

An Epistemologist Looks at the Hot Hand in Sports

Steven D. Hales
Bloomsburg University

Recently psychologists and statisticians have mooted a surprising thesis: Despite nearly universal beliefs to the contrary, there is no such thing as streak runs of success in sports; no one has ever been on a roll or had hot hands. Here are some sample statements of the view. According to Stephen J. Gould, "Everybody knows about hot hands. The problem is that no such phenomenon exists" (4: p. 465). Thomas Gilovich, Robert Vallone, and Amos Tversky write, "Probably . . . most players, spectators, and students of the game believe in the hot hand, although our statistical analyses provide no evidence to support this belief" (3: pp. 302-303). Robert M. Adams concurs, "Even though virtually any basketball player, fan, or commentator would scoff at the notion that the 'hot hand' is only an illusion, the present data confirm that" (1). Skeptical claims that no one knows as much as they think they do are a very familiar theme in epistemology. It is noteworthy, then, that no epistemologist has heretofore investigated the criticisms of the hot hand doubters named above. Moreover, this skeptical view about hot hands has burst the seams of scholarly arcana and into the public eye.¹ Getting the matter right is thereby doubly important. In this paper, I will defend the view that there is such a thing as hot hands in sports, that they are ubiquitous, and that players and observers are often right in identifying them.

Stephen J. Gould writes, "We believe in 'hot hands' because we must impart meaning to a pattern—and we like meanings that tell stories about heroism, valor, and excellence . . . and we have no feel for the frequency and length of sequences in random data" (4: p. 468). While this may be true at some deep level, it is certainly not the reason sports participants cite on behalf of hot hands. Anyone who has ever played a sport will cite internal, phenomenological, felt experience in favor of hot hand phenomena. An interviewer once asked five-time Wimbledon champion Bjorn Borg, then at the height of his powers, what it felt like for him when he was playing at the top of his game. Borg replied that he felt that he could do anything—put the ball on a dime at any angle, anywhere on the court, at the speed he chose, with the spin he wanted. Similarly, Purvis Short, of the NBA's Golden State Warriors, has said, "You're in a world all your own. It's hard to describe. But the basket seems to be so wide. No matter what you do, you know the ball is going to go in" (9: p. 16). A seemingly natural understanding of these attitudes is expressed in saying that a player has a better chance of making a shot after having just made his last two or three shots than he does after having missed his last two or three shots. Ninety-one out of 100 basketball fans polled believe this statement; that is, they believe that success breeds success (3: p. 297).

This idea is the driving force in the first argument against hot hands, an argument endorsed by all the skeptics (1, 3, 4, 9, 10).²

Argument I: Success Does Not Breed Success

1. Someone has a hot hand only if they are performing in a way that success breeds success.³
2. Empirical study indicates that success does not breed success in sports.
3. Therefore there are no hot hand phenomena in sports.

Players on the Philadelphia 76ers believed that success breeds success, just as the fans did. When they feel hot, their confidence increases. In interviews the 76ers often said that after making a few shots in a row they “know” that they are going to make their next shot, that they “almost can’t miss.” This has a plausible *a priori* explanation: When a player realizes that he is hot, his confidence in his subsequent shots increases. He relaxes and doesn’t overplay his shots. He just gets in the groove and hits them smoothly and cleanly. Regrettably (and remarkably) the data fail to bear this out. In fact, they show a slight negative correlation between a hit and the following shot.⁴ The 76ers were just a little bit likelier to miss after hitting three in a row. The converse is true too—they are likelier to hit after a cold period of zero or one hit in the last four attempts than they are to continue missing. Moreover, this finding held true for both field goals (shot under defensive pressure) and free throws (shot without such pressure), and in studies of the New Jersey Nets and the New York Knicks (3: pp. 303-304). Knowing this, we can refit our *a priori* explanations: When a player realizes he is hot, he tends to push the envelope and attempt more difficult shots, believing that, as Borg said, he can do anything he wants. Such a strategy then leads predictably to failure. How wonderfully malleable *a priori* explanations are!

