Part III – Gathering Data

Ch. 13 – Experiments and Observational Studies

Experiments v. Observational Studies

- Usually statisticians are looking for answers to questions like these:
  - Does smoking cause lung cancer?
  - Does a new AP Stat book provide better AP Exam results?
  - Does a particular medication reduce pulse rate?
- We answer questions like these in two ways: through observational studies and controlled experiments
- Observational Study: Observes individuals and measures variables of interest but does not attempt to influence their responses
- Experiment: Deliberately imposes some treatment on individuals in order to observe their responses

Types of Observational Studies

- A <u>retrospective study</u> identifies a group of subjects and examines their past
  - To determine the effect of coal mining on lung health, examine the health histories of a sample of 500 coal miners
- A <u>prospective study</u> identifies a group of subjects and then tracks them over a period of time
  - Identify a set of miners early in their careers and track their health and other factors in their lives over 20 years

What Can Observational Studies Tell Us?

- Observational studies can find relationships between variables or identify trends, but cannot show cause and effect
- For example, an observational study may find that students using our new textbook get better AP exam results, but it cannot show that this difference is due to the book – there may be other factors
- To show cause and effect, we need to do a carefully controlled experiment
- This is ideal, but not always practical, especially when dealing with people

Randomized, Comparative Experiments

- In order for an investigation to be considered an experiment, we must do something to influence our subjects (impose a treatment)
- In order for it to be a good experiment, we have to provide a careful design which includes some specific elements
- Two of the most important elements are that our design must include random assignment to two or more groups, and then do a comparison of those groups

Vocabulary of Experiments

- Factor: Explanatory variable (there may be more than one)
- Levels: The different values chosen for each factor
- Response Variable: The result being measured and compared
- Experimental Units: The individuals on which the experiment is done
- Subjects or Participants: Human experimental units
- Treatment: The specific combination of levels from all factors that an experimental group will be receiving

Example 1

- I want to compare two common blood pressure medications – Cardizem and Lotensin to see which is more effective. I plan to randomly assign 50 high blood pressure patients to receive Cardizem, and 50 to receive Lotensin. At the end of 30 days, I will compare the change in the patients' blood pressure.
- Identify each of the parts of this experiment

Example 1

- Factor: Type of medication
- Levels: Cardizem and Lotensin
- Response Variable: Change in blood pressure
- Experimental Units: High blood pressure patients (subjects)
- Treatment: Group 1: Cardizem, Group 2: Lotensin

Example 2

- Suppose I am trying to make the perfect pound cake. I plan to test 3 different baking temperatures (325°, 375° and 425°), and 2 different baking pans (glass and metal). I am going to bake 24 cakes, and see which cakes my family thinks taste the best.
- Identify the parts of this experiment

Example 2

- Factors: Temperature, Pan Type
- Levels: Temperature - 325°, 375° and 425°; Pan - glass & metal
- Response Variable: Family opinion
- Experimental Units: Cakes
- Treatment: Six treatments (325° in glass, 375° in glass, 425° in glass, 325° in metal, 375° in metal, 425° in metal)

3 Principles of Experimental Design

- Control: Limit the effects of lurking variables on the response (comparison is the most basic form)
- Randomization: Use impersonal chance to assign subjects to treatments
- Replication: Repeat the experiment many times to confirm results
  - Use many subjects within one experiment
  - Repeat the experiment many times on different groups of subjects

Using the Principles

- Let's reconsider my blood pressure medication experiment
- Control: My two groups should, as much as possible, be kept under the same conditions
- Randomization: My subjects should be *randomly assigned* to my two treatment groups
- Replication: I have used 100 subjects in this experiment. My results should also be verified by other scientists' testing for further confirmation

