LS88: Sports Analytics

The Hot Hand

The Hot Hand

What is the hot hand?

The basic idea is that a player can get “hot” and have a higher likelihood of hitting shots

A player like Klay is commonly said to be a streaky shooter

And therefore he gets hot. And apparently when he’s hot he’s better than anyone ever

A good example is the NBA Jam On Fire mode

The Hot Hand

There's been a lot of work on the Hot Hand

One of the most famous is from Amos Tversky and collaborators (GVT)

GVT popularized the idea that the Hot Hand is a cognitive error

- ➔ Kahneman and Tversky did extensive work on cognitive bias/error/fallacies
- ➔ Humans (even well trained statistical types) don't intuitively "understand" randomness
- ➔ Ex: we underestimate how much "clumping" there is in random data

The Hot Hand

Miller & Sanjurjo
➔ Showed an error in the GVT analysis
➔ They've been a big proponent of the hot hand existing

Other recent work suggests there is a hot hand
➔ Using play-by-play or player tracking datasets, detected recent performance has predictive power on the next at-bat or shot taken

The Hot Hand

An analysis from Harvard shows player's believe in the hot hand

➔ There is a heat check shot: their shot difficulty goes up if they think they're hot

Also: after accounting for shot difficulty and defender distance, recent performance increases the likelihood of making the next shot

If you make 1 extra shot in your last 4 shots. How much do we expect your shooting percentage to increase on the next shot?

The Hot Hand

1 made shot in the last 4 attempts

Increase in shooting percentage of about 1.2 pct points

A baseball study shows an increase of about 30 points in batting average when a player is hot (or about 3 pct points)

The Hot Hand

What's the conclusion?

Some analyses say yes, some say no.

- ➔ The effect sizes are not large
  In my opinion, they aren't capturing the popular notion of the hot hand
- ➔ There is some mathematical theory that suggests even if the effects were large, you might not be able to tell
- ➔ We'll go through an exercise that refutes the hot hand

Most likely, we'll never definitively know.

Testing the Hot Hand

How do we test the hot hand?

What do we measure, ie what is our “test statistic”?

How does one test a hypothesis in general?

- What’s the data?
- What’s the null/alternative hypothesis?
- What’s the statistic? Does the statistic make sense for what we want to measure?
- How should the statistic behave under the null hypothesis?
- How does the observed statistic from data compare to the statistic under the null hypothesis?
- Other considerations: what chance do we have of even rejecting the hypothesis?

Testing the Hot Hand

To test a hypothesis, we first have to

- ➔ Determine our data: we’re going to use shooting performances from Klay
- ➔ Determine our null/alternative hypothesis: there is no hot hand vs there is a hot hand

But there are a lot of other things to address:

- ➔ What statistic should we use to test the hypothesis? Does the test statistic make sense for what we want to measure?
- ➔ How does the test statistic behave under the null hypothesis?
- ➔ How does the observed value from data compare to the test statistic under the null hypothesis?
- ➔ Given the size of our dataset and the potential size of the hot hand effect, what chance do we have of even detecting the hot hand and thus rejecting the null hypothesis?

Testing the Hot Hand

Let’s address in a demo where it’ll make a lot more sense

Tversky Test Statistic

For a streak of length *k*, define:

$$T_{k,hit} = \text{Prob}(\text{Make } k+1 \text{ shots in a row } \textit{GIVEN} \text{ Already made } k \text{ shots in a row})$$
$$= \frac{\#\{\text{Streaks of } k+1 \text{ makes in a row}\}}{\#\{\text{Streaks of } k \text{ makes in a row}\}}$$

$$T_{k,miss} = \text{Prob}(\text{Make } (k+1)\text{-st shot } \textit{GIVEN} \text{ Already missed } k \text{ shots in a row})$$
$$= \frac{\#\{\text{Streak of } k \text{ misses followed by make}\}}{\#\{\text{Streaks of } k \text{ misses in a row}\}}$$

$$T_k = T_{k,hit} - T_{k,miss}$$

Testing the Hot Hand

Let’s address in a demo where it’ll make a lot more sense

Interpreting Klay’s 60 Point Game

The game was noteworthy for the volume of shooting and scoring

The actual efficiency numbers were not particularly extraordinary for a player of Klay's ability.

