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Testing Claims in Sports

Is Steph Curry a Streaky Shooter?

In 2015, Steph Curry won his first National Basketball Association (NBA) Most Valuable Player award and helped the Golden State Warriors win the championship over LeBron James and the Cleveland Cavaliers. Curry is most famous for his ability to shoot, often boasting **streaks** of several made shots in a row. Does being a good shooter mean he is a **streaky** shooter as well? Or are the outcomes of his shots **independent,** meaning that his ability to make a shot isn't affected by the outcome of his previous shot?

In each chapter of this book, we will open with an interesting sports question and then attempt to answer it with an investigative process that involves four components: formulating questions, collecting data, analyzing the data, and interpreting the results.

We have already formulated a question: Is Steph Curry a streaky shooter? To begin to answer this question, we need to collect some data. Here are the outcomes—in order—of each of Curry's 23 shots in a recent game, where Y represents a made shot and N represents a missed shot:[1]

Y Y Y N Y Y Y N N Y N N N N Y N Y Y N N Y Y Y

key terms

A **streak** is a set of one or more consecutive outcomes that are all the same. In the sequence WWWL, there are two streaks: a streak of three Wins and a streak of one Loss.

An athlete is **streaky** if he or she tends to have streaks longer than expected by random chance alone. An athlete with a longer-than-expected streak of successes is said to have the *hot hand*.

The outcomes of an athlete's attempts are **independent** if his or her ability to be successful is the same following a successful attempt and following an unsuccessful attempt.

Is there evidence that Curry was a streaky shooter in this game? Here are the outcomes of the same 23 shots, but grouped by streaks of Y or streaks of N:

YYY N YYY NN Y NNNN Y N YY NN YYY

Most of Curry's shots occur as part of a streak of Ys or a streak of Ns, suggesting that he might be a streaky shooter. It's also possible that the outcomes of Curry's shots are independent and that the streaks of Ys and Ns occurred by random chance alone.

To decide which of these explanations is more plausible (believable), we can simulate Curry's performance in this game to determine the lengths of streaks that are likely to happen by random chance alone. To do this, we need to learn how to model athletic performance.

Section 1: Modeling Athletic Performance

In mathematics, a model uses equations and graphs to represent a real-life situation. In this book, we will use the following model when analyzing an athlete's or team's performance:

PERFORMANCE* = *ABILITY* + *RANDOM CHANCE

Understanding the role of *RANDOM CHANCE* and the difference between *ABILITY* and *PERFORMANCE* is central to any sophisticated analysis of sports data. Throughout the rest of this book, these terms will appear in capitals and italics to remind you of their importance.

key terms

An athlete/team's ***ABILITY*** is a true but unknown value that describes what the athlete/team would do if given an infinite number of opportunities in a specific context.

An athlete/team's ***PERFORMANCE*** is what the athlete/team actually did in a limited number of opportunities in a specific context. We use an athlete/team's *PERFORMANCE* to estimate their *ABILITY*.

RANDOM CHANCE describes the variation between an athlete/team's *PERFORMANCE* and their *ABILITY*.

UNDERSTANDING THE MODEL: FLIPPING COINS

Most colleges have football, basketball, and soccer teams, but few (if any) colleges have coin-flipping teams. For a moment, however, let's pretend that coin flipping is the newest rage in sports and that being a member of the coin-flipping team is a prestigious honor.

During tryouts, the coach carefully evaluates each student to see if he or she has what it takes to be on the team. To estimate the *ABILITY* of each student, the coach instructs each of them to flip a coin 10 times and try to get as many heads as possible. The first student impresses the coach with 7 heads in 10 flips and is promptly rewarded with a spot on the team. The next student, however, manages only 2 heads in 10 flips and is cut on the spot.

In this example, the *PERFORMANCES* of the two students were very different. But was it fair to give one student a spot on the team and cut the other? Did the first student really have a greater *ABILITY* to flip heads? That is, if the coach let each of them flip the coin millions of times, would the first student really be better at getting heads? Or was the difference in their *PERFORMANCES* simply due to *RANDOM CHANCE?*

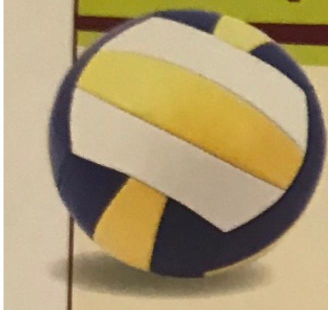
In this case, it seems more reasonable to think that both students had the same *ABILITY* to flip heads and that the difference in *PERFORMANCE* was due to *RANDOM CHANCE* alone. If they were to continue flipping coins, the *PERFORMANCE* of the first student is likely to decrease to about 50% and the *PERFORMANCE* of the second student is likely to increase to about 50%.

