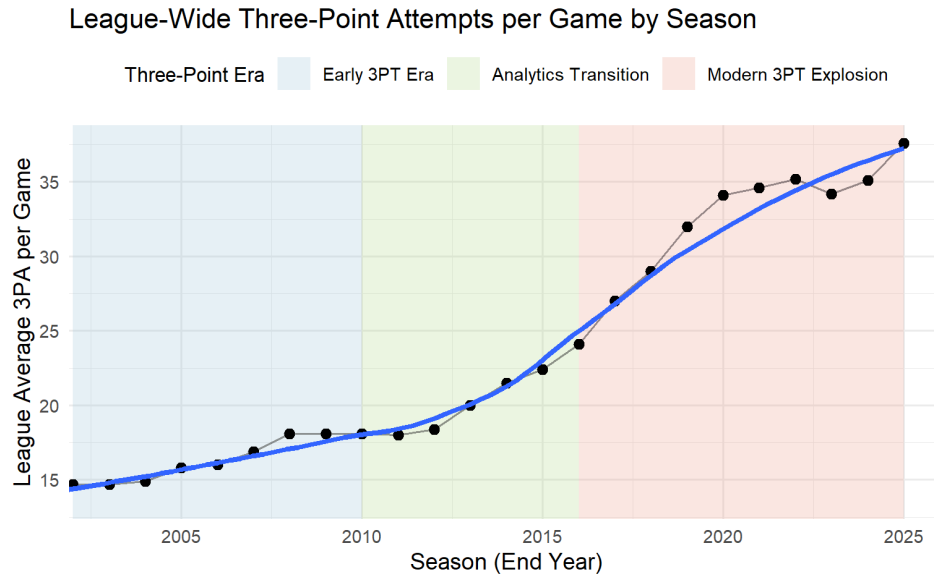# MS Thesis Extended Abstract
Cameron An

The perception of streak-based shooting in basketball has been fiercely debated among statisticians, sports scientists, and the general public for decades. Streak-based shooting refers to a phenomenon in which players temporarily reach a "hot hand" state after a certain number of successful shots. In other words, a player has a higher percentage of making a shot given that the previous shot or shots were successful. The origin of hot hand analysis dates back to the 1985 seminal paper by Gilovich *et al., The Hot Hand in Basketball: On the Misperception or Random Sequences*. Gilovich analyzed the presence and strength of the hot hand phenomenon using shot sequence data from 48 home games of 76ers players throughout the 1980-81 season. Using conditional probabilities, he found that players shot at a lower percentage compared to their overall shooting percentage when conditioning on the previous shot being a success, contrary to the hot hand belief. This discovery led to the widespread belief that streak-based shooting was a fallacy and any prolonged streaks were the result of random chance rather than a genuine "hot" state.

This conclusion was challenged in 2018 by authors Joshua B. Miller and Adam Sanjurjo, who reasoned that Gilovich's analysis of streak-based shooting was subject to a bias that systematically overestimated the probability of making a shot following a streak. Instead of relying exclusively on conditional probabilities, Miller and Sanjurjo used a permutation test that accounted for the bias in Gilovich's study. Upon correcting for this bias, the authors found that many previous hot hand analyses that dismissed the hot hand phenomenon were fundamentally flawed and their conclusions reversed once properly adjusted.

My analysis utilizes Miller and Sanjurjo's permutation test to study the presence and magnitude of the hot hand effect of 3-point shots over time in the NBA. Data was collected from the hoopR package, which gathers play-by-play data from official league sources for all NBA games dating back to the 2001-02 season. The sample was restricted to the top 30 shooters in 3-point attempts (3PA) per season from the 2001-02 to 2024-25 regular season, for a total of (30 players * 24 seasons) 720 player-seasons. A player-season is defined as a single observation corresponding to a single player's performance over one specific season, treating the same player in different seasons as separate observations. Shot sequence data for each player-season was gathered and analyzed using Miller and Sanjurjo's permutation test.

We define a shot immediately following a streak of at least three successful shots as an 'opportunity'. Opportunity shots represent a chance for the shooter to demonstrate a hot hand effect. Initial analysis in *Figure 1* displays the league-wide average number of 3-point attempts per game over time.

League-Wide Three-Point Attempts per Game by Season

While not specifically pertaining to hot hand scenarios, the increasing trend in league-wide 3-point attempts demonstrates a larger emphasis on 3-point shooting over time. Whether this is a result of streak-based shooting requires further investigation.