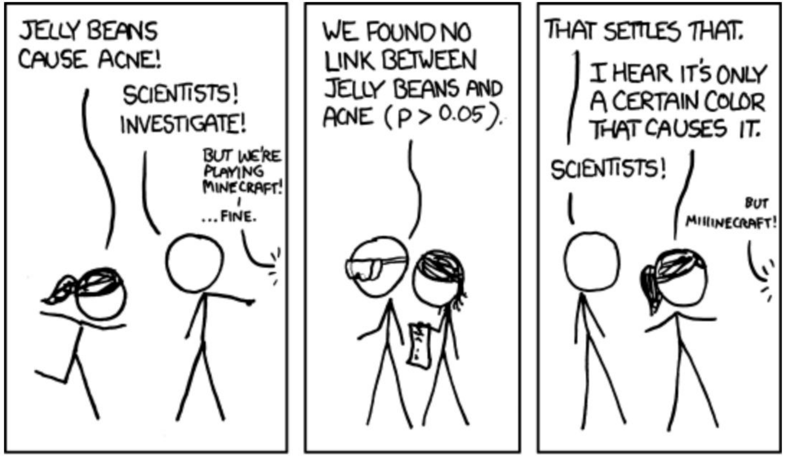
A few notes:

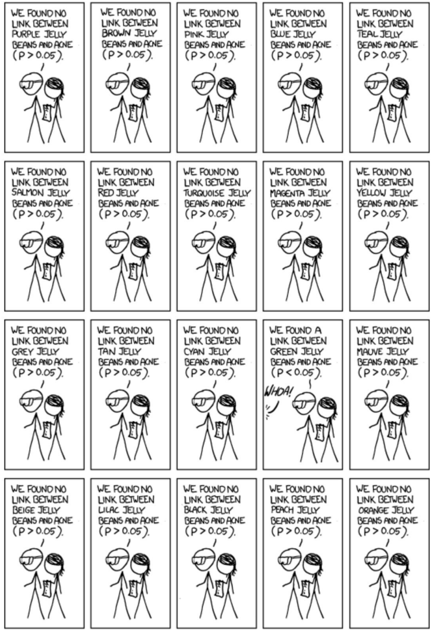
- ➔ We lumped together 2s and 3s but it doesn’t change much
- ➔ The statistics do seem on the extreme end but the story is more complicated

Interpreting Klay’s 60 Point Game

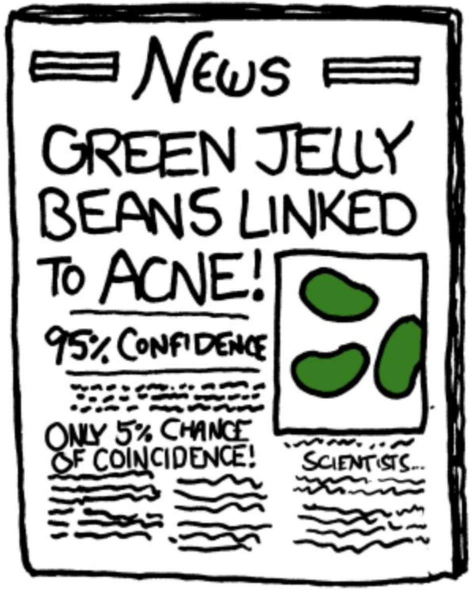
- ➔ Klay has played a lot of games,
  He’s had a lot of opportunities to put up gaudy numbers (~300 since Steve Kerr started coaching for the Warriors).
- ➔ A 1 in 100 rarity for a random no-hot-hand weighted coin flip player should happen about 3 times over 300 games.
- ➔ We've accidentally cherry-picked this game and our standard for extremeness needs to be much higher

Related Issue: Multiple Testing





Related Issue: Multiple Testing



Interpreting Klay’s 60 Point Game

Perhaps Klay’s 60 point game is our green jelly bean: over 300 games, we should expect to see extreme performances like this

How often does Klay have an extreme looking performance compared to what would be predicted by the weighted coin flip model?