UNDERSTANDING THE MODEL IN A SPORTS CONTEXT

Suppose a basketball player's *ABILITY* to make a free-throw is 50%. That is, if she were able to take millions and millions of free-throws without getting tired or improving during the process, she would make about 50% of them. During a game, she is fouled while attempting to shoot and is awarded two free-throws. Do we know she will make exactly 1 of the 2 shots? No! If she missed both shots, does this imply that her *ABILITY* to make a free-throw is 0%? Of course not! This situation illustrates a fact that every athlete has experienced at one time or another: *PERFORMANCE* is not the same as *ABILITY.*

Because we are often interested in predicting future *PERFORMANCES,* we are usually interested in an athlete's *ABILITY,* rather than his or her past *PERFORMANCES.* Unfortunately, we can never actually know an athlete's *ABILITY* because we cannot observe an infinite number of attempts in a specific context. However, we can use an athlete's *PERFORMANCES* to estimate his or her *ABILITY.* And while our estimate of an athlete's *ABILITY* won't be exactly correct, it should be reasonably close to the truth if our estimate is based on a large number of *PERFORMANCES.*

example PERFORMANCE or ABILITY?



Andrii Gorulko/Alamy

Michael Spomer/AP Images

In the 2016 Summer Olympics, U.S. volleyball player Kim Hill served the ball 18 times in the bronze-medal match.[2] Of these serves, 22% (4/18) were **aces**.

PROBLEM: In this context, explain the difference between *PERFORMANCE* and *ABILITY*.

SOLUTION: Kim Hill's *ABILITY* is her ace percentage if she could attempt millions of serves in this context. Her *PERFORMANCE* in this match (22% aces) is an estimate of her *ABILITY*.

sports term

In volleyball, tennis, and other sports where a player serves the ball, a serve is called an **ace** if the other team/player does not successfully return the ball to the other side.

When describing Kim Hill's *ABILITY* in the preceding example, the phrase "millions of serves in this context" means everything that could affect her *PERFORMANCE* remains the same: same opponent, same ball, same court, same environmental conditions, and so on. It also means that the millions of attempts don't wear her out or cause her to improve due to the massive amount of practice.

Section 1 Exercises

The solutions to all exercises numbered in red may be found in the Solutions Appendix, starting on page 638. The page reference icon (like the one next to Exercise 5) points back to a parallel example.

1. You and your friends are playing tennis. In this context, explain what it means if you claim that the outcomes of your serves are independent.
2. You and your friends are playing darts and always aim for the bulls-eye. In this context, what does it mean for the outcomes of throws to be independent?
3. During a basketball game, a broadcaster claims that a particular shooter has the hot hand. Explain what this means in the context of basketball.

4. You and your friends are at the bowling alley and one of your friends claims he has the hot hand. Explain what this means in the context of bowling.

PG 6 5. In a recent game, NBA basketball player Russell Westbrook took 21 shots and made 11 of them.[3] In this context, explain the difference between *PERFORMANCE* and *ABILITY.*

6. In the 2016 National Championship game, Clemson quarterback Deshaun Watson attempted 56 passes and completed 36 of them. In this context, explain the difference between *PERFORMANCE* and *ABILITY.*

7. In the 2016 NBA season, Steph Curry had the highest free-throw percentage among regular players, while Andre Drummond had the lowest. If each of them made 9 out of 10 free-throws in a particular game, which one of these *PERFORMANCES* would likely be featured on SportsCenter? Explain your reasoning.[4]

8. In the 2016 Major League Baseball (MLB) season, DJ LeMahieu had the highest batting average among regular players, while Danny Espinosa had the lowest. If each of them had a 5-for-5 game (5 hits in 5 at-bats), which one of these *PERFORMANCES* would likely be featured on SportsCenter? Explain your reasoning.

9. Describe a situation from your own life (or from the career of another athlete) where your *PERFORMANCE* exceeded your *ABILITY.* Make sure to clearly contrast the concepts of *PERFORMANCE* and *ABILITY* in your description.