One might conclude that the empirical results show that the internal phenomenology of being hot is unreliable. As one group of researchers puts it, “The sense of being ‘hot’ does not predict hits or misses” (3: p. 310). Other critics have intimated even more strongly that since one’s own felt experience is not wholly trustworthy, it adds nothing to the statistical study of the hot hand.

This is not the best explanation of the data. A more plausible interpretation is that the 76ers are mistaken in thinking they can tell when their streaks of success will end. That is, either they erroneously believe that their prior success is causally efficacious into the future, or they reason inductively that having made several shots in a row is compelling evidence that they will make the next one. It is of course interesting that neither form of reasoning turns out to be reliable, but this does not undercut the players’ beliefs that they are hot. The problem isn’t that their internal feelings of having a hot hand are wrong, but rather that they have a misguided optimism about how long their streak will last, and where they are in it. They believe that they are towards the beginning or in the middle of a success streak. In fact, they may well be at the end of one, and their next shot will be a miss. The streak could be 3 successful shots in a row, or it could be 10. Upon sinking the 3rd basket, a player may well feel confident about hitting the 4th, believing hopefully that he is at the beginning of a 10-streak instead of at the close of a 3-streak. What the data show here is not that one’s internal sense of being hot is wrong but that there is no telling how long one will remain hot. The streak could

end at any time, and induction from past success fails. Joe DiMaggio couldn't feel a cold front coming in as he walked onto the baseball field on July 17, 1941. In fact, maybe he felt pretty optimistic about making a hit. Who wouldn't, having made a hit in each of 56 previous games?⁵ Does this positive attitude, however statistically mistaken or epistemically unjustified, show that Joe wasn't hot during his streak? Of course not.

The second skeptical argument tries a different tack: Hot hands are not undone by the failure of streaks to cause or predict future success, but by the very predictable nature of the streaks themselves.

Argument II: Streaks Are Predictable

1. Someone has a hot hand only if their streak of success is statistically unlikely.
2. Empirical study has shown that there are no statistically unlikely streaks of success in sports.
3. Therefore, there are no hot hand phenomena in sports.

Supporters of this argument include Gould (4) and Gilovich, Vallone, and Tversky (3). There has been much fervor over whether the second premise of this argument is true. Gould endorses it except for "one major exception, one sequence so many standard deviations above the expected distribution that it should never have occurred at all: Joe DiMaggio's 56-game hitting streak in 1941" (4: p. 467). Debate over this "exception" has generated a small cottage industry devoted to computing the exact probability of DiMaggio's streak (e.g., 2, 7, 11). The noteworthy thing about Gould's claim concerning the DiMaggio streak is that unless one accepts the first premise in Argument II, there is no reason at all to take the streak's statistical unlikelihood as proof of hot hands. It is this premise that requires critical scrutiny.

Precisely how unlikely does a streak of success need to be before we are prepared to count it as a legitimate instance of hot hands? Gould sets the bar extremely high, admitting only what he calls "the most extraordinary thing ever to happen in American sports" (4: p. 467). But why should we follow suit? It is not as if DiMaggio's streak was somehow so momentous that its description is beyond the reach of probability. Every run of success will be more or less probable given the average skill of the player involved. Let us suppose that DiMaggio's streak was very improbable—one recent estimate is that there was only a 1/3700 chance of its occurring (11). So not only did DiMaggio have hot hands, they were white hot. Yet is there no room for red hot hands, or even mildly warm ones? Suppose someone achieves a sports success with only 1/100 chance of its occurring. The only reason to think that it does not have every bit as much of a claim to being a case of hot hands as the DiMaggio streak is the acceptance of Gould's arbitrarily high standards. Every sporting event will fall somewhere on the curve, whether it is four standard deviations from the mean or only one. It is nonsense to suppose that there is something "off the chart." There is no principled way of parsing the above-average portion of the curve into "hot hand" and "not hot hand" zones.

