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Moosehead: Is it a Traveling Game?

STAT 530: Experimental Design and Analysis

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Introduction

Moosehead is a game of skill and precision that is played individually with a group of people (i.e. not a team game). An ice cube tray is placed a certain distance (normally, two feet) away from the edge of a table. Each player has three opportunities to bounce a coin off the table into one of the ice cube slots. Each row of the ice tray is numbered one through seven, where row 1 is closest to the player and row 7 is furthest away. After the player has bounced the three coins into the ice tray, the points are totaled based on their location in the ice tray, while any coin not in a slot is deemed zero points. The minimum points possible is zero (three misses) and the highest is 21 (three coins successfully landed in the 7th row).

While the majority of Moosehead games are played in homes, people may wish to play in other locations. What happens if there is no table to play on? Would it make a difference to the players if there were no quarters to throw, but instead they needed to use a different type of coin? Perhaps there is not enough space to have a game played at full length. Is it possible to play Moosehead on the go, can there be a mobile version of the game, using materials that can be packed away for easy access? Essentially, can Moosehead effectively be played in an environment that is different than "standard?"

Experiment

The process used to obtain the data is as follows: three people were selected to play Moosehead based on their prior experience. One person, the *advanced* player, has many years of experience playing Moosehead. The second person, the *intermediate* player, has experience in playing Moosehead, but does not play regularly. Lastly, the *beginner*, has no experience in playing Moosehead. Three factors were chosen as the main effects of the experiment; type of coin, distance, and surface type. The levels of factors were chosen by a random number generator, which set the order for each person's trial (which totaled eight runs). Each person completed three separate trials.

Factors

Moosehead is often played on different surfaces and at different distances, depending on where it is being played. Which factors contributed to players obtaining high scores in some games and low scores in another? There are some factors that could contribute to a players score, such as the focus of the player (do they become easily distracted?), and the motor skills of the player (are they inebriated or clear headed). Choosing factors that can be controlled, our factors include material of the surface, coin type, and ice cube tray distance from the edge of the table.

Surface. The first factor to be analyzed is the material of the surface being played on. Typically, the game is played on a table. However, what if a table is not available to be played on? Would a plastic cutting board, something that is easily mobile, as well as accessible, suffice as a playing surface? The first type of surface was a laminate table $(-)$ and the second was a plastic cutting board placed on top of the table $(+)$. The ice cube tray was raised to match the height of the cutting board when the cutting board was used in the trial, to imitate playing on a level surface.

Coin Type. The second factor that we considered was the type of coin that the players use. All U.S. coins have different sizes and weights. Most games of Moosehead are played with quarters, but we wanted to see if there would be a difference in results if a different size of coin was used. The quarters used were dated post 1964, weighed 5.67 grams and measured 0.955 inches in diameter. The second

coin we used was the US Presidential Dollar, which weighed 8.1 grams and measured 1.043 inches in diameter. The quarter was chosen to be the low level $(-)$ and the dollar was chosen as the high level $(+)$ for our second factor.

Distance. The last factor we decided to measure was distance of the ice cube tray from the edge of the table. The standard distance for Moosehead is two feet, however in a mobile game, there may not be enough space to provide two feet from the person. We wanted to test if there was a difference between one and a half feet $(-)$, the altered distance, and two feet $(+)$, the standard distance.

Design *2^3 factorial design with 3 replications*

Remember that our experiment had three factors: surface, coin, and distance of the ice tray. Each factor had two levels that were randomly assigned for each trial until all combinations were used. Hence the design of our experiment was a 2^3 factorial design with eight runs. Each player was asked to repeat the process three times making the final design of our experiment a 2^3 factorial design with three replications.

Each player was allowed five "warm-up" tosses to practice the technique necessary to make the coin bounce off the table. While keeping their elbow behind the edge of the surface, each player bounced their three coins for each of the eight possible designs. The specification of the elbow remaining behind the table was intended to prevent any unwanted distance changes. The response variable was the sum of the three coins point values in each run; remember that a coin that did not end up in the ice tray was recorded as a zero.

The design of the experiment can be seen in Figure 1.

