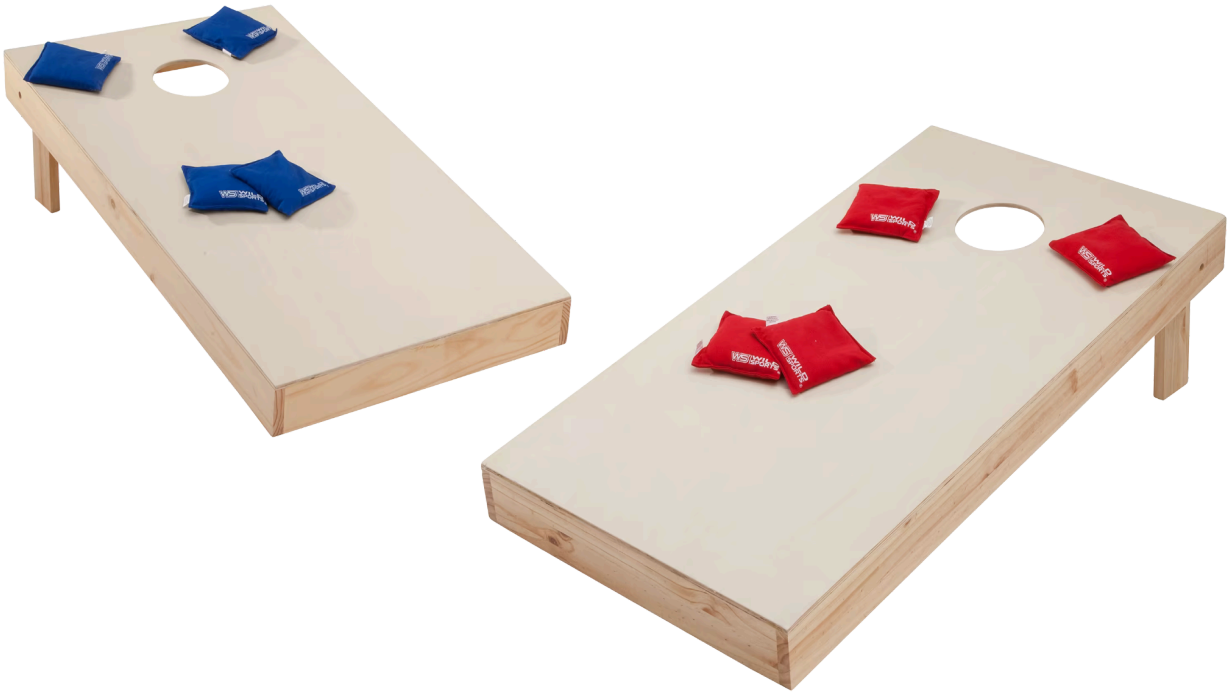
Competitive Cornhole Dynamics:

An Analysis on Competitive Cornhole and Factors that Contribute to Scoring



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Introduction

The sport of cornhole has been gaining popularity and has even been featured on sports networks like ESPN, which is where we initially found our inspiration from. The game is straightforward, involving players tossing bags filled with corn kernels or beans into a hole on a raised platform. The basic scoring is simple: a bag in the hole scores 3 points (a "cornhole"), a bag on the board scores 1 point (an "ace"), and a bag that misses the board scores 0 points (a "miss"). However, beyond these basics, the game has depth and strategy, with terms like "slider," "airmail," and "blocker" describing different types of throws.

Analyzing data in cornhole can involve tracking various statistics to improve strategy and performance. This could include things like slide-in rates, airmail rates, and blocker success rates, which are often used to track professional players' performance.

