What you will learn about:
Experiment Design

Pennies:
Hand
#

DESIGN OF EXPERIMENTS

Statistical Reasoning involves these steps:

- formulate a Question that can be answed with data
- Collect Data
- Dispky + Summurize Data
- Interpert Results + make generalizations

1. A common science experiment attempts to determine if mung bean seeds that are given a gentle zap in a microwave oven are more likely to sprout than mung bean seeds that are not given a zap.

Mung beans that were zapped in a microwave oven

Treatments Conditions you want to Compare

a. In such an experiment, what are the **treatments?** What is the **response variable?**

Treatment: Zapped in microwave / Not zapped

R.V. Sprout or not

Response Variable Outcome you want to measure.

b. For this experiment, Carlos zapped 10 mung bean seeds and 8 sprouted. Explain why Carlos should not conclude that mung bean seeds zapped in a microwave are more likely to sprout than if they had not been zapped.

He doesn't know the rate at which unzapped seeds sprouted.

c. For her experiment, Mia took 20 mung bean seeds, picked 10 that looked healthy and zapped them. Of the 10 that were not zapped, 3 sprouted. Explain why Mia should not conclude that mung bean seeds zapped in a microwave are more likely to sprout than if they had not been zapped. "Healthy" → more likely to sprout.

d. For her experiment, Julia took 4 mung bean seeds, selected 2 at random to be zapped, and zapped those 2. Both seeds that were zapped sprouted. The 2 seeds that were not zapped did not sprout. Explain why Julia should not conclude that mung bean seeds zapped in a microwave are more likely to sprout than if they had not been zapped.

Not enough seeds.

e. Design an experiment to determine if mung bean seeds are more likely to sprout if they are zapped in a microwave.

Subjects:

Groups being tested

2. In a typical experiment, two or more treatments are randomly assigned to an available group of people called **subjects**. The purpose of an experiment is to estabish cause and effect. Does one treatment cause a different response than the other treatment? A well-designed experiment must have three charateristics.

- Random Assignments: Treatments are randomly Assigned to subjects
- Sufficent Number of subjects: Enough subjects to make an accurate evaluation
- Control Group: Group that receives no treatement.

a. Which charateristic(s) of a well-designed experiment was (were) missing in Problem 1 in the mung bean seed study of:

Carlos	Mia	Julia
Control Group.	Random Assignment	Sufficient # of Subjects

b. Which charateristic of a well-designed experiment, if any, were missing from your penny-stacking experiment?

c. What can go wrong if treatments are not assigned randomly to subjects? Data becomes skewed

Introduce Bias

Results are inaccurate

3. In 1954, a huge medical experiment was carried out to test wether a newly developed vaccine by Jonas Salk was effective in preventing polio. Over 400,000 childern partcipated in the portion of the study described here. Children were randomly assigned to one of two treatments. One group received a placebo (an injection that looked – and felt – like a regular immunization but contained only salt water). The other group received an injection of the Salk vaccine.

   a. What are the treatments in the Salk experiment? What is the response variable?

   Treatment — Salt water
   Vaccine

   R.V. — Does Vaccine prevent Kids from getting polio.

   b. Did the test of the Salk vaccine have the three charateristics of a well-designed experiment?

4. Many difficulties in testing the Salk vaccine had been anticipated. Which of the three charateristics of a well-desinged experiment helped overcome each difficlty described below? Explain.

a. The incidence of polio was very low, even without immunization.

Large # of Subjects

b. The vaccine was not expected to be 100% effective.

Control Group

c. One possible approach would have been to immunize all children in the study and compare the incidience of polio to that of children the same age the previous year. However, the incidence of polio varied widely from year to year.

Random Assignment

d. One possible experiment design would have been to let parents decide whether their child was vaccinated and compare the rates of poilo of the vaccintated and unvaccinated children. In the United States, poilo was primarily a disease of children from middle- and upper- income families and so those children's parents are specially anxious to get them vaccinated.

Random Assignment

5. Many studies have shown that people tend to do better when they are given special attention of when the believe that are getting competent medical care. This is called the placebo effect. Even people with post-surgical pain report less discomfort if they are given a pill that is actually a placebo (a pill containing no medicine) but which they believe contains a painkiller.
One way to control for the placebo effect is to make the experiment **subject blind**, the person receiving the treatment does not know which treatment he or she is getting. That is, the

subjects in both treatment groups appear to be treated exactly the same way.
In an **evaluator-blind** experiment, the person who evaluates how well the treatment works does not know which treatment the subject received. If an experiment is both subject blind and evaluator blind, it is called a **double blind**.

a. The Salk experiment was double blind. One reason this was nessesary was because the diagnosis of polio is not clear-cut. Cases that cause paralysis are obvious, but they are the exception. Sometimes polio looks like a bad cold and so professional judgement is needed. How might a doctor's knowledge of whether or not a child had been immunized affects his or her diagnosis? How might this lead to the wrong conclusion about how well the vaccine works?

b. Could you make the penny-stacking experiment subject blind? Evaluator Blind? Double Blind? Expalin

6. A lurking variable helps to explain the association between the treatments and the response but is not the explanation that the study was designed to test. Treatments are assigned randomly to sbjuects to equalize the effects of possible lurking varialbes amoung the treatment groups as much as possible. Analyze each of the following reports of studies with particular attention to possible lurking variables.

a. Researchers from the Minnesota Antibiotic Resistance Collaborative reported an attempt to deal with the problem that bacteria are becoming resistant to antibiotics. One reason for increasing resistance is that some people want antibiotics when

they have a cold, even though cold viruses do not respond to antibiotics.
Five medical clinics distributed colorful kits containing Tylenol decongestant, cough syrup, lozenges, powdered chicken soup, and a tea bag to patients with cold symptoms. At five other medical clinics, patients with similar symptoms were not given these kits. Patients with colds who visited clinics that made the kits available were less likely to fill prescriptions of antibiotics than patients with colds who visited clinics where the kits were not available.

i. What are the treatments in the study? What is the response variable?

ii. Why is this not a well-designed experiment? How could you improve it?

iii. What lurking variable might account for the difference in responses?

b. Researchers supplied 238 New York City households with hand-washing soaps, laundry detergents, and kitchen cleansers. Half of the households, selected at random, were given antibacterial products, and the other half received products that were identically packaged but without the antibacterial ingredient.
The participants were asked weekly about any disease in the household. The researchers found no differences in frequency of infectious disease symptoms over one year.

i. Does this study have the three characteristics of a well-designed experiment?

ii. Suppose that instead of assigning the treatments at random to the households, the researchers simply compare the frequency of infectious disease symptoms one a year in households that use the antibacterial products and those that do not. Describe lurking variables that might invalidate the conclusion of the study.

c. A December 2004 article on Washingtonpost.com entitled "In AP-vs-IB Debate, A Win for Students" reports on a study by the National Center for Education Accountability that show that "even students who fail AP examinations in high school are twice as likely to graduate from college in five years as students who never try AP." This study followed 78,079 students in Texas.

i. What are the treatments? What is the response variable?

ii. Do you think that the conclusion came from a well-designed experiment?

iii. What lurking variables could account for the differences in response for the two groups?

iv. Can you design an experiment to establish that taking AP courses, even if you fail the exam, means you are more likely to graduate from college in five years?