Blocking

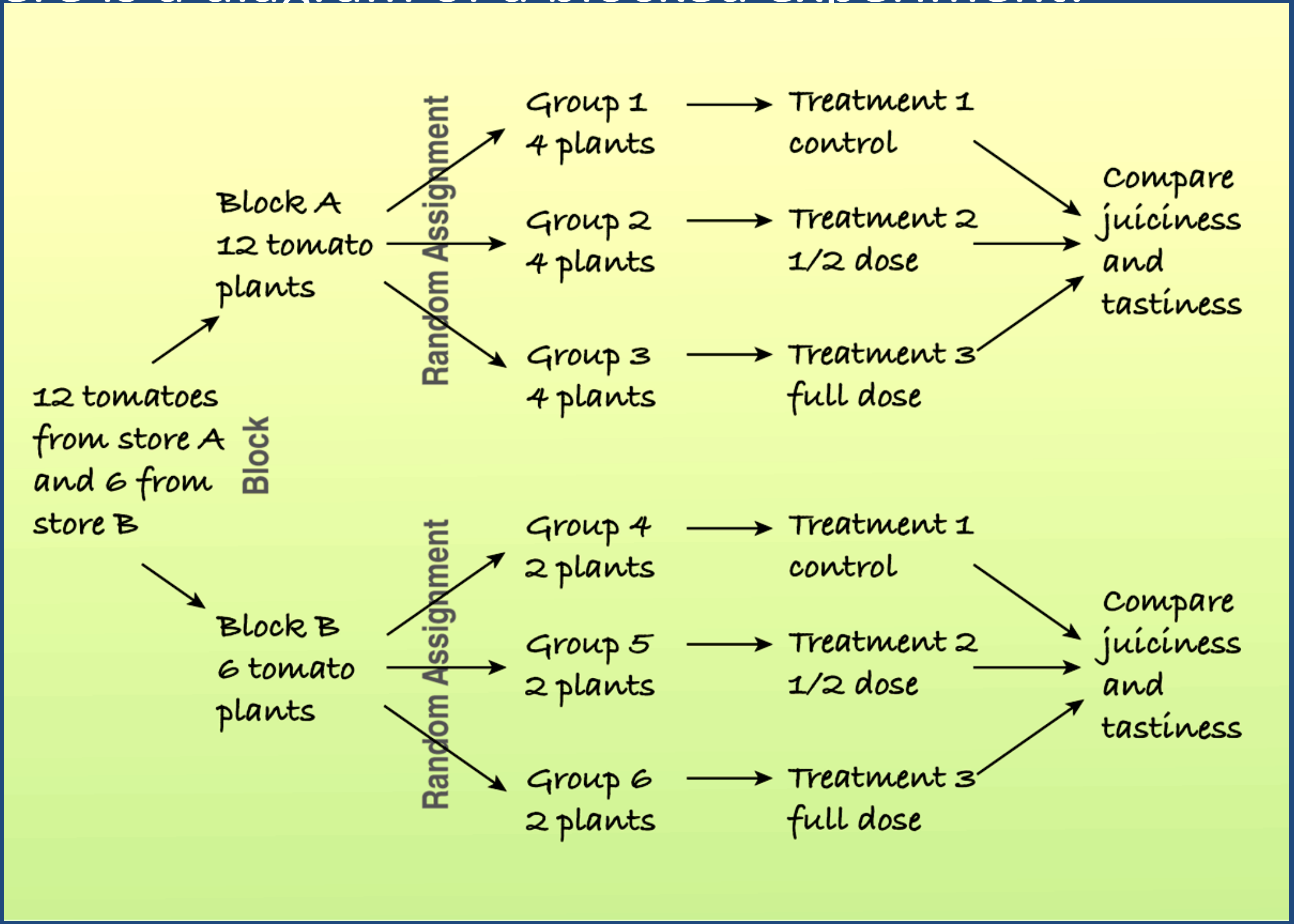
- Blocking is an additional form of control
- First divide the subjects up by some shared characteristic (gender, health history, etc.), then carry out the randomized experiment within each block
- Blocks should be homogeneous (within the group, subjects are the same)
- This should seem familiar – it's the same idea as stratified sampling
- Blocking (along with other forms of control) takes care of variables I know about, while randomization takes care of variables I don't know about

Describing with Diagrams

- Randomized experiments are often described with a diagram
- Suppose we want to test a new type of fish food:

Blocking (cont.)