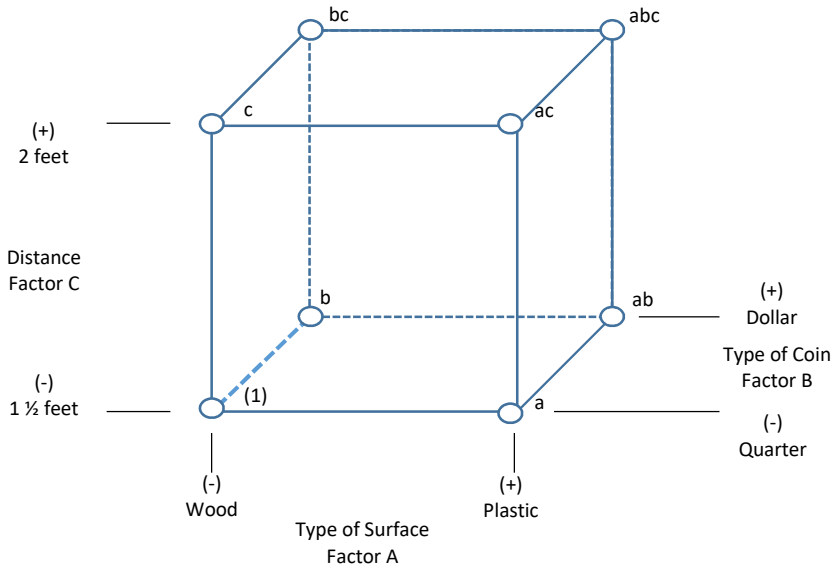

Figure 1(a) Geometric Design

	Factors		
Run	A	B	C
1	-	-	-
2	-	-	+
3	-	+	-
4	-	+	+
5	+	-	-
6	+	-	+
7	+	+	-
8	+	+	+

Figure 1(b) Design Matrix

Results

Part of the interest in this study is to find out if different factors affected different level players. For this reason, as mentioned above, the experiment was broken down into three player levels. We examine each skill level separately below to test for significant factors at the 90% confidence level. We will also determine if the model was adequate for each skill level based on the normality and equal variances assumptions.

Beginner

The normal plot below (figure 2) shows that the only significant factor in the model for a beginner should be factor A (surface type). This is verified by the low p-value of .0248 in the ANOVA table (figure 3). Therefore, we can conclude that the surface type is indeed a significant factor for a beginner in Moosehead. Furthermore, we can conclude that the coin type (factor B) and the distance (factor C) are not a significant factor for the beginner.

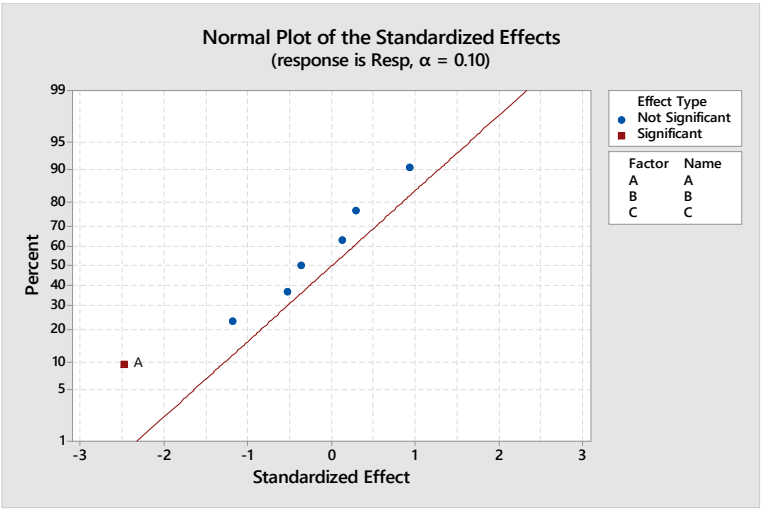

Figure 2 Beginner Normal Plot

Source	DF	Type III SS	Mean Square	F Value	Pr > F
A	1	155.0416667	155.0416667	6.13	0.0248
B	1	2.0416667	2.0416667	0.08	0.7800
C	1	35.0416667	35.0416667	1.39	0.2564
AB	1	0.3750000	0.3750000	0.01	0.9046
AC	1	7.0416667	7.0416667	0.28	0.6050
BC	1	22.0416667	22.0416667	0.87	0.3644
ABC	1	3.3750000	3.3750000	0.13	0.7197

Figure 3 Beginner ANOVA table

Looking at the normal probability plot below (figure 4), we can see that the residuals generally follow a linear line and hence we can say that there is no violation of normality. Looking at the residual vs. fitted value plot below (figure 5) we can see that there are indications of a pattern.

