CONDUCTING EXPERIMENTS

Learning Objectives

By the end of this lesson we will:

- Be able to tell the difference between an observational study and an experiment
- Identify the experimental units, explanatory variable, response variable, and treatments in an experiment
- Understand the necessity of comparison, random assignment, control and replication in a well-designed experiment
- Describe and design a completely randomized experiment
- Describe and design a randomized block design experiment highlighting the purpose of blocking
- Explain what is possible or not possible to infer about a statistical study

Vocabulary

Observational study- is when individuals are observed but the variable of interest is not influenced

Experiment- imposes a treatment on individuals and their responses to treatments are recorded

Explanatory Variable: helps explain or predict changes in the response variable

Response Variable- is the measured outcome of a study

Confounding- occurs when two or more variables are associated in a way that we can't determine which one/both are influencing the response variable

Vocabulary

Placebo- is a fake treatment (no active ingredient) that looks like the other treatments

Treatment- is a condition applied to individuals in an experiment

Experimental units- are the individuals to which the treatments are applied

if human → subjects

Factors- When an experiment has multiple explanatory variables, they are called factors.

Levels- are the various treatments for each of the factors

Control Group- can be an inactive treatment group, an active treatment group, or a group that receives no treatment
- provides a baseline for comparison

Placebo Effect- is when some subjects respond favorably to any treatment even a placebo

Vocabulary

Single Blind- either the subjects or the person measuring the response are not aware of what treatment was assigned

Double Blind- neither the subject nor the person measuring the response are aware of what treatment was assigned

Random assignment- occurs when experimental units are assigned treatments by chance

Statistically significant- is when the observed response is so dramatic that it would rarely happen by chance

Block- is a group of individuals, that are known before the experiment, to be similar in some way

Control- means to keep other variables constant for all experimental units

Replication- means to use enough experimental units so we can see a difference in the effects of the treatment from chance variation

4 ESSENTIALS TO EXPERIMENTAL DESIGN

1. Comparison-use a design that compares two or more treatments

2. **Random Assignment-**use a chance process to assign experimental units to treatments.

Purpose-this creates roughly equivalent groups of experimental units and will spread the effects of other variables (ones we are not measuring a response for but could be confounding) across treatment groups

3. Control-keep other variables that might affect the response the same for all groups

4. Replication-use as many experimental units as possible in each group

Purpose-any differences in the effects of the treatments can be distinguished from differences that happen purely by chance between the groups

OUR GOAL IS TO <u>ALWAYS</u> SEEK WAYS TO REDUCE VARIABILITY!

Identify if a study is observational study or an experiment

1. Ms. Hogan is interested in seeing if traditional classroom instruction produces higher test scores than virtual online classes. She gives 100 AP statistics students a pretest. She then randomly divides them into two groups. One group goes through the course in a traditional classroom setting and the other group takes the course online. At the end of the school year she tests all the students again to compare their scores. Is this an observational study or an experiment? Explain your answer.

This is an experiment. Treatments are imposed on the subjects (traditional vs. online instruction).

Identify if a study is observational study or an experiment

2. Do cell phones cause brain cancer? A study looked at a group of 500 people who had brain cancer. The study matched up each cancer patient with another person of the same age, gender, and race, who did not have cancer. They then asked them a series of questions detailing cell phone usage. They came to the conclusion that cell phone use is not associated with risk of brain cancer. Is this an observational study or an experiment? Explain your answer.

This is an observational study. No treatments were imposed on the subjects.

Identifying experimental units, explanatory variables, response variables, & treatments

3. Refer back to the traditional classroom vs. virtual class scenario. Identify the experimental units, the explanatory and response variables, and the treatments.

Experimental Units: 100 AP Stats students
Explanatory Variable: type of classroom setting
Response Variable: test scores
Treatments: traditional classroom instruction
online classroom instruction

4. Increasing heart rate with exercise. Students in Ms. Hogan's AP stats class are interested in how exercise affects heart rate. Students first measured their resting heart rate. Then students did squats for 30 seconds, 60 seconds, and 90 seconds. They squatted with no weights, 2-pound dumbbells, and 5-pound dumbbells. 36 students took part in the activity. 4 students participated in each combination of time and weights. After the exercise they measured their heart rate. Identify the experimental units, the explanatory and response variables, and treatments.

