, the publication of the Gilovich paper raised a number of eyebrows. Fans and commentators who followed the NBA, as well as other researchers, raised statistical and logistical arguments about the research and scrutinized the data and interpretations. One of the most persuasive

From T.D. Lee, 2011, *Motor control in everyday actions* (Champaign, IL: Human Kinetics).

arguments is that basketball data are insensitive to many factors that occur in a game, such as who is guarding the player, the length of time since a rest, the length of time after coming back from a rest (see "Shooting Two From the Line" in chapter 11), and the distance of the shot (see "The Gimme Putt" in chapter 3), each of which could have influenced the data Gilovich analyzed.

But the story doesn't end there. Evidence has now been found of hot hand streaks in sports such as bowling and horseshoes—sports that may be less prone than basketball to confounding factors that influence the continuance of streaks. The evidence is not yet complete on this topic, so a final answer remains to be determined. But, returning to our three schools of thought on who should take the shot with the game on the line, determining who is due based on the law of averages appears to be the worst predictor of any individual future performance. Sequential performances of skilled athletes may not be completely independent, and perhaps the nature of the sport plays a determining role in the hot hand. In the end, however, a player's level of skill is ultimately the best predictor of success for any single subsequent performance. The statistical independence school of thought provides the most reliable advice of all: Give the ball to your best shooter.

Self-Directed Learning Activities

1. Explain the hot hand belief in your own words.
2. Explain the gambler's fallacy in your own words.
3. Pick a sport other than basketball and describe a situation in which a variety of predictions could be made about the next event based on the hot hand, law of averages, and statistical independence schools of thought.
4. Describe an experiment that you could perform that would test the predictions you made in question 3. Provide some basic details about how you would conduct the experiment, including information about the athletes you would try to recruit to participate.

Suggested Readings

Gilovich, T., Vallone, R., & Tversky, A. (1985). The hot hand in basketball: On the misperception of random sequences. *Cognitive Psychology, 17,* 295–314.

Oskarsson, A.T., Van Boven, L., McClelland, G.H., & Hastie R. (2009). What's next? Judging sequences of binary events. *Psychological Bulletin, 135,* 262-285.

Schilling, M.F. (2009). Does momentum exist in competitive volleyball? *Chance, 22*, 29-35.

From T.D. Lee, 2011, *Motor control in everyday actions* (Champaign, IL: Human Kinetics).