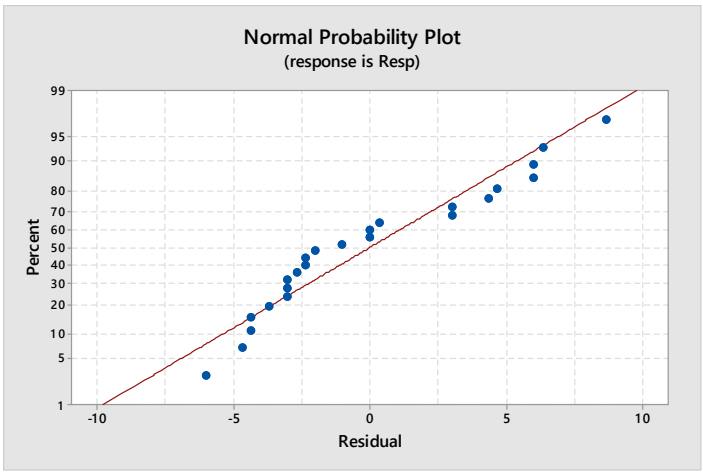

Figure 4 Beginner Normal Probability Plot

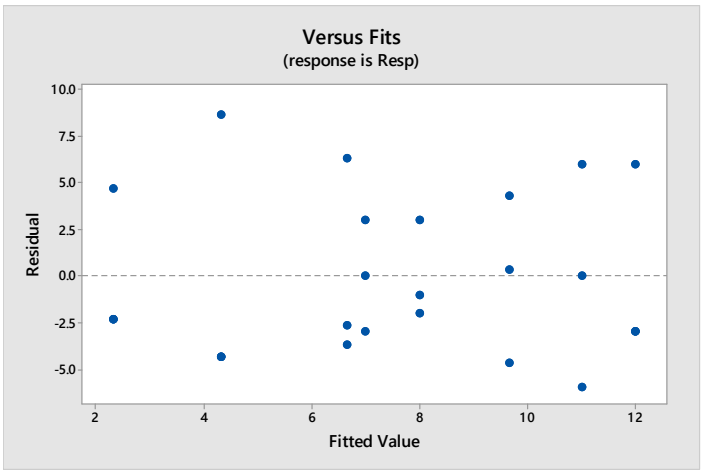

Figure 5 Beginner Residual vs. Fitted Value

When looking at the residual plot for each variable as well (figure 6), we see that the columns for each do not seem to be equal. For this reason, a Levene's test must be used to verify the assumption of equal variances is not violated. Since factors A, B, and C have p-values of .5689, .4866, and .3336 respectively, we can conclude that there is no violation of equal variances.[1] Therefore, the model is adequate.