Thus if "unlikely" in premise one is made strong enough, à la Gould, then the argument is bound to be right. Yet this smacks of thievery. If "unlikely" is weakened enough, then every positive deviation from the mean will count as a

case of hot hands—some are just hotter than others—premise two will be false, and the conclusion will not follow. We could fix our improbability standard for hot hands at some precise level by fiat, but there is no principled way of doing so. Argument II is therefore of little interest. It is sound only if we agree to a purely arbitrary account of how statistically unlikely a streak of success must be to count as an instance of hot hands.

Argument III: The Frequency of Streaks Is Predictable

1. Someone has a hot hand only if the number of successes in a row exceeds that predicted by chance.
2. Empirical study has shown that there are no success streaks whose frequency exceeds the number predicted by chance.
3. Therefore, there are no hot hand phenomena in sports.

Defenders of this argument maintain that a run of success “can be properly called streak shooting only if their length or frequency exceeds what is expected on the basis of chance alone” (3: p. 296). Each sequence of hits (successful field goals in basketball, for example) or misses (unsuccessful ones) is counted as a “run.” In any random process, there will be such runs. For example, suppose I flip a fair coin a dozen times. Despite the fact that the probability of tossing heads is .5, if I were to get exactly HTHTHTHTHTHT, this would be quite surprising, as the probability of this sequence is only .00024, whereas the probability that it is some other sequence is .99975. If I do the flipping and get a sequence other than strict heads/tails alternation, this should be completely expected, because it is so enormously likely that I get such a result. Suppose I do the flipping and get, say, HHHHTHTHTTHT. While this specific result is not so likely, it is very probable, as we have seen that a result like this one is obtained. Such sequences are noticeably “clumpy,” containing bursts of heads and runs of tails. In addition, the example just given shows more heads than tails. In the long run, the number of heads and tails will approach equivalence but not in short stretches like this.

In defense of the second premise of Argument III, Gilovich and his colleagues studied field goals made by the Philadelphia 76ers during 48 home games in the 1980–1981 season, and also conducted a controlled study of 26 Cornell University basketball players. In examining these data sets, the question posed was whether any player had more success runs than one would expect from flipping a coin. The answer was no.⁶

Suppose the chance of making each basket is .5 (obviously this value has to be computed on a player-by-player basis). If a player shoots 16 rounds of four shots per round, on average only one of these rounds will be a run of four hits ($.5^4 = 1/16$). The same is true of coin tossing; on average four heads will come up once every 16 rounds of four flips. This does not mean that making baskets is nothing but chance. To borrow an example from Gould, Michael Jordan will get more runs of four in a row than Joe Airball because his average success rate is higher, and Jordan’s average success rate is higher because of his superior skill, effort, talent, and the usual sporting virtues. Suppose Jordan shoots field goals with a .6 probability of success. About one out of eight sets of four shots will be four hits in a row ($.6^4$). If Joe, on the other hand, is only half as good from the field as Jordan, making .3 of his field goal attempts, he will get four straight roughly only once

every 125 attempts (.3⁴). Nothing besides probability is needed to explain the pattern of runs. Therefore, Argument III concludes that there is no such thing as a hot hand.

While these are interesting empirical findings, Argument III is unsound. The problem is neither the way the study was conducted, nor the way the numbers are calculated. As in the second argument, the error is in the first premise, which is problematic in several ways. First, *prima facie*, this is a strange requirement for a hot hand. One might instead conclude that an unusual number of success streaks shows *streakiness*—a player who runs hot and cold. Gilovich and his colleagues also conclude that contrary to popular perception, players are never streaky, but this is a different matter from having hot hands. The other, more vital problem with the first premise is that it incorporates the same arbitrariness that we saw in Argument II. To what extent should the number of streaks deviate from statistical expectations in order for it to count as hot hands? There seems to be no non-arbitrary place to draw the line. Do we draw it at statistical significance? At three standard deviations from the expected distribution? As with the “statistically unlikely” criterion of Argument II, any number of streaks can receive a statistical modeling: Some patterns of success runs are just considered less probable than others. The common thread in Arguments II and III is that essential to the hot hand is success beyond what is to be expected from a chance process. This is the root error.