Interpreting Klay's 60 Point Game

Klay shot 68.4% on 19 two-point attempts in the 60pt game

- ➔ 2014-15 to 2017-18, he had 21 games where he shot at least 15 2-pt shots
- ➔ In 1 of those (this 60 pt game) he shot at least 68.4%
- ➔ Coin flip model: we'd expect about 1 game shooting at least 68.4%

Klay shot 57.1% on 14 three-point attempts in the game

- ➔ 2014-15 to 2017-18, he had 74 games where he shot at least 10 3-pt shots
- ➔ In 15 of those, he shot at least 57.1%
- ➔ Coin flip model: we'd expect about 15 game shooting at least 57.1%

Interpreting Klay’s 60 Point Game

He took 33 shots and it's his only game with at least 29 shots.

That's fairly special but is it really that special given that the team was passing the ball to Klay and allowing him to shoot?

It’s like riding out your luck at a casino game:

- You perceive a run of luck and decide to keep playing
- While the run may last longer than usual, it wasn't anything but a product of luck

The takeaway: Klay's shooting performances for his career are just not out of line with what we expect from our coin flip model.

How hard is it to detect the hot hand?

Suppose we had a hot hand shooting player, would our methodology work?

The idea here is to simulate and test the theoretical underpinnings of our method

To do this, we'll compare a shooter who exists hot hand shooting to a weighted coin flip shooter

Hot Hand Shooters

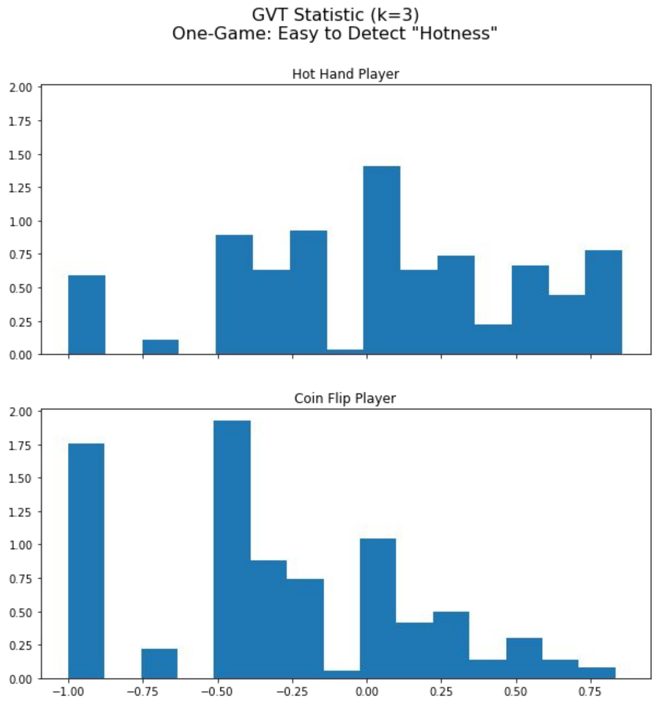
- Very hot shooter
  - In 1 game, shoots 14 shots. In a season, 8 shots per game
  - Normally shoots 39%
  - If he makes 3 in a row, he jumps to 80%
  - In the long run over many shots, he’s a 43% shooter
- Pretty hot shooter
  - In a season, 8 shots per game
  - Normally shoots 42%
  - If he makes 3 in a row, he jumps to 60%
  - In the long run over many shots, he’s a 43% shooter

Statistical Power

- ➔ We'll simulate a game or a 82 game season 1000 times
- ➔ We will look at the histogram of the statistic for the hot hand shooter and the coin flip shooter
- ➔ Statistical power is the concept of how likely we would be to detect the hot hand effect