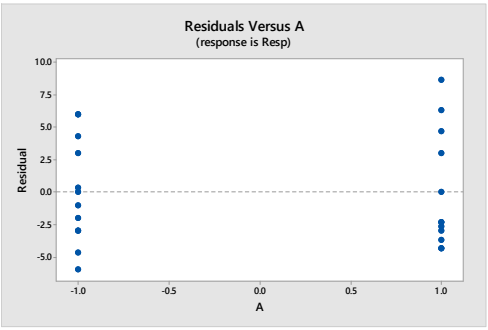

Figure 6a Beginner Factor A vs. Residual

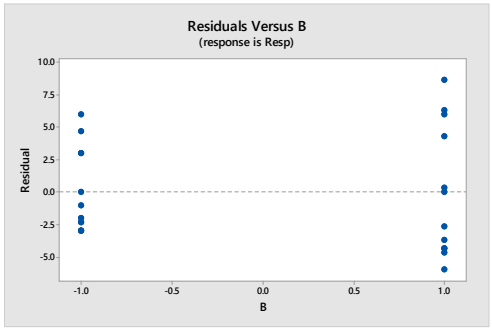

Figure 6b Beginner Factor B vs. Residual

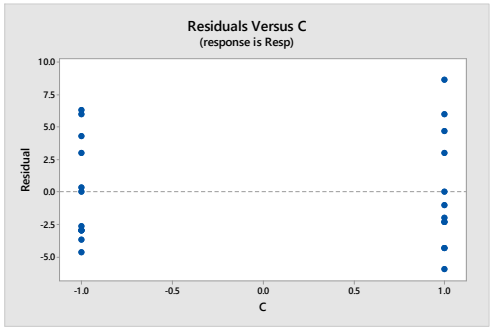

Figure 6c Factor C vs. Residual

Based on the cube plot below (figure 7), we would suggest that a beginner player plays the game with all three factors at the low level. This would mean that the beginner bounces quarters off a wooden surface with the ice cube tray set at a foot and a half from the edge of the table.

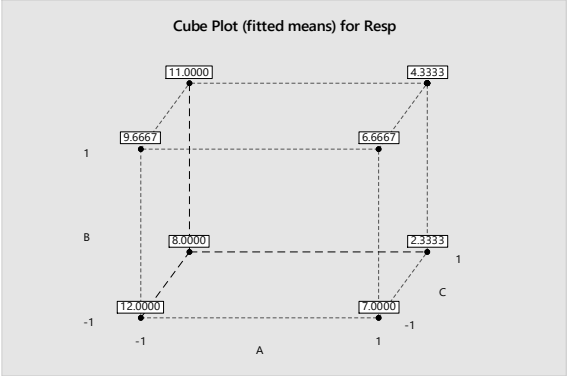

Figure 7 Beginner Cube Plot

[1] Levene's Test Tables can be found in Appendix A

Intermediate

The normal plot below (figure 8) shows that there were no significant factors in the model for the intermediate player. This is verified by the there being no p-values below the alpha level of .10 in the ANOVA table (figure 9). Therefore, we can conclude that there are no significant factors involved for the intermediate player in Moosehead.

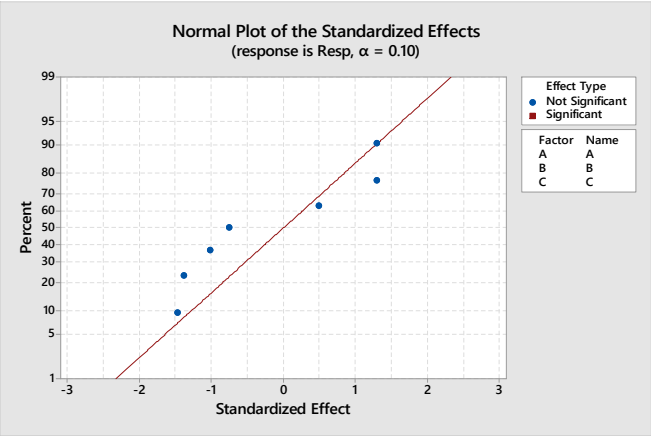

Figure 8 Intermediate Normal Plot

Source	DF	Type III SS	Mean Square	F Value	Pr > F
A	1	45.37500000	45.37500000	2.15	0.1617
B	1	35.04166667	35.04166667	1.66	0.2157
C	1	12.04166667	12.04166667	0.57	0.4608
AB	1	22.04166667	22.04166667	1.05	0.3218
AC	1	5.04166667	5.04166667	0.24	0.6315
BC	1	35.04166667	35.04166667	1.66	0.2157
ABC	1	40.04166667	40.04166667	1.90	0.1871

Figure 9 Intermediate ANOVA table

Looking at the normal probability plot below (figure 10), we can see that the residuals generally follow a linear line and hence we can say that there is no violation of normality. Looking at the residual vs. fitted value plot below (figure 11) we can see that there are no indications of a pattern.