This paper reflects an initiative to quantitatively analyze the game by observing and recording specific metrics during competitive play. Our analysis is motivated by the potential to uncover statistical patterns that could inform playing strategies and elucidate factors contributing to player performance. The inspiration for this project is rooted in a growing interest in sports analytics, as evidenced by academic and recreational sources that examine the impact of strategy and skill in games similar to cornhole

Our dataset was generated from an extensive observation of 300 rounds of cornhole, with each round comprising four throws per player and two players per round. The table below presents a snapshot of the first few rounds, capturing essential data points:

GameID	Round	CurrentScore	T1_B1_L	T1_B1_E	T1_Points
ACOKnoxvilleDay1_1	1	0 - 0	7	7	0
AugustaDay1_Match1	1	0-0	13	4	4
AugustaDay1_Match1	2	0-4	11	1	2
AugustaDay1_Match1	3	0-6	14	8	1
AugustaDay1_Match1	4	7-0	14	8	5

In this table, the T in the column names represents Thrower, E represents Ended, L represents Landed, B stands for Bag.

The data was collected using the image to the right as a baseline for Landed and Ended:

The data was systematically collected by all team members who each watched and recorded the details of 50 rounds of cornhole gameplay equalling 300 observations total. Observations were made by watching games, rather than participating, to ensure objective data collection. The dataset includes variables such as Game ID (a unique identifier for each game), player name, handedness (R for right-handed, L for left-handed), board side (the side of the cornhole board from which the player threw), bag starting and ending positions (numbered 1-15 or 'Off' for off the board), and points scored in the round.

Each row in the data represents a single throw from a player, allowing for a detailed analysis of individual performance. The observation period spanned several tournaments, with data collected in real-time to

capture the dynamic nature of the game. Variables were chosen to reflect both the skill of the players (such as points scored and successful 4-baggers) and the context of each throw (such as handedness and board side), which could influence performance. The dataset provides a foundation for analyzing individual and game-wide strategies, potentially leading to a deeper understanding of competitive cornhole dynamics.

Summary

Table 1a

Statistic	Minimum	Q1	Median	Mean	Q3	Maximum	SD	Mode
Points Per Round	0	0	0	0.9586093	2	7	1.499566	0

Four_Bagger	Frequency	Relative_Frequency
Yes	135	22.35%
No	469	77.65%

Thrower_Handedness	Frequency	Relative_Frequency
Right	20	100%
Left	0	0%

In the following two tables, RF stands for Relative Frequency

Table 1b

Landing_Spot	Bag1_F	Bag1_RF	Bag2_F	Bag2_RF	Bag3_F	Bag3_RF	Bag4_F	Bag4_RF
1	2	0.33%	1	0.17%	0	0%	1	0.17%
2	0	0%	7	1.16%	7	1.16%	8	1.33%
3	0	0%	0	0%	0	0%	3	0.5%
4	4	0.66%	6	0.99%	10	1.66%	11	1.83%
5	4	0.66%	24	3.97%	34	5.63%	59	9.8%
6	4	0.66%	1	0.17%	8	1.32%	9	1.5%
7	18	2.99%	14	2.32%	16	2.65%	15	2.49%
8	76	12.6%	99	16.39%	126	20.86%	120	19.93%
9	13	2.16%	15	2.48%	13	2.15%	14	2.33%
10	36	5.97%	29	4.8%	29	4.8%	31	5.15%
11	216	35.82%	231	38.25%	226	37.42%	208	34.55%
12	24	3.98%	50	8.28%	36	5.96%	41	6.81%
13	34	5.64%	21	3.48%	17	2.81%	9	1.5%
14	153	25.37%	93	15.4%	73	12.09%	51	8.47%
15	19	3.16%	12	1.99%	8	1.32%	12	1.99%
16	0	0%	1	0.17%	1	0.17%	10	1.66%

Table 1c

Ending_Spot	Bag1_F	Bag1_RF	Bag2_F	Bag2_RF	Bag3_F	Bag3_RF	Bag4_F	Bag4_RF
1	10	1.66%	12	1.99%	12	1.99%	12	1.99%
2	5	0.83%	5	0.83%	10	1.66%	21	3.49%
3	5	0.83%	11	1.82%	9	1.49%	12	1.99%
4	48	7.96%	45	7.45%	36	5.96%	30	4.98%
5	251	41.63%	275	45.53%	326	53.97%	363	60.3%
6	33	5.47%	36	5.96%	33	5.46%	27	4.49%
7	35	5.8%	27	4.47%	21	3.48%	14	2.33%
8	181	30.02%	152	25.17%	106	17.55%	52	8.64%
9	18	2.99%	17	2.81%	16	2.65%	9	1.5%
10	1	0.17%	1	0.17%	0	0%	0	0%
11	1	0.17%	1	0.17%	2	0.33%	0	0%
12	0	0%	1	0.17%	1	0.17%	0	0%
13	1	0.17%	0	0%	0	0%	0	0%
14	4	0.66%	1	0.17%	2	0.33%	0	0%
15	0	0%	1	0.17%	0	0%	0	0%
16	10	1.66%	19	3.15%	30	4.97%	62	10.3%