Many different statistics were considered to quantify the streakiness of a particular sequence. The ensuing analysis utilizes the *Difference in proportion of S (after streaks of S - other trials)* streak statistic, which computes the difference between the proportion of makes following three consecutive successes and the proportion of makes on all other shots. Results from the permutation test are presented in *Figure 2*, which displays the top 20 player-seasons that exhibited the greatest hot hand, as denoted by their p-values. The negative values in the *null_mean* column reflect the bias in Gilovich's study, showing that under the null assumption of independent shots, makes following a streak of three are systematically less likely than those on all other shots. Despite showing a hot hand tendency for more than 20 player-seasons, the number of significant hot hand player-seasons was less than the anticipated $.05 * 720 = 36$ under the assumption of random shooting. Additional testing with CDF plots and histograms of p-values reveal that the overall distribution closely resembles what would be expected under the null hypothesis, providing little evidence of a systematic hot hand effect in the observed data. Further testing is required to confirm the findings, but current results suggest do not support a hot hand tendency for top shooters in the NBA.

Figure 2:

Top 20 Player–Seasons with the Lowest Permutation-Test p-values (Streak Length = 3)

player	season	n_shots	n_successes	n_runs	phat_after_Sstreak	phat_other_trials	diff_in_proportions	null_median	null_mean	null_sd	p_value	z_score
Allan Houston	2003	387	174	183	0.610	0.431	0.179	-0.006	-0.012	0.091	0.008	2.096
Rudy Fernandez	2011	362	116	152	0.600	0.312	0.288	-0.013	-0.018	0.139	0.008	2.196
Allan Houston	2002	181	81	81	0.667	0.409	0.258	-0.011	-0.019	0.136	0.010	2.043
Dorell Wright	2011	521	194	214	0.556	0.359	0.197	-0.009	-0.015	0.099	0.010	2.150
Nate Robinson	2009	384	125	171	0.588	0.313	0.275	-0.018	-0.023	0.131	0.011	2.277
JJ Redick	2019	590	236	299	0.556	0.390	0.166	-0.005	-0.009	0.083	0.011	2.107
Kevin Love	2015	391	143	191	0.571	0.358	0.213	-0.013	-0.018	0.113	0.012	2.056
Jordan Clarkson	2019	423	134	192	0.571	0.312	0.259	-0.017	-0.024	0.128	0.012	2.206
Quentin Richardson	2009	329	120	151	0.591	0.349	0.242	-0.033	-0.028	0.127	0.013	2.133
Anthony Edwards	2022	480	170	219	0.545	0.345	0.200	-0.008	-0.018	0.110	0.014	1.992
Jamal Crawford	2007	319	100	130	0.600	0.304	0.296	-0.028	-0.033	0.155	0.015	2.121
C.J. Miles	2016	373	133	156	0.560	0.342	0.218	-0.024	-0.023	0.121	0.018	1.986
Donovan Mitchell	2021	394	153	193	0.583	0.376	0.208	-0.014	-0.016	0.108	0.019	2.074
Saddiq Bey	2021	439	169	199	0.556	0.374	0.182	-0.006	-0.012	0.102	0.019	1.891
Chris Whitney	2002	127	51	58	0.667	0.374	0.293	-0.028	-0.047	0.186	0.020	1.826
Deron Williams	2013	431	159	199	0.538	0.358	0.180	-0.022	-0.022	0.107	0.024	1.891
Tyrese Maxey	2024	402	149	201	0.556	0.362	0.194	-0.006	-0.012	0.113	0.024	1.811
Chandler Parsons	2014	344	129	161	0.565	0.361	0.204	-0.019	-0.024	0.125	0.030	1.820
Gary Trent Jr.	2022	460	178	203	0.541	0.374	0.167	-0.013	-0.015	0.102	0.030	1.776
LeBron James	2009	391	134	179	0.529	0.334	0.195	-0.010	-0.024	0.123	0.031	1.778

References

Gilovich, T., Vallone, R., & Tversky, A. (1985). The hot hand in basketball: On the misperception of random sequences. *Cognitive psychology*, *17*(3), 295-314.

Ross, K. (2017). Classroom investigations of recent research concerning the hot hand phenomenon. *Journal of Statistics Education*, *25*(3), 145-157.

Miller, J. B., & Sanjurjo, A. (2018). Surprised by the hot hand fallacy? A truth in the law of small numbers. *Econometrica*, *86*(6), 2019-2047.