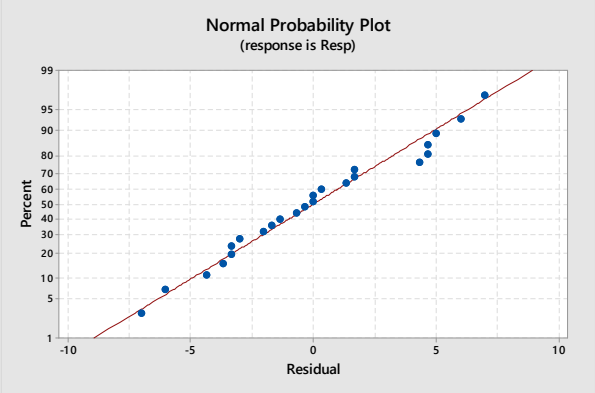

Figure 10 Intermediate Normal Probability Plot

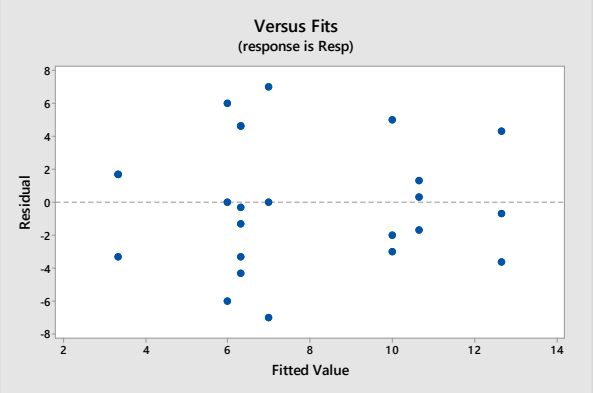

Figure 11 Intermediate Residual vs. Fitted

When looking at the residual plot for each variable as well (figure 12), we see that the variances in factors A and C seem to have different height columns but factor B seems to have pretty equal variances. A Levene's test was run to verify that the assumption of equal variances is not violated. Since factors A, B, and C have p-values of .9500, .5026, and .5014 respectively, we can conclude that there is no violation of equal variances.[1] Therefore, the model is adequate.

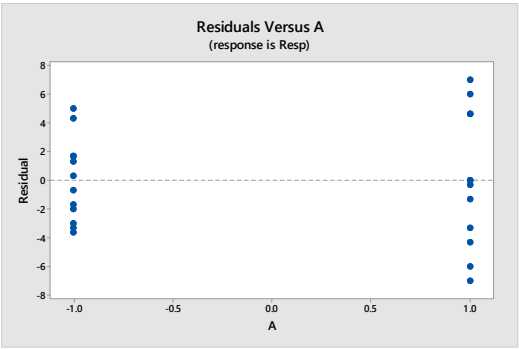

Figure 12a Factor A vs. Residuals

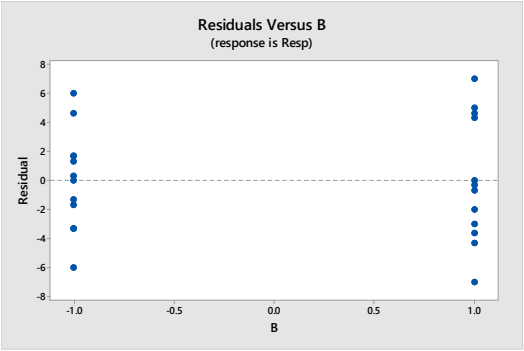

Figure 12b Factor B vs. Residuals

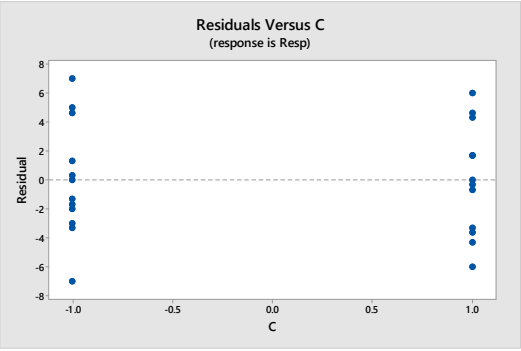

Figure 12c Factor C vs. Residuals

Based on the cube plot below (figure 13), we would suggest an intermediate player plays the game with factor A at the low level and factors B and C at the high level. This means the player maximized their score bouncing quarters off a wooden surface at a distance of 2 feet from the edge of the table.