The tables provided summarize the key statistics observed during our analysis of cornhole games. The first table in Table 1a focuses on the sole quantitative variable we monitored, which was the points scored

in each round. We computed various statistical measures including the Mean, Minimum, Q1 (First Quartile), Median, Q3 (Third Quartile), Maximum, Standard Deviation (SD), and Mode for this variable. We can see that the data reveals that scoring per round tends to be rare in cornhole, highlighting the value attributed to each point. The second table displays the frequency on Four-Baggers and the third table displays the frequency of Thrower Handedness.

In addition to the quantitative analysis, Tables 1b, 1c, and the second table in 1a present an overview of the categorical variables we tracked. For each categorical variable, we documented both the frequency and relative frequency of occurrences for each possible value within the variable. Some occurrences were notably rare, such as ending in zone 15, which only occurred once for Bag #2, with a relative frequency of 0.17%. Conversely, the most frequent occurrence observed was Bag #4 ending in zone 5, with a frequency of 363 and a relative frequency of 60.3%.

Figure 1

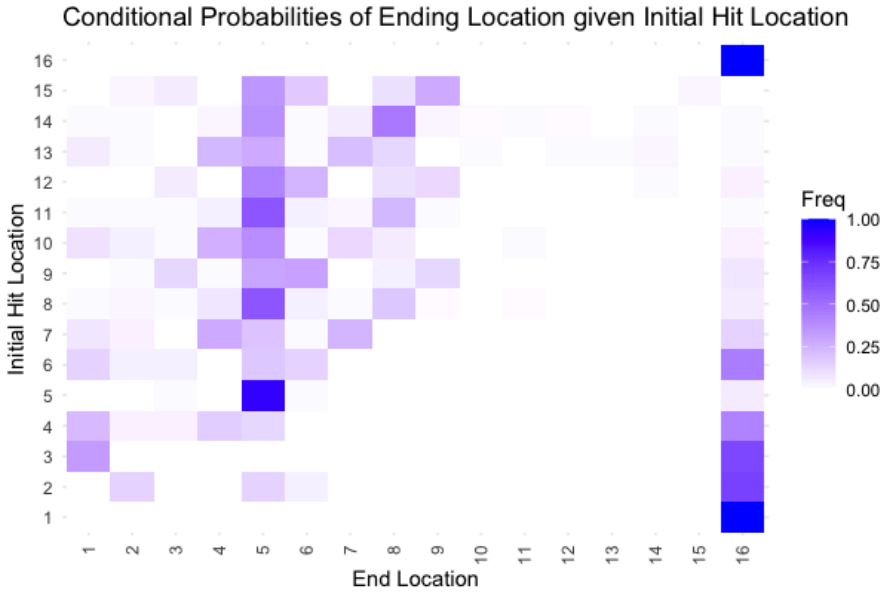
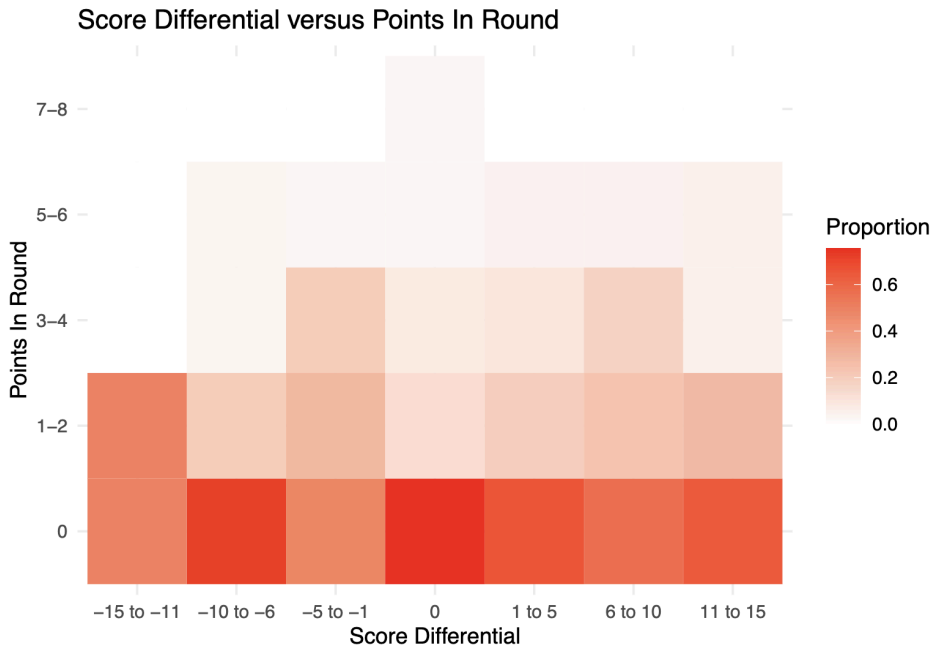


