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The Study of Paper Airplanes Flight Distances: Based on Paper, Size, and Fold

Abstract:

After Professor Pyott’s Statistics 320 class decided to perform an experiment focusing on the effects of fold, size, and paper when measuring the distance of a paper airplanes flight, the number of treatment levels needed to be decided. The class concluded that a 3X2 factorial design would make for simpler analysis and then needed to think about methods to minimize lurking variables. To do so, a blocking variable was used for each thrower, as well as a randomization was applied to each block. The test analysis of a 3-way ANOVA and adequate assumption checks provided support that the thrower and size variables were significant, as well as the 3-way interaction.

Introduction:

The reasoning behind this experiment was simply that an experiment was a necessary portion of Professor Pyott’s Statistics 320 Experimental Design class. The class needed to decide on a topic that would be fitting for some sort of factorial design and incorporate experimental methods such as blocking and randomization. After some thoughtful conversation, it was decided that flying paper airplanes peeked the most interest among everyone and it was a plausible experiment that would fit with the limited resources available. The class wanted to know what the most important factor was when trying to get the farthest flight possible. After doing some simple research, the class decided that the 3 variables to focus on would be airplane size, paper, and fold. The results of the experiment proved that the thrower in did in fact influence the flight distance, also proving that the blocking method used was important when performing the experiment.

Methods:

There were three independent variables with two levels each in the paper airplane experiment, and these include the style of the fold of the plane, the material used to fold the plane, and the size of the paper used to fold the plane. The style folds that were used were found from John Collin’s, *The New World Champion Paper Airplane Book.* The easy-peasy style was a shorter plane in length but had wider wings while the javelin style was longer and had slimmer wings. The paper materials options where between printing paper and the suggested paper provided in John Collin’s book which had a little more weight and thickness to it. And lastly, the sizes were a standard 8.5 X 11 size and a smaller piece only 80% of the original. The task performed was the launch, flight, and landing of the individual paper airplanes, and the dependent variables measured are three different types of lengths from the launch point to the landing position. These include the vertical distance from the launch point to the farthest point on the plane, the horizontal distance that the plane flew from the launch point to the farthest point of the plane in its landing position, and the hypotenuse distance which is calculated with the first two distances using the Pythagorean theorem. All the distances were measured in inches and recorded in an organized excel spreadsheet. It was expected that the Javelin styled plane, which has a longer and slimmer body folded with the larger sized piece of book paper to fly the farthest due to observation from classroom trials and based off quick readings from John Collin’s *The New World Champion Paper Airplane Book*. It was also expected the easy-peasy styled airplane folded with the smaller sized copy paper to travel the shortest distance due to the smaller wingspan and floppier material.

Before the experiment was started, it was decided to use a 3-way ANOVA test to run analysis on the 2 X 3 factorial design. To check the necessary assumptions, the Shapiro-Wilk test and Levene’s test would be performed. To reduce confounding and lurking variables such as draft, temperature, launching inconsistency and fold quality, the group decided to perform the experiment with a blocking variable for each thrower as well as randomize the order of the airplanes thrown within each block. Each type of plane was thrown twice, allowing each thrower to throw 16 planes total. The group decided to have each style of plane thrown twice due to the expected power of the experiment. With a large effect size and 8 different groups, we wanted a larger power value of about 76%, so to create such, there had to be 32 runs performed.

Results:

Chart, waterfall chart

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Figure 1 Figure 2

= 0.8827). There was a statistically significant interaction between paper, size, and fold *F* (1, 23) =

4.2158, *p* = 0.0515914 when statistical significance for a large effect size was accepted at *p* < 0.10. There was also statistical significance for thrower, *F* (1, 23) = 16.9008, *p* = 0.0004268, and size, *F* (1, 23) = 9.1560, *p* = 0.0060130 which can be seen on the boxplots above (Figure 1 and 2). Neither paper, *F* (1, 23) = 0.7333, *p* = 0.4006438, nor fold *F* (1, 23) = 2.4079, *p* = 0.1343802 were statistically significant. Furthermore, none of the two-way interactions including size with fold: *F* (1, 23) = 0.0865, *p* = 0.7713351; fold with paper: *F* (1, 23) = 0.0241, *p* = 0.8779141; and size with paper: *F* (1, 23) = 0.4698, *p* = 0.4999471 were statistically significant.

Discussion:

After planning, performing, and analyzing this experiment, I realized that despite however much planning you may put into an experiment, there will be changes that suddenly occur during the experiment. In the pilot study, it felt like we had thought of everything, the supplies, the location, the variables we would focus on, but as soon as it came time to execute the experiment, we added two new response variables. Flexibility was important, especially with such a big group. When designing the experiment, it proved very important to block off the thrower variable as it showed to have a large effect when it came to variability. Furthermore, the pilot study was important because there were parts of the experiment that no one was really thinking of until we got down to throwing the airplanes such as the “correct” way to launch it. During the practice throws, it was decided that the designated throwers would all throw the planes by the front as that seemed to give the consistently farther distance. Events like these happened all throughout the planning process, but they made for a better outcome.

Conclusion:

The experiment to test the significance of the fold, size, and paper of a paper airplane’s flight distance resulted in significance for the size, the thrower, and the 3-way interaction. The most important discovery in this experiment was the significance of the throwers found by blocking the two throwers in the experiment. No one seemed to think that the thrower would have such an impact on the distance, and although this isn’t what the study focused on, it would be an interesting topic to study in the future. Another helpful follow up experiment might be to test several different sizes of airplanes rather than just two different ones to see which size proves to be the best in terms of distance.

References:

Collins, J. M. (2013). *The New World Champion Paper Airplane Book.* Clarkson Potter/ Ten Speed.

Ellis, P. D. (2010). *The Essential Guide to Effect Sizes: Statistical Power, Meta-Analysis, and the Interpretation of Research Results.* New York, United States of America: Cambridge University Press.

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Chart

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Chart, line chart

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