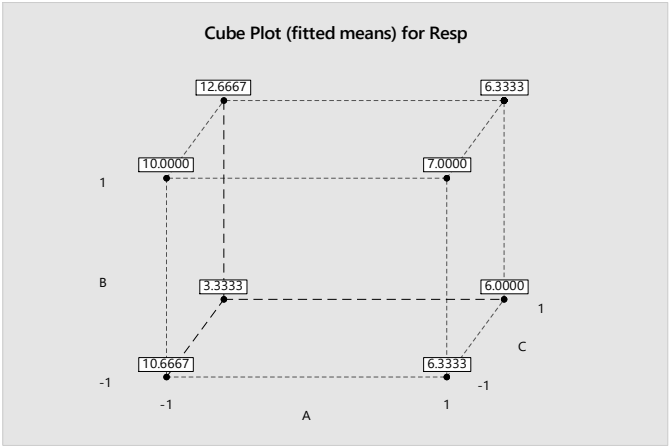

Figure 13 Intermediate Cube Plot

Advanced

The normal plot below (figure 14) shows that factor A and factor AB are significant factors in the model for an experienced player. This is verified by the low p-values of .0149 and .0985, respectively, in the ANOVA table (figure 15). Therefore, we can conclude that surface type (factor A) and the interaction between surface type and type of coin (factor AB) are significant factors for an experienced player in Moosehead. Furthermore, we can conclude the distance (factor C) is not a significant factor for the experienced player.

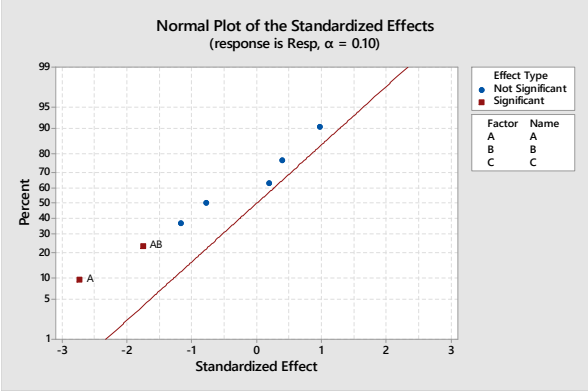

Figure 14 Advanced Normal Plot

Source	DF	Type III SS	Mean Square	F Value	Pr > F
A	1	130.6666667	130.6666667	7.45	0.0149
B	1	16.6666667	16.6666667	0.95	0.3442
C	1	2.6666667	2.6666667	0.15	0.7018
AB	1	54.0000000	54.0000000	3.08	0.0985
AC	1	10.6666667	10.6666667	0.61	0.4469
BC	1	24.0000000	24.0000000	1.37	0.2593
ABC	1	0.6666667	0.6666667	0.04	0.8479

Figure 15 Advanced ANOVA table

Looking at the normal probability plot below (figure 16), we can see that the residuals generally follow a linear line and hence we can say that there is no violation of normality. The residual vs. fitted value plot below (figure 17) shows that there are some indications of a pattern.