10. Describe a situation from your own life (or from the career of another athlete) where your *PERFORMANCE* fell short of your *ABILITY*. Make sure to clearly contrast the concepts of *PERFORMANCE* and *ABILITY* in your description.

Section 2: Simulating Athletic Performance

At the beginning of the chapter, we asked if Steph Curry was a streaky shooter in a recent game where he made 13 of his 23 shots. To determine if there is convincing evidence that Curry was a streaky shooter, we need a way to measure streakiness. Because a streaky shooter has streaks that are longer than expected, a streaky shooter should have a relatively small number of streaks. Thus, we will use the total number of streaks as our measure of streakiness, where *a small number of streaks indicates that a player is streaky.*

For example, imagine if Curry had only 2 long streaks during the game:

YYYYYYYYYYYYY NNNNNNNNNN

A sequence of 23 shot outcomes with only 2 streaks is good evidence of streakiness!

On the other hand, if he alternated his 13 made and 10 missed shots, he could have as many as 21 streaks:

Y N Y N Y N Y N Y N Y N Y N Y N Y N Y N YY N YY

Answers to Odd-Numbered Exercises

Chapter 1

Section 1

1. The player's *ABILITY* to make a successful serve is the same following a successful serve and following an unsuccessful serve.

3. The shooter has a longer-than-expected streak of making a shot.

5. Westbrook made 11 out of 21 shots for a *PERFORMANCE* of 11/21 ≈ 52.4%. Westbrook's *PERFORMANCE* is an estimate of his *ABILITY*, which is what his shooting percentage would be if he could attempt millions of shots in this context.

7. Both players had the same *PERFORMANCE* of 90%. Andre Drummond would most likely be featured on SportsCenter because the difference between Drummond's *PERFORMANCE* and *ABILITY* is greater than the difference between Curry's *PERFORMANCE* and *ABILITY*.

9. Answers will vary.

Section 2

11. (a) The Orioles' *ABILITY* to win a game is the same following a win or a loss.
    (b) The Orioles tended to have longer streaks than expected by *RANDOM CHANCE* alone.
    (c) The Orioles had 67 streaks during the 1998 season.
    (d) Create a spinner with a 48.8% region to represent a win and a 51.2% region to represent a loss. Spin the spinner 162 times to represent the 162 games. Record the outcome of each game, then count the number of streaks. Repeat this process many times.
    (e) When the outcomes of 162 games are independent for the 1998 Baltimore Orioles, the simulated number of streaks varies from 67 to 96.
    (f) Because it is unlikely for a non-streaky team to get 67 or fewer streaks by *RANDOM CHANCE* alone (probability ≈ 1/100 = 0.01), there is convincing evidence that the 1998 Baltimore Orioles were a streaky team.

13. (a) James's *ABILITY* to make a shot is the same following a made shot or a missed shot.
    (b) James tended to have larger streaks than expected by random chance alone.
    (c) James had 9 streaks during Game 1 of the 2017 NBA finals.
    (d) Simulation numbers will vary. In our set of 100 simulated games, James had 9 or fewer streaks in 41 of the 100 games by *RANDOM CHANCE* alone.
    (e) Because it is likely for a non-streaky shooter to get 9 streaks or fewer by *RANDOM CHANCE* alone (probability ≈ 41/100 = 0.41), there is not convincing evidence that LeBron James was a streaky shooter in Game 1 of the 2017 NBA finals.

Section 3

15. The parameter is the mean volume of all the bottles of cola bottled at the factory that hour. The statistic is 16.03 ounces, the mean volume of the 10 randomly selected bottles of cola that hour.

17. (a) A student entering the assembly is equally likely to be a girl whether the student that entered immediately before is a girl or a boy.
    (b) There are 12 streaks in this set of 40 students.
    (c) Create a spinner with a 50% region to represent a girl and a 50% region to represent a boy. Spin the spinner 40 times to represent the 40 students entering the assembly. Record the gender of each student, then count the number of streaks. Repeat this process many times.
    (d) When the genders of 40 consecutive students are independent, the simulated number of streaks varies from 13 to 29.
    (e) Because it is unlikely for independent genders of 40 consecutive students to have 12 or fewer streaks by *RANDOM CHANCE* alone (probability ≈ 0/100 = 0), there is convincing evidence that students at this school tend to