Experimental Units: 36 students in Ms. Hogan's AP Stats class
Explanatory Variable: Types of exercise
Response Variable: heart rate
Treatments

9 treatments

Types of Experimental Designs

Completely Randomized design- assigns experimental units to the treatments strictly by chance

-it does not require that each treatment be assigned to an equal number of experimental units

-the only requirement is that treatments are assigned to the groups using a random process

Randomized Block Design- blocking is used first to separate experimental units into groups based on some characteristic and then we proceed to randomly assign experimental units treatments within each block separately

-we block to account for variation in the response due to the variable we are blocking for

-this allows us to determine if one treatment is really more effective than the other

Matched Pair Design-is a common type of block design used when we want to compare two treatments

-the idea is to create blocks by matching pairs of similar experimental units

-we use a chance process (random assignment) to determine which of the pair gets the first treatment

-often the "pair" in a matched pairs design is just one experimental unit which serves as it's own control (still randomize order of treatments)

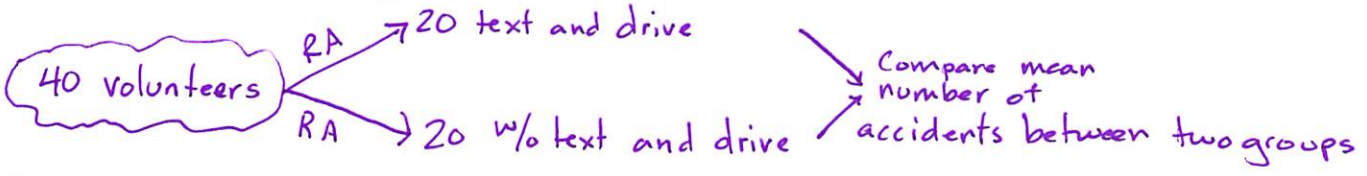
Design the best experiment for the given scenarios

5. Is texting while driving really that distracting?

40 of Ms. Hogan's students have volunteered for a study to determine how distracting texting is while driving. Orange County Sheriff's department has given us a driving simulator to use in the experiment.

Choose an experimental design that you think will answer this question the best. Explain your choice. Now design the experiment!

Completely Randomized Design → randomy assign into two groups (texting/no texting)



Take the 40 volunteers and write each of their names on equally sized slips of paper. Place in a container, mix well. Draw out 20 slips. These students will text and drive. The remaining students will drive without texting. Record the number of accidents for each student. Compare mean number of accidents for each group.

Types of Experimental Designs

6. How do different types of television shows impact young children? 80 five-year-olds, 40 males and 40 females, have been chosen to participate in the study. The treatments are 10 minutes of fast-paced children's programming and 10 minutes of slow-paced children's programming. After the 10 minutes the children will take a test for mental ability and attention span.

Choose an experimental design that you think will answer this question the best. Explain your choice. Now design the experiment!

Matched Pairs design because there are two treatments and each child could do both to compare results for each child.

Assign one 5-year-old one of the treatments by flipping a coin. If it lands on heads, assign them 10 min of fast-paced programming. If it lands on tails, assign them 10 min of slow-paced programming. Give them the test. Record results. Wait a period of time and give them the remaining treatment. Give the test again. Record results. Compare the test scores for that child. Repeat this process for the remaining 79 5-year-olds.

Inference on Studies

What conclusions can we draw from a study?

Random Selection of individuals from the whole population allows us to make inference about the population if the results are **statistically significant.**

Random assignment of individuals to groups allows us to make inference about cause and effect.

We have to ask ourselves two questions once we have collected data in a study.

1. Were the individuals for the study randomly selected from the population of interest?

-If the answer to this question is yes, then we can make an inference about the population of interest. If the answer is no, we can't make an inference about the population.

Inference on Studies

2. Were the individuals randomly assigned to groups?

-If the answer to this question is yes, then we can make an inference about cause and effect. If the answer is no, we can't make a cause and effect inference.

Random sampling helps to avoid bias and gives us a good estimate of the truth about the population.

The purpose of random assignment creates groups that are as similar as possible.

Experiments rarely randomly choose individuals from the population so that limits most experiments from making an inference about a whole population.

Observational studies do not randomly assign individuals to groups so you can't make an inference about cause and effect.

What can we infer?

7. Does playing classical music increase test scores? Ms. Hogan wants to study the effects of playing classical music, while testing, on her students. She randomly assigns two of her AP Statistics classes to listen to classical music and two classes no music while taking an exam. The students who listened to classical music had a test average of 80.2. The students who tested without music had a test average of 77.5. What conclusions can be drawn from this study? Explain.

The students were not randomly selected so we can't generalize our results for all students.
The students were randomly assigned to groups so we can establish cause and effect for these students.

8. Do female students at Olympia High School spend more time studying than male students? AP Statistics students randomly selected 100 male and 100 female students and asked them how many hours a night they study. Female students surveyed averaged 1.875 hours per night and male students averaged .975 hours per night. What conclusions can be drawn from this study? Explain.

The students were randomly selected so we can generalize our results to all students at this school.
The students were not randomly assigned to groups so we can't establish cause and effect.