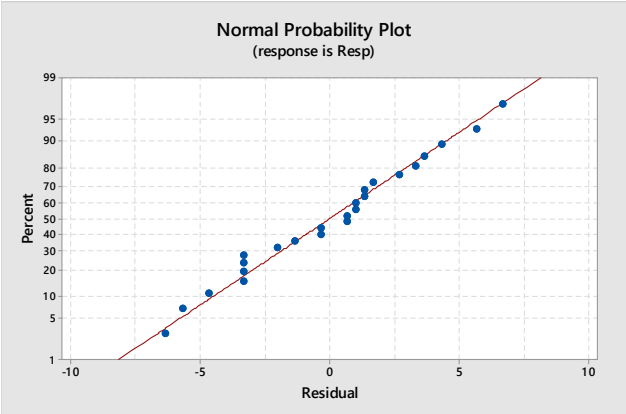

Figure 16 Advanced Normal Probability Plot

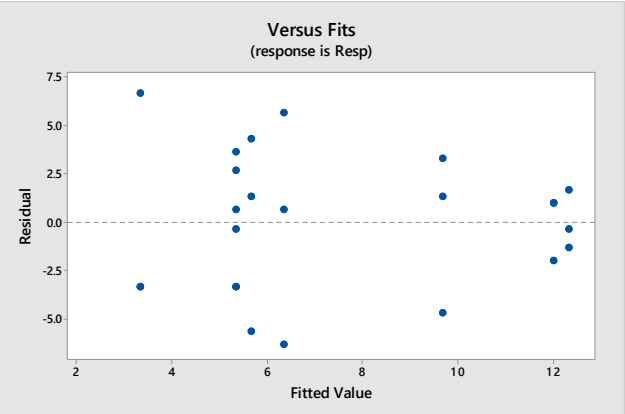

Figure 17 Advanced Fitted Value vs. Residuals

Analyzing the residual plot for each variable as well (figure 18), we see that the columns for each do not seem to be equal. For this reason, a Levene's test must be used to verify the assumption of equal

variances is not violated. Since factors A, B, and C have p-values of .4245, .2672, and .3264 respectively, we can conclude that there is no violation of equal variances.[1] Therefore, the model is adequate.

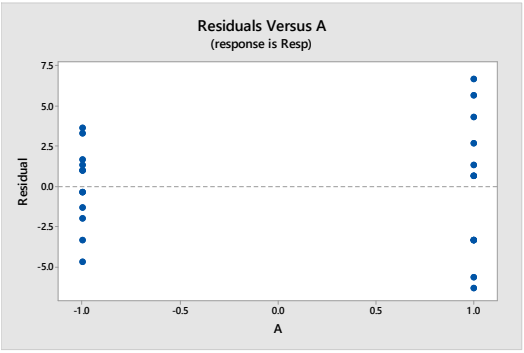

Figure 18a Advanced Factor A vs. Residuals

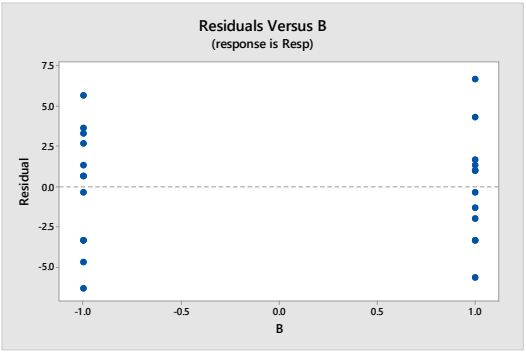

Figure 18b Advanced Factor B vs. Residuals

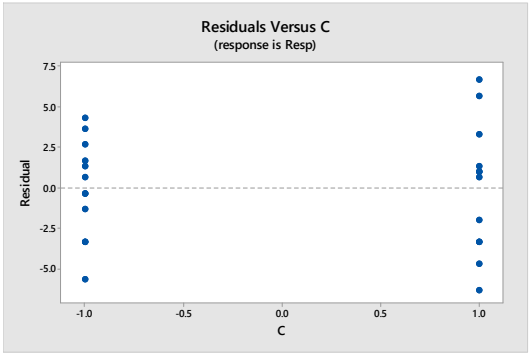

Figure 18c Advanced Factor C vs. Residuals

Based on the cube plot below (figure 19), we would suggest an experienced player play the game with factors A and C at the low level and B at the high level. This translates to the game being played on a wooden surface with dollar coins and at a distance of one and a half feet from the edge of the table. This is supported by the interaction plot below (figure 20) that shows the mean response is maximized with factor A at the low level and factor B at the high level.