- Here is a diagram of a blocked experiment:



Statistical Significance

- What happens if the fish being fed the new food turn out healthier than the fish being fed the old food?
- We have to decide whether the difference in fish health between the two groups is due to random chance (some fish are just healthier than others), or whether the difference is big enough for us to decide that the food is causing the difference
- If the differences between groups are too big to be attributed to chance alone, we call these differences "statistically significant"

Sampling v. Experimentation

- In sampling you are selecting part (a sample) of a large group (the population) in order to estimate a population parameter
- In an experiment you are dividing up all of your available experimental units among different treatment groups in order to assess the differences between treatments
- Your subjects will not always be a representative group of the larger population – be careful of generalizing your results beyond the group you used in your experiment

Blinding

- When we know what treatment was assigned, it’s difficult not to let that knowledge influence our assessment of the response, even when we try to be careful.
- In order to avoid the bias that might result from knowing what treatment was assigned, we use <u>blinding</u>.

Blinding (cont.)

- There are two main classes of individuals who can affect the outcome of the experiment:
  - those who could influence the results (subjects, treatment administrators, technicians)
  - those who evaluate the results (judges, treating physicians, etc.)
- When all individuals in *either one* of these classes are blinded, an experiment is said to be <u>single-blind</u>.
- When everyone in *both* classes is blinded, the experiment is called <u>double-blind</u>.

Example

- Suppose we are testing a new fertilizer on tomato plants. We are going to give one group of tomatoes the fertilizer and another group no fertilizer and compare the quality of the tomatoes. Should the subjects testing the tomatoes and the people caring for the tomatoes be blinded?

Example

- In 2007, deaths of a large number of dogs and cats were ultimately traced to contamination of some brands of pet foods. The manufacturer now claims that the food is safe, but before it can be released, it must be tested. How would you set up an experiment to test the new food?

Example

- Should the vet be blinded in this experiment? Why or Why not?

Placebos

- Often simply applying *any* treatment can induce an improvement.
- To separate out the effects of the treatment of interest, we can use a control treatment that mimics the treatment itself.
- A “fake” treatment that looks just like the treatment being tested is called a placebo.
  - Placebos are the best way to blind subjects from knowing whether they are receiving the treatment or not.

Placebos (cont.)

- The placebo effect occurs when taking the sham treatment results in a change in the response variable.
  - This highlights both the importance of effective blinding and the importance of comparing treatments with a control.
- Placebo controls are so effective that you should use them as an essential tool for blinding whenever possible.

The Best Experiments…

- are usually:
  - randomized.
  - comparative.
  - double-blind.
  - placebo-controlled.

Control Group

- The experimental units assigned to a baseline treatment level, typically either the default treatment, which is well understood, or a null, placebo treatment. Their responses provide a basis for comparison

Example

- Suppose you wanted to test a $300 piece of software designed to shorten download times. You could just try it on several files and record the download times, but you probably want to compare the speed with what would happen without the software installed. This baseline measurement would be the control treatment.

Confounding Variables

- When the levels of one factor are associated with the levels of another factor, we say that these two factors are confounded.
- In some experiments it is not possible to avoid confounding variables.

Example

- After many dogs and cats suffered health problems caused by contaminated foods, we’re trying to find out whether a newly formulated pet food is safe. Our experiment will feed some animals the new food and others a food known to be safe, and a veterinarian will check the response. Why would it be a bad design to feed the test food to some dogs and the safe food to some cats?

Answer

- This would create confounding variables. We would not be able to tell whether any difference in animals’ health were attributable to the food they had eaten or to the difference in how the two species responded. A better design would be to have a random sample of both cats and dogs try the test food and another random sample of both cats and dogs eat the safe food.

Confounding Variables

- A confounding variable is associated with a factor and affects the response.
- We can’t tell whether the effect we see was caused by our factor or by the confounding variable or by both working together.
- One of the purposes of blinding in an experiment is to combat a possible source of confounding variables.

Exit Slip

- Some people claim they can get relief from migraine headache pain by drinking a large glass of ice water. Researchers plan to enlist several people who suffer from migraines in a test. When a participant experiences a migraine headache, he or she will take a pill that may be a standard pain reliever or a placebo. Half of each group will also drink ice water. Participants will then report the level of pain relief they experience.

Exit Slip

- (a) The factors
- (B) The levels
- (c) The subjects studied
- (d) Response Variable
- (e) The treatment
- (f) The design (random, blocked, blind, double –blind, placebo)

Homework 13-1

- Pg. 312 # 3, 8, 9, 10, 11, 14
- Read pg. 301 to Pg. 303 and take notes about blinding and placebos.