Project Report

Sara LaPlante, Katina Papadakis, Dean Pospisil, Heather Shen

Introduction and Background

In this experiment, our motivating question is how rehearsing a swing before a throw or throwing with the other hand changes performance in the game of cornhole. Cornhole is a game in which participants take turns throwing bean bags at raised platforms with holes in them from a distance of 27 feet. If the bag falls through the hole on the board, three points are awarded to the player. If the bag lands on the board without falling into the hole, the player wins one point. Each round consists of four throws, where the points of the player are summed and added to the team's total score. The game is played until one team receives 21 points.

The hypotheses being tested in this experiment are that there is no difference between dominant and nondominant hand and that there is no difference between mimicking the swing before throwing the beanbag and throwing it without preparation. We chose these two factors to compare because both are easy to implement for a cornhole player to adjust their score. This could be useful for imposing a handicap to reduce a better player's advantage and make the game more interesting. Similar to sports such as golf, the idea behind mimicking the swing before hitting the ball (or throwing the beanbag) is to mentally prepare and physically practice before the actual swing.

We are also interested in the possible existence of an interaction between the factors, because for instance, mimicking the swing before throwing could improve a player's throw on their non-dominant hand more than on their dominant hand (which they are already used to throwing with). This could affect the strategy that one pursues during the cornhole game.

Experimental Design

To simulate an actual game, our experiment consisted of four players playing successive rounds of cornhole (one round is four throws). The experimental unit is a single round in which a player attempts four times to get a bean bag into the cornhole. We compared four treatments, which are the combinations of the factors dominant hand vs. nondominant hand and swinging beforehand vs. no swinging beforehand:

1. Dominant hand and no swinging before throwing
2. Dominant hand and swinging before throwing
3. Nondominant hand and no swinging before throwing
4. Nondominant hand and swinging before throwing

Given that we are interested in which hand or technique improves a player's score, the outcome of interest is score, which we calculate by summing the points from the four throws of a round, as you would do in each round of a game. (For example, if a player hit the board once, missed twice, and then got one bean bag in the hole, their score for the round would be 1+0+0+3=4.) The treatment factors are swing (yes vs. no) and hand (dominant vs. nondominant). Our model will include the fourt treatments and will also test for an interaction effect.

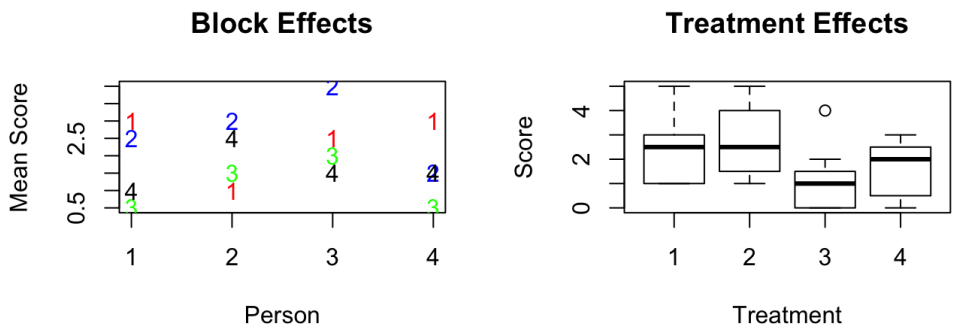
Further, we were concerned that scores would vary by player, so the design is a Randomized Complete Block Design that includes players as experimental blocks. Each block was assigned to throw two rounds (eight throws) of cornhole for each of the four treatment combinations. Within each block, we used a random number generator to randomly assign the order of these rounds. To illustrate this, consider player one's throws. Player one threw a total of eight rounds of cornhole. Their first round was randomly assigned dominant hand, no swing, and their second round of throws was assigned dominant hand, swing. So to start, player one threw a full round of throws with their dominant hand and swing, followed by a full round of throws with their dominant hand and no swing. The experiment continued in this way.

