Lesson 2: Observational Studies and Experiments

In Lesson 1, we learned about *sample surveys* or methods to choose a sample. A good sample survey (sampling method) always uses *randomness* when choosing the participants to eliminate *bias* and produce data that will allow us to make claims and predictions about a population.

There are two other ways to gather data for statistical analyses: they are called *observational studies* and *experiments*. *Randomness* plays a role in these methods as well.

<table>
<thead>
<tr>
<th>An <strong>observational study</strong> observes individuals and measures variables of interest but does not attempt to influence the responses. Data is collected. Nothing is influenced by the researcher.</th>
<th>An <strong>experiment</strong> deliberately imposes some treatment on individuals to measure their responses. In an experiment, the researcher has <strong>control</strong> of the variables of interest.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look but don’t touch! <em>(No treatment)</em></td>
<td>Look and touch! <em>(Treatment)</em></td>
</tr>
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This guy is basically Captain Observational Study. He has his clipboard ready, and his cape!

These two are doing an experiment for sure. She is doing some major science. He is “helping.”

The pictures are silly, but they help us remember that in experiments you are doing something, not just watching!

Before we explore these further, the most important skill is being able to tell the difference between an observational study and an experiment. The most important thing is to look to see if the researcher is imposing a treatment!

Ask yourself: *Are they doing something to the people/things in the study?* If yes, then it is an experiment. If no treatment is imposed, then it is an observational study!

Example 1:
Does reducing screen brightness increase battery life in laptop computers? To find out, researchers obtained 30 new laptops of the same brand. They chose 15 of the computers at random and adjusted their screens to the brightest setting. The other 15 laptop screens were left at the default setting (moderate brightness). Researchers then measured how long each machine’s battery lasted. Was this an observational study or an experiment? Explain:

*Experiment* - The researchers imposed a treatment, in this case, screen brightness.
Example 2:
Does eating dinner with their families improve students' academic performance? According to an ABC News article, "Teenagers who eat with their families at least five times a week are more likely to get better grades in school." This finding was based on a sample survey conducted by researchers at Columbia University. Was this an observational study or an experiment? Explain:

Observational Study - No treatment was imposed. The researcher simply used the results of the sample survey.

Surveys, questionnaires, online polls (like a twitter poll), researching available data from other sources, and a guy with a clipboard in a mall asking you questions are all examples of observational studies. Sample surveys are a type of observational study.

All sample surveys are observational studies, but not all observational studies are sample surveys.

Observational studies do not allow us to show causation, or cause and effect relationships.

When the subjects are selected randomly, we are able to use the data from an observational study to make claims about a population.

Observational studies are great for describing a specific group, comparing groups, or examining the relationship/patterns between variables.

Example 3:
Consider the multiple choice below, don't answer it yet!
Which scenario describes an observational study that is not a sample survey?
1) For a class project, students in Health class ask every tenth student entering the school if they eat breakfast in the morning.
   
2) A social researcher wants to learn whether or not there is a link between attendance and grades. She gathers data from 15 school districts.
3) A researcher wants to learn whether or not there is a link between children's daily amount of physical activity and their overall energy level. During lunch at the local high school, she distributed a short questionnaire to students in the cafeteria.
4) Sixty seniors taking a course in Advanced Algebra Concepts are randomly divided into two classes. One class uses a graphing calculator all the time, and the other class never uses graphing calculators. A guidance counselor wants to determine whether there is a link between graphing calculator use and students' final exam grades.

Circle the option of data collection that each choice best describes to help answer the question.

Choice 1: sample survey observational study experiment

Choice 2: sample survey observational study experiment

Choice 3: sample survey observational study experiment

Choice 4: sample survey observational study experiment
An **experiment** is the only way to establish a **cause and effect** relationship between two variables. Experiments are also great at examining relationships between two variables.

In an experiment, you have **control** over the variables of interest. If you observe a significant difference, you know it had to be caused by the treatment you imposed.

A well-designed experiment uses **randomization** to assign subjects to different groups. This helps to make the groups as similar as possible and eliminates bias.

In a very simple **controlled experiment**, you would have two groups (experimental and control). At the end of the experiment, you compare the results of the two groups.

**Control group (placebo group):** Receives a dummy treatment/placebo; sometimes they don’t receive a treatment at all. This group serves as a baseline.

**Experimental group:** Receives the treatment. This is the group we hope to observe a change in.

All experiments do not necessarily have to have a control group. Many experiments examine more than one variable and have multiple treatments. These are just some of the basics of experimental design.

Example 4:
A professor is interested in whether giving a practice exam has an impact on the performance of students on their final exam. The professor has a class of 60 students. He randomly selects 30 of them to receive no practice exam, the other 30 of them receive a practice exam. At the end of the study the exam results are compared.

![Diagram of experiment setup]

a.) Which treatment was given to the control group? **A: No Practice Exam**

b.) Which treatment was given to the experimental group? **B: Practice Exam**

c.) At the end of the experiment the means for the two groups were $\bar{x}_1 = 75.5$ and $\bar{x}_2 = 82.3$.

Find $\bar{x}_2 - \bar{x}_1$.

$$82.3 - 75.5 = 6.8$$

d.) The professor was not surprised by this result. Explain why he might think this way.

We **expected** the practice exam group to score better on the exam producing a positive difference.
It will eventually be our goal in statistics to determine if the difference that we observed is large enough to make a claim that it couldn’t have happened by chance alone. If that is true, this means that something is likely happening in our study. This is the beginning of the idea of **statistical significance**.

Example 5:

a.) Describe how a controlled experiment can be created to examine the effect of whitening ingredient $X$ in a brand of toothpaste.

> Subjects randomly divided into 2 groups. One will get toothpaste with ingredient $X$ and the other group will get regular toothpaste. Whitening will be compared.

b.) If, at the end of the study, the researchers observed a significant difference in whitening, could they conclude that ingredient X caused the change in whitening?

> Yes - Experiments give evidence for cause and effect.

Example 6:

Which statement about statistical analysis is false?

1) Experiments can suggest patterns and relationships in data.
2) Experiments can determine cause and effect relationships.
3) Observational studies can determine cause and effect relationships.
4) Observational studies can suggest patterns and relationships in data.

In summary, some things to look for:

<table>
<thead>
<tr>
<th>Observational Studies</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observe only, no treatment</td>
<td>Treatment is imposed</td>
</tr>
<tr>
<td>Good for patterns and relationships</td>
<td>Good for cause and effect</td>
</tr>
<tr>
<td>Participants might be randomly selected</td>
<td>Participants are randomly assigned to treatments</td>
</tr>
<tr>
<td>Surveys, research, clipboard, watch and record</td>
<td>Control, placebo, comparison groups</td>
</tr>
</tbody>
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Just to fill the page, here is a guy who is definitely ready to do an experiment!