Lesson 28: Drawing a Conclusion from an Experiment

Classwork

In this lesson, you will be conducting all phases of an experiment: collecting data, creating a randomization distribution based on these data, and determining if there is a significant difference in treatment effects. In the next lesson, you will develop a report of your findings.

The following experiments are in homage to George E. P. Box, a famous statistician who worked extensively in the areas of quality control, design of experiments, and other topics. He earned the honor of Fellow of the Royal Society during his career and is a former president of the American Statistical Association. Several resources are available regarding his work and life including the book *Statistics for Experimenters: Design, Innovation, and Discovery* by Box, Hunter, and Hunter.

The experiments will investigate whether modifications in certain dimensions of a paper helicopter will affect its flight time.

Exercise 1: Build the Helicopters

In preparation for your data collection, you will need to construct 20 paper helicopters following the blueprint given at the end of this lesson. For consistency, use the same type of paper for each helicopter. For greater stability, you may want to use a piece of tape to secure the two folded body panels to the body of the helicopter. By design, there will be some overlap from this folding in some helicopters.

You will carry out an experiment to investigate the effect of wing length on flight time.

a. Construct 20 helicopters with wing length $= 4$ inches, body length $= 3$ inches. Label 10 each of these helicopters with the word "long."

b. Take the other 10 helicopters and cut one inch off each of the wings so that you have 10 helicopters with 3 inch wings. Label each of these helicopters with the word "short."

c. How do you think wing length will affect flight time? Explain your answer.

Exploratory Challenge 1: Data Collection

Once you have built the 20 helicopters, each of them will be "flown" by dropping the helicopter from a fixed distance above the ground (preferably 12 feet or higher—record this height for use when presenting your findings later). For consistency, drop all helicopters from the same height each time, and try to perform this exercise in a space where possible confounding factors such as wind gusts and drafts from heating and air conditioning are eliminated.

a. Place the 20 helicopters in a bag, shake the bag, and randomly pull out one helicopter. Drop the helicopter from the starting height, and, using a stopwatch, record the amount of time it takes until the helicopter reaches the ground. Write down this "flight time" in the appropriate column in the table below. Repeat for the remaining 19 helicopters.

Some helicopters might fly more smoothly than others; you may want to record relevant comments in your report.

Flight Time (seconds)

Long Wings	Short Wings

b. Why might it be important to randomize (impartially select) the order in which the helicopters were dropped?

(This is *different from* the randomization you perform later when you are allocating observations to groups to develop the randomization distribution.)

Exploratory Challenge 2: Developing Claims and Using Technology

With the data in hand, you will now perform your analysis regarding the effect of "wing length."

Experiment: Wing Length

In this experiment, you'll examine whether wing length makes a difference in flight time. You will compare the helicopters with long wings (wing length $= 4$ inches) to the helicopters with short wings (wing length $= 3$ inches). Since you are dropping the helicopters from the same height in the same location, using the same type of paper, the only difference in the two groups will be the different wing lengths.

Questions: Does a 1-inch addition in wing length appear to result in a change in average flight time? If so, do helicopters with longer wing length or shorter wing length tend to have longer flight times on average?

Carry out a complete randomization test to answer these questions. Show all 5 steps and use the "Anova Shuffle" Applet described in the previous lessons to assist both in creating the distribution and with your computations. Be sure to write a final conclusion that clearly answers the questions in context.

Lesson Summary

In previous lessons, you learned how to carry out a randomization test to decide if there was a statistically significant difference between two groups in an experiment. Throughout these previous lessons, certain aspects of proper experimental design were discussed. In this lesson, you were able to carry out a complete experiment and collect your own data. When an experiment is developed, you must be careful to minimize confounding effects that may compromise or invalidate findings. When possible, the treatment groups should be created so that the only distinction between the groups in the experiment is the treatment imposed.

Problem Set

One other variable that can be adjusted in the paper helicopters is "body width." See the blueprints for details.

1. Construct 10 helicopters using the blueprint from the lesson. Label each helicopter with the word "narrow."

2. Develop a blueprint for a helicopter that is identical to the helicopter of the blueprint used in class except for the fact that the body width will now be 1.75 inches.

3. Use the blueprint to construct 10 of these new helicopters, and label each of these helicopters with the word "wide."

4. Place the 20 helicopters in a bag, shake the bag, and randomly pull out one helicopter. Drop the helicopter from the starting height, and, using a stopwatch, record the amount of time it takes until the helicopter reaches the ground. Write down this "flight time" in the appropriate column in the table below. Repeat for the remaining 19 helicopters.

Flight Time (seconds)

Narrow Body	Wide Body

5. Question: Does a 0.5 inch addition in body width appear to result in a change in average flight time? If so, do helicopters with wider body width or narrower body width tend to have longer flight times on average? Carry out a complete randomization test to answer these questions. Show all 5 steps and use the "Anova Shuffle" Applet described in previous lessons to assist both in creating the distribution and with your computations. Be sure to write a final conclusion that clearly answers the questions in context.