Arguments II and III are on the right path in one sense: They correctly link having a hot hand with the nature of streaks. My contention is that a hot hand just *is* a streak or run of success, with no arbitrary restrictions on how rare or improbable it must be. If Michael Jordan hits 10 free throws in a row, he *does* have a hot hand, even if statistically this is a reasonably likely occurrence given his skill as a player and the large number of free throws he shoots. Even if after hitting those 10 free throws in a row Jordan misses the 11th, and empirical study tells us that his success with the first 10 made it no likelier that he would make the 11th, this is no reason to think that he didn't have a hot hand. Gilovich and his colleagues write, “Evidently, people tend to perceive chance shooting as streak shooting” (3: p. 311). This is entirely right. There are then two possible conclusions to draw: (a) The skeptics are mistaken in distinguishing between chance and streak shooting, and (b) everyone else is wrong in thinking that there is such a thing as streak shooting. The skeptics, naturally, opt for the second. But I argue that there are good reasons for choosing the first conclusion, not the least of which is that such a view preserves and explains the widespread belief that players have hot hands.

The hot hand critics have to assume an error theory. They maintain that people are just uniformly mistaken in believing that they ever have a hot hand and always wrong in believing that others do. The skeptical view is not just that success makes people too optimistic about future success, or that the internal sense of being hot is sometimes wrong. Rather, the skeptics maintain that it is always wrong. This is a bitter pill to swallow. Sure, sometimes people are universally wrong about things that seem compelling; the history of science is replete with instances. The sun's motion in the sky and the evidence of design in the universe are familiar examples. Nevertheless the preservation of widespread antecedent belief is one desideratum in theory choice (6: pp. 66-67). Conservatism is not a *sine qua non*, but we should jettison widely held, intuitively plausible beliefs only if this is mandated by a clearly

superior theory to the one in which our beliefs are embedded. The hot hand skeptics have not met this condition.

To take another example, suppose I flip a fair coin a dozen times and get three tails in a row. This is better than average, since the mean is .5. There is a clear sense in which it was luck that I tossed three tails in a row (good luck if that's what I wanted, bad luck if not). I had a "hot hand" for tossing tails and can detect my hot hand through observation. Of course this does not imply that the fourth toss was likelier to be heads or that probability cannot explain why I got three tails in a row. The fact that success in sports has been shown to be assimilable to a coin-tossing model gives an interesting conceptual result: Certain potential analyses of hot hand are shown to be empirically inadequate. This does not show that all analyses of hot hand are empirically inadequate. Indeed, Gould's recognition that being hot has to do with the nature of streaks, and the admission of Gilovich and colleagues that ordinary people do not discriminate between chance and streak success runs are important indicators of the correct analysis.

One possible objection here is that a distinction should be drawn between above-average success runs due in some identifiable sense to the player's skill and effort, and those runs due to fortuitous deviant causal mechanisms. Only the former, goes the objection, are genuine examples of hot hands. Tossing five consecutive tails in a row with a fair coin is not an act of skill. Neither is birdieing several holes in a row at golf through a series of bizarre shots and circumstances. Are these legitimate examples of hot hands? I feel the pull in both directions. My inclination is to say that hot hands are simply above-average success runs, however they are accomplished. I think this accords best with our everyday expressions of running hot or being on a roll. Yet even if one insists on adding a clause requiring this success to be the result of some appropriate causal mechanism, my central point remains untouched. The core element of having hot hands is deviation above mean performance—not success breeds success, extreme statistical unlikeliness, or somehow outpacing chance, as the skeptics contend.