Data and Analysis

Exploratory Analysis

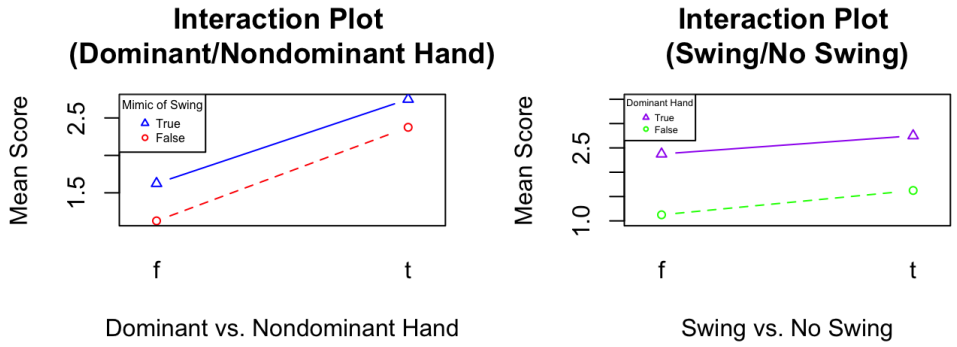
Treatment	Min	1st Quartile	Median	Mean	3rd Quartile	Max
Dominant, no swing	1	1	2.5	2.375	3	5
Dominant, swing	1	1.75	2.5	2.75	4	5
Nondominant, no swing	0	0	1	1.125	1.25	4
Nondominant, swing	0	0.75	2	1.625	2.25	3

The plot on the left below indexes the scores by person. The ordering of mean scores for the conditions is not always the same across people, but there's no clear block effect. The boxplot for the four treatments suggests a difference between the nondominant hand conditions (3 and 4) and the dominant hand conditions (1 and 2).



Left: Plot of mean scores by person. Number labels of data points indicate treatment. Right: Boxplots of scores by treatment. Treatment numbers correspond to numbering in introduction.

The lines of the interaction plots are nearly parallel, suggesting no interaction between our factors.



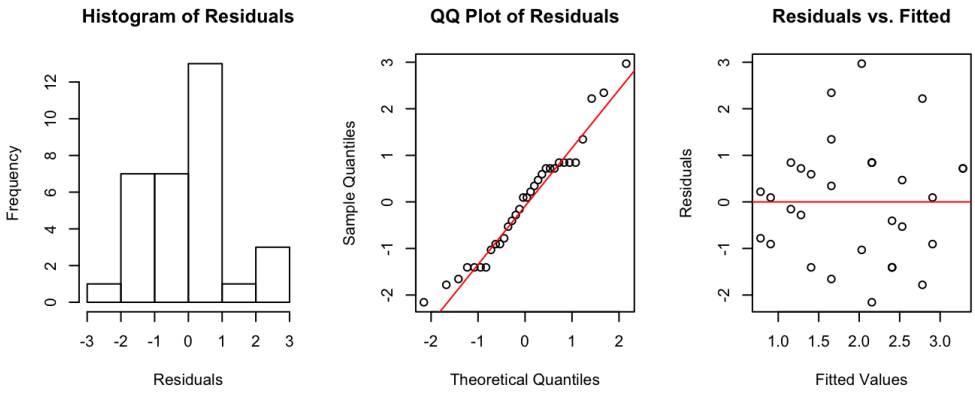
Interaction plots for the two factors.

Validating Model Assumptions

Before choosing between the interaction and additive models, we first checked that our assumptions were valid. First, the ANOVA model assumes independence of observations. Given the relatively small number of rounds each player threw, we believe there is essentially no correlation between observations over time. That is, it is unlikely that in two rounds of cornhole a player would become exhausted enough for it to effect their game play (and all players were asked to warm up in an identical way before beginning the experiment).

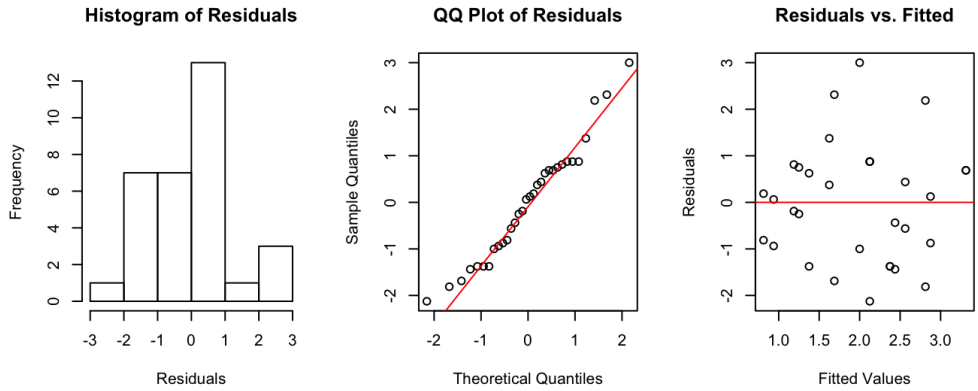
The ANOVA model also assumes that the errors are normally distributed with a mean of zero. To check this assumption, we plotted a histogram of the residuals as well as a QQ plot, and this assumption appears to be mostly met.