Figure 1 illustrates the conditional probability of a bag's ending location given its initial landing location. We can see the highest probabilities between 5 and 5, 16 and 16, and 1-3 and 16. These all make sense as if you land in the hole or off the board you will obviously stay in that position and if the bag hits with force at the top of the board there's a high likelihood it will not stay. Other noteworthy probabilities are landing on 8 or 11 and ending in 5 and landing on 14 and ending at 8.

Figure 2



Pearson's Chi-squared test:
data: contingency_matrix
X-squared = 22.343, df = 24, p-value = 0.5588

Figure 2 illustrates the conditional probability of the points scored in a round given a certain score differential. The figure shows that when the score in a game is tied (Score Differential = 0), over 60% of the time no points are scored. However, when the player builds a lead (Score Differential > 0) a lesser proportion of points scored are 0, i.e. more points are scored. This is substantiated by row "1-2", which shows that at greater score differentials, a higher proportion of points are 1-2 vs. 0, and similarly a higher proportion are 3-4 than before. A similar conclusion can be seen from the opposite side. When the player falls down by greater margins (Score Differential < 0), i.e. "-5 to -1" vs. "-15 to -11" a greater proportion of points are nonzero. However this association is weaker as the "-10 to -6" range actually sees a greater proportion of 0s scored than "-5 to -1".

Insights

Ideal Targets

With cornhole becoming an increasingly popular sport, it is important to understand the strategies involved to be as successful as possible in the sport. One of the biggest strategies seen in cornhole is where the ideal place to aim is on the board. As seen in Figure 1, it is evident that certain areas on the board have higher probabilities of resulting in a cornhole. Bags landing in sections 11 and 8 had high probabilities of ending up in section 5, resulting in a cornhole. These should be seen as the ideal sections to aim for on the board when a player is throwing their bag. Speaking from a defensive perspective, the ideal place for the bag to end would be right in front of section 5, which would be section 8. The landing

section that produced the highest probability of ending in section 8 was found to be section 14. Section 14 would represent the ideal section to aim for on the board when a player is looking to play defense and defend the hole. This would lead to their opponent having to navigate around their bag to score a cornhole, which leads to more throws aiming directly for section 5 which in turn leads to more overthrows. Landing sections 1, 2, 3, 4, and 6, the sections above and beside section 5, all have high probabilities of ending off the board, showing that forcing your opponent to make these throws high up on the board will more than likely lead to them not scoring a point on that throw.

In order to find evidence that there is a strong association between where the bag lands and where the bag will end on the board, we decided to conduct Fisher's exact test on our contingency table used for Figure 1.