What of the phenomenology of hot hands? Does my analysis of hot hands give short shrift to the importance of the basket seeming wider or the sense of things slowing down? I do not think so. Unlike the skeptics, I take seriously the phenomenology of hot hands and the observation of hot hands. When people believe they have a hot hand, they may well be usually right. When they are right, their internal sensation of being hot represents the world: They are shooting above their norm, serving better than average, punting deeper than usual, deviating above the mean. This may all be within the bounds of normal statistical variance, but that only serves to explain the phenomenon. I am arguing that the nature of hot hands involves above-average success, whereas at best the phenomenology of feeling hot constitutes evidence for having hot hands. Whether the sense of being hot is an all-or-nothing quality, whether it comes in degrees, and how well it correlates to actual success in performance are matters for further study. We should not assume a priori either that the internal phenomenology of hot hands is an infallible indicator of actually being hot, or that every episode of hot hands is accompanied by an internal recognition of it. The empirical studies are right in taking hot hands to be an empirical, quantifiable matter.

There are also valuable practical lessons to be learned from the studies. For example, coaches who give instructions that a hot player be given the ball more or see more court time may be making a costly error. Statistically the hot streak could

end at any moment. Thus the strategy of “give it to the hot player” is no better than that of a Vegas gambler who, having won her last three blackjack hands, bets the house on the fourth. However, the lesson the authors of these studies draw—that there are no hot hands—is wrong. Gamblers often speak of streaks of luck or running hot or being on a roll. Does this imply that they think some force other than chance (skill, or perhaps divine intervention)⁷ is at work? Some may, although surely professional gamblers would not think of such a streak as anything other than a chance distribution of success. This hardly prevents them from reasonably commenting on a night’s success as being a run of luck or referring to themselves as having been hot. In other words, they knowingly assimilate streak shooting (of dice, say) to chance shooting. The two may be coextensive, but the former is not eliminable in favor of the latter. Rather, the latter is an explanation of, or an analysis of, what is understood by “streak.”

Nietzsche wrote, “Because something has become transparent to us, we think it will no longer offer us any resistance—and are then amazed when we discover we can see through it but cannot go through it! It is the same folly and amazement as overcomes the fly in the face of a pane of glass” (5: p. 444). The skeptics have done much to make hot hand phenomena transparent, but the glass is still there. They argue that empirically there is no more to hot hands than a predictable distribution of success runs that receives an easy statistical modeling; hence, hot hands are a “statistical illusion.” This professed view is similar to arguing that temperature is nothing but the frenetic motion of molecules,⁸ and therefore, there is no such thing as heat, nor can humans tell when something is cold by touch alone. The explanation of a phenomenon alone does not eradicate it, as we should have well learned from recent philosophy of mind and cognitive science.

In sum, there are three prominent arguments that conclude there are no hot hands in sports. The first argument of the hot hands critics creates a tradition in the very act of destroying it. By making “success breeds success” a necessary condition of having hot hands, the critics have established a previously undefended and barely articulated account of hot hands, only to demolish it. Instead I have argued that there are good reasons to reject “success breeds success” as a requirement for having hot hands. While it is true that many players believe that future success is more likely when they are already hot, either this is only a belief that their current “hot” state has causal efficacy into the future, or it is inductive reasoning that their current high rate of success is evidence of future success. Yet neither disjunct makes “success breeds success” part of the concept of having hot hands.

The second two arguments offered by the hot hand critics are of a well-known skeptical pattern: Set the standards for knowledge of X extremely high, then show that no one meets those standards. The canonical reply to this strategy, of which I availed myself, is to reject those standards in favor of more modest ones that charitably preserve our claims of knowledge. The skeptical insistence upon exceedingly rare streaks or statistically remote numbers of streaks as being the only legitimate instances of hot hands is arbitrary and severe. I have argued that “being hot” denotes a continuum, one that is nothing other than deviation from the mean itself. And this obviously comes in degrees.

So what is proven by the hot hand studies? Some conclusions correctly drawn by the skeptics include (a) having a hot hand does not increase the chance of success for one’s upcoming shot; (b) players who believe that their recent run of successful shots increases the chance of making their next shot are unjustified in

this belief; (c) players perceived as streaky do not have more success runs than is statistically expected; and (d) having a hot hand is not the result of a causal mechanism beyond the laws of probability. Unfortunately, the skeptics erroneously infer that the previous results mean that there are no hot hands and that everyone is wrong in thinking otherwise. Instead, I have argued that being hot does not have to do with the fecundity, duration, or even frequency of streaks. It has to do with their existence. The conclusions to be drawn are (a) one has a hot hand when one is playing better than average; (b) players often know when they are playing better than average; and (c) observers can often tell when players are playing better than average. This judgment of countless fans, coaches, and players is vindicated.