Finally, the ANOVA model assumes that there is constant variance in the errors. To check this, we plotted fitted values vs. residuals, which shows that this assumption is met. Further, we checked the residual variance across treatments; the largest variance (2.75) divided by the smallest variance (1.125) gave us a value of 2.44, which falls below four and thus by our rule of thumb, these differences in variance should not cause concern.



Checking normality of residuals and constance variance assumptions for the full interaction model.

After removing the interaction term from our ANOVA model, we again checked our assumptions of independence, normal errors, and constant variance. We again found no cause for concern. The relevant plots are reproduced below.



Checking normality of residuals and constance variance assumptions for the additive model.

ANOVA Tables

Full Interaction Model:

	DF	Sum of Squares	Mean Squares	F-value	P-value
Person	3	3.594	1.1979	0.6171	0.6104
Dominant	1	11.281	11.2812	5.8113	0.0236*
Swing	1	1.531	1.5312	0.7888	0.3829
Dominant:Swing	1	0.031	0.0313	0.0161	0.9001
Residuals	25	48.531	1.9413		

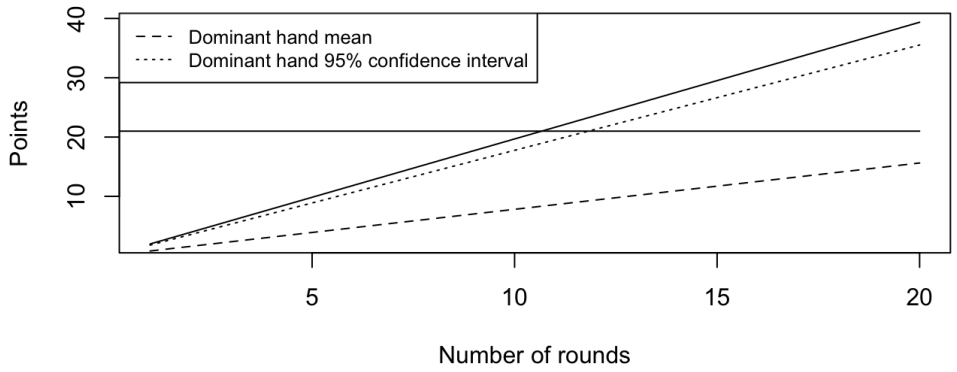
Additive Model:

	DF	Sum of Squares	Mean Squares	F-value	P-value
Person	3	3.594	1.1979	0.6414	0.59531
Dominant	1	11.281	11.2812	6.0399	0.02097
Swing	1	1.531	1.5312	0.8198	0.37355
Residuals	26	48.563	1.8678		

As suggested by the interaction plots, there is not a significant interaction effect, so the additive model is more appropriate for these data. There is a significant effect of dominant vs nondominant hand and thus, we reject the null hypothesis that the true mean of scores obtained with the dominant vs nondominant hand are the same. The mean difference between the hands was 1.18 points per 4 tosses. The 95% confidence interval was (0.19, 2.18).

Summary and Discussion

There was not enough evidence to suggest an effect of mimicking the swing vs no preparation or an interaction effect between the two factors in our experiment. However, we had enough evidence to reject our null hypothesis that stated there was no effect of dominant vs nondominant hand. To give a sense of scale of this difference given our average score it would take 10.6 turns to finish a game in terms of number turns if the true mean were our estimate (1.18) you would finish at 6.6 turns and we are 95% confident you would finish between between 5.1 and 9.7 turns. So at the very least finishing about a turn early than average.



Expected Game Length

In terms of making a game more competitive if you find your friend is on average getting 1 point more than you per a round than having them use their dominant hand should on average make the odds roughly even.

Limitations

There were several limitations to this experiment. The outcome variable used was the score per round, calculated by summing together the scores of four throws. This outcome theoretically had a range of 0 to 12, but in our results ranged only from 0 to 5, with a large proportion of zeroes. This was due in part to idiosyncracies of scoring – in cornhole, you do not receive points for throws that hit the board and bounce off. Had we given points for these throws, there would have been a wider range of scores and more opportunity to detect differences in means between the conditions. Though we treated score as a continuous outcome, it is technically a discrete and non-linear variable, and as mentioned earlier, scores were largely clumped near zero. Finally, it is not clear that our results would generalize from our participants to a bigger population. Our participants (the authors) are not consistent cornhole players, so the scores on average were lower than for a general population of players, and again it's possible that more differences would have been found had the values not tended so strongly toward zero.