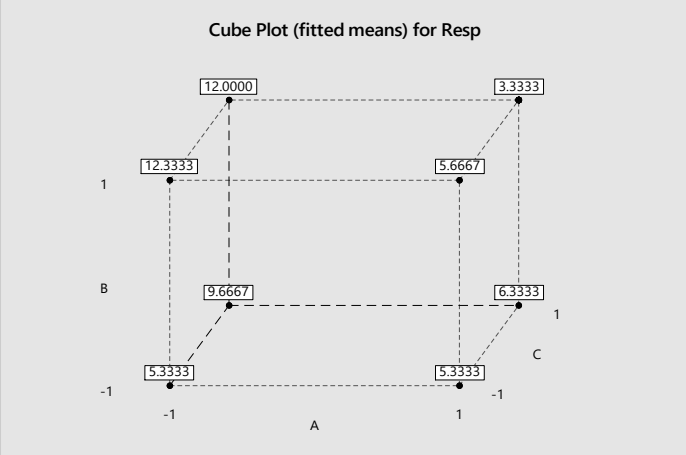

Figure 19 Advanced Cube Plot

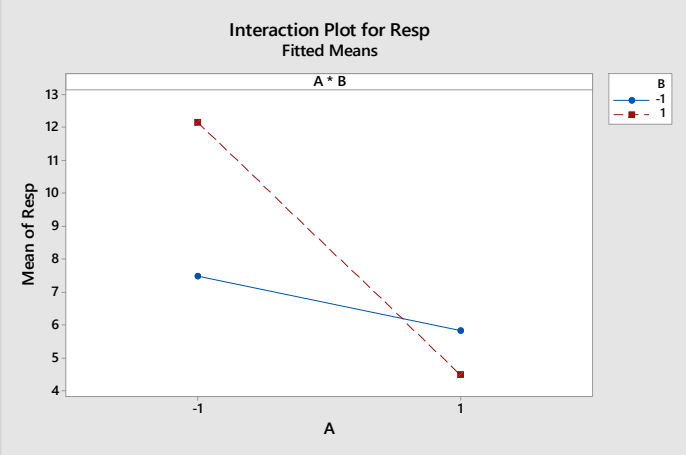

Figure 20 Advanced Interaction Plot for Factor A and B

Conclusions

After conducting our experiment for three different players with varying skill levels, we were able to draw conclusions from their results. Each player had a different factor or set of factors that seemed to have an effect on their ability to perform well while playing Moosehead. While the skill level of the player seemed to play a role in the results, it was not in the way we would have imagined. The experienced player had two factors that would affect his play consistently. It makes sense that more factors would affect their play since they are the most technically sound in the game and would notice

small differences more. However, if that is the case, we would expect the intermediate player to have more factors affect them (or at least the same number) as the beginner. In our experiment that is not the case with the intermediate player being able to play consistently under all conditions presented, while the beginner was affected by the surface type.

Whether we wanted to explore this experiment further or run it again to verify results there are a few things we could have done differently. Due to the nature of how the game works, misses happen quite often. Therefore, maybe a new way of recording the response variables should be used that doesn't weight misses as heavily as a zero. Perhaps, more repetitions should be conducted to get a more accurate picture of the factors. However, based on our results, we recommend that beginning players use a table, quarters, and play at a closer distance. For intermediate players, we recommend a table, dollar coins, and a further distance. For advanced players, a table, dollar coins, and a closer distance is recommended.

Overall, we would recommend that Moosehead is not played in a mobile setting for the best results. However, if one wanted to play on the go, we do not recommend using a plastic cutting board as the bouncing surface.

Appendix A

Beginner Levene's Tests

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
A	1	146.3	146.3	0.33	0.5689
Error	22	9622.3	437.4		

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
B	1	470.4	470.4	0.50	0.4866
Error	22	20663.6	939.3		

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
C	1	762.2	762.2	0.98	0.3336
Error	22	17154.3	779.7		

Intermediate Levene's Tests

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
A	1	2.1901	2.1901	0.00	0.9500
Error	22	11956.3	543.5		

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
B	1	234.9	234.9	0.46	0.5026
Error	22	11124.0	505.6		

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
C	1	307.6	307.6	0.47	0.5014
Error	22	14484.4	658.4		

Advanced Levene's Tests

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
A	1	160.2	160.2	0.66	0.4245
Error	22	5320.3	241.8		

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
B	1	661.5	661.5	1.30	0.2672
Error	22	11230.3	510.5		

Levene's Test for Homogeneity of Y Variance ANOVA of Squared Deviations from Group Means					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
C	1	433.5	433.5	1.01	0.3264
Error	22	9464.7	430.2		