Bibliography

1. Adams, R.M. "The 'Hot Hand' Revisited: Successful Basketball Shooting as a Function of Intershot Interval." *Perceptual and Motor Skills*. 74:934, 1992.
2. Berry, S. "The Summer of '41: A Probabilistic Analysis of DiMaggio's 'Streak' and Williams's Average of .406." *Chance*. 4(4):8-11, 1991.
3. Gilovich, T., Vallone, R., and Tversky, A. "The Hot Hand in Basketball: On the Misperception of Random Sequences." *Cognitive Psychology*. 17:295-314, 1985.
4. Gould, S.J. *Bully for Brontosaurus*. New York: W.W. Norton, 1991.
5. Nietzsche, F. *Daybreak*. (R.J. Hollingdale, Trans.). Cambridge, UK: Cambridge University Press, 1881.
6. Quine, W.V.O., and Ullian, J.S. *The Web of Belief*. New York: Random House, 1970.
7. Short, T., and Wasserman, L. "Should We Be Surprised by the Streak of Streaks?" *Chance*. 2(2):13, 1991.
8. Staff, Science Desk. "'Hot Hands' Phenomenon: A Myth?" *The New York Times*. April 19, 1988: C1.
9. Tversky, A., and Gilovich, T. "The Cold Facts About the 'Hot Hand' in Basketball." *Chance*. 2(1):16-21, 1989.
10. Wardrop, R.L. "Simpson's Paradox and the Hot Hand in Basketball." *The American Statistician*. 49(1):24-28, 1995.
11. Warrack, G. "The Great Streak." *Chance*. 8(3):41-43, 60, 1995.

Notes

¹It made the front page of the *New York Times's* science section (8), for example.

²It should be noted that Waldrop accepts the analysis of hot hand as success breeds success, but he gives a somewhat different explanation of what accounts for fans' belief in the "statistical illusion" of hot hands. This difference is not relevant here.

³The authors on this topic do not make the logical status of this premise clear. In particular it is hard to tell whether statistical unlikelihood is supposed to be both necessary and sufficient for having a hot hand or just a necessary condition. In this and subsequent proposals, I assume, weakly, that the proposal is offered as a necessary condition.

⁴Following several authors on this topic, I am using "hit" as a generic term for successful performance.

⁵Don't think that DiMaggio's failure to get a hit in the 57th game was to be expected because his long streak of luck increased the probability that he would soon miss. This is the Reverse Gambler's Fallacy.

⁶To be fair, in a later article, Tversky and Gilovich back off a bit and say that their

data only shows that there is no hot hand in basketball and that they are not generalizing to all sports (9: p. 21). This modesty is not shared by all the hot hand skeptics and is not relevant to the arguments I will make against the skeptical view. So, for simplicity, I am slightly overstating their latest view.

⁷Perhaps we shouldn't underestimate the popularity of providential appeals to explain what is obviously chance. Recently the local paper recounted a highway accident in which a truck driver was killed. The police blocked off the area, preventing traffic until the accident site was cleaned up. During the cleanup, a small plane in distress crash-landed on the strip of cleared-off highway. The pilot of the plane was quoted as saying that God had saved them by providing a place to land when they needed it. The pilot apparently found it unremarkable that God would regard assassinating a hapless truck driver to be the most expedient way of saving the plane's passengers. I sometimes wonder what the truck driver's family thought about the divine will.

⁸A view, by the way, that must be in error—at least if we take seriously physicists' claims that the very early universe was quite hot, and it was only after it cooled a bit that molecules could form.

Acknowledgments

Thanks to Richard Brook, Steven Rieber, and the three referees of the *Journal of the Philosophy of Sport* for their criticisms of an earlier version of this paper.