Fisher's Exact Test for Count Data with simulated p-value (based on 10000 replicates)

data: contingency_table
p-value = 9.999e-05
alternative hypothesis: two.sided

Fisher's exact test is used to determine if there are nonrandom associations between two categorical variables. The obtained p-value from this test is seen to be very small, which indicates strong evidence against the null hypothesis of independence between the row and column variables (bag landing location and bag ending location). With such a small p-value, we would reject the null hypothesis and conclude that there is a statistically significant association between the bag landing location and bag ending location variables. The "two-sided" alternative hypothesis suggests that the association could be in either direction (positive or negative).

Momentum

One of the main objectives of this analysis of cornhole strategy, as described in the introduction, was to identify and explain factors contributing to player performance. Figure 2 represents our approach to the idea of a "momentum" element within the game. The hypothesis stems from our knowledge from other sports, such as golf or basketball, in which a player that is playing exceptionally well, continues that trend due to boosted confidence and decreased stress. In the process of illustrating this relationship, Figure 2 displays the proportion of points in a round, given the pre-round score differential as a scatterplot. With this approach, there was an expectation that there would be a linear positive relationship between score differential and the chance of non-zero points won in a round. This was done by first grouping the potential points scored into buckets of similar values and creating a metric that measured the percentage of rounds that scored in the given bucket, for each possible score differential. For example, the statistic is calculated as followed for the number of instances a player scored 1-2 points, given a tied game:

$$\frac{\#\ \textit{of Rounds of Scoring 1-2 points} \cap \textit{Score Differential of 0}}{\#\ \textit{of Rounds with a Score Differential of 0}}$$

This metric, applied to the other points scored buckets and pre-round score differential situations, resulted in a the following findings, as illustrated in Figure 2:

Pre-Round Score Differential	Percentage of Rounds with 1-2 Points Won	Percentage of Rounds with 3-4 Points Won	Percentage of Rounds with 5-6 Points Won
0	12%	8%	2%
1-5	20%	9%	4%
6-10	23%	17%	4%
11-15	27%	5%	5%

The table above, in tandem with Figure 2, suggests that there is merit behind the original hypothesis. It can be seen that when the pre-round score differential is increasing, the percentage of rounds in which the leader, the first thrower, wins 1-2 points occurs at an increasing rate. It peaks at 27% when the leader of the match is winning by 11 to 15 points. This trend continues with the cornhole player ahead by 6 to 10 points having the highest percentage of rounds in which they win 3-4 points, at 17%. Finally, the kill-shot big-point rounds also hit their highest rate, 5%, when the cornhole player is ahead by 11 to 15 points.

These findings support the argument about motivation being an influential factor in positive results in cornhole. It is possible to deduce from Figure 2 and the table that the increase in confidence that follows a sizable lead, will continue into the next round because of the player's own belief that they are "on" and that influences better play, and more successful risky toss attempts. The other way to interpret this data, that still supports the hypothesis, is that a player with low momentum, that is in a great point deficit, will have low confidence but will still attempt to overcome that through unsuccessful, risky play styles.

This statistic does contain some flaws, however. The main issue is that this metric, based around the "motivation" factor, doesn't prepare for an overwhelming mismatch between players. For instance, a professional cornhole player versus a novice will likely not be very close, the professional is likely to win by over 10 points. For the data that was collected in this project, it is possible that the only times in which there was an outstanding score differential, there was an obvious mismatch in talent which resulted in winning more rounds by nonzero points. Furthermore, the p-value of the Chi-squared test didn't allow a rejection of the null hypothesis. Although we notice a trend in the data within this motivation metric, it will take more observations of similar results to prove it significant in the future.

Future Work (Critiques)

In looking back on our methods of data collection and analysis, we identified multiple opportunities for refinement. A notable oversight was our failure to track interactions between bags, an element that is key to strategy in cornhole. Specifically, it would be beneficial to identify whether a bag went into the hole off the initial throw or off contact from another bag from a later throw. This would prove insightful in

understanding strategic context such as a player's decision to aim at a certain place on the board. While watching film, we observed that if multiple bags had already landed in front of the hole, in the 8 spot, a player might try to throw the bag directly into hole or throw it behind the bags already on the board with the intention of it lightly landing flat on the board, perhaps in fear of knocking in an opponent's bag off of a potential slide. Additional data collection such as the aforementioned would have allowed for more targeted data analysis, particularly in understanding a player's context-based decision making.