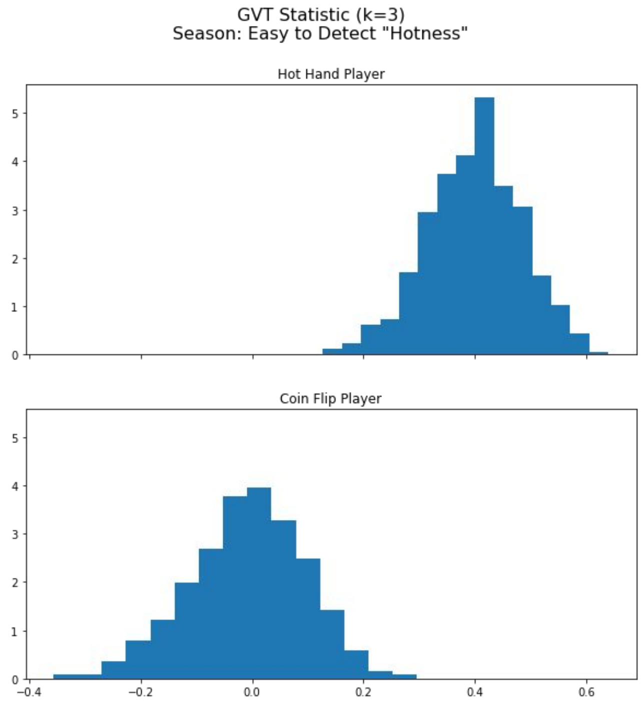
Detecting the Hot Hand in 1 Game

- The two distributions are different, but values from -1 to 1 are plausible for the two distributions
- Around 15% of the time the statistic for the hot hand shooter in this 1 game would surpass 95% quantile of the null distribution
- Statistical power of 15% of detecting this effect is *very* weak



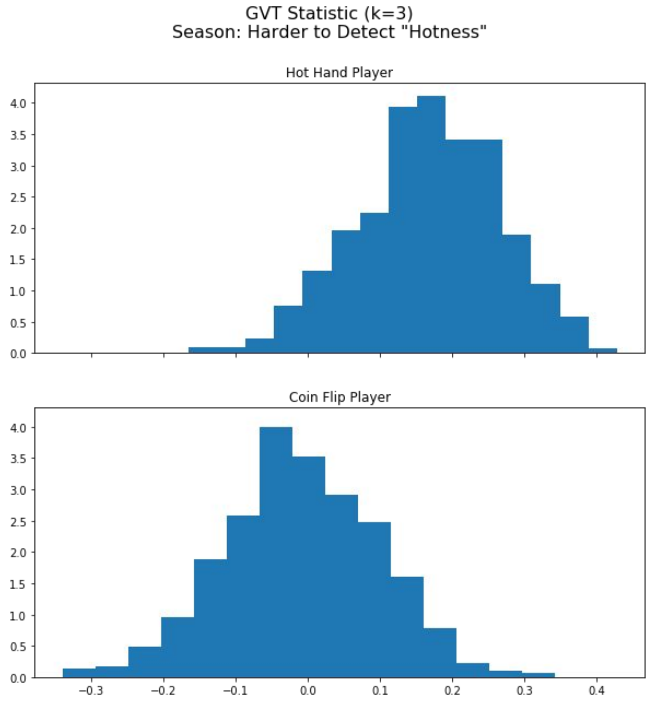
Detecting the Hot Hand in a Season

- ➔ The two distributions are dramatically different now
- ➔ 99% of the time we're going to observe a value over a season for the hot hand player that will surpass the 95% quantile of the null distribution
- ➔ The statistical power is incredibly strong here and suggests that if a shooter truly had this streaky shooting behavior, we'd detect it



Detecting the Hot Hand in a Season

- For the not-as-hot hand shooter, the two distributions are still dramatically different now
- However, only 53% of the time we're going to observe a value over a season for the hot hand player that will surpass the 95% quantile of the null distribution
- The statistical power is still strong here so we have a good chance of detecting this shooter



Summary

- ➔ There's a fair amount of research on the hot hand but the captured effects aren't particularly large
- ➔ We looked at Klay in a game and over a season
- ➔ His extreme game was special, but mostly for the amount of shots taken because his shooting percentage was about what we'd expect to see
- ➔ Over a season, Klay doesn't seem to show a hot hand
- ➔ An important question to ask is, should we have detected the hot hand? Under some types of truly hot hand models, yes, we probably would have detected the hot hand