7.4: Experiments

Learning Objectives

- Understand the difference between an observational study and an experiment
- Plan a well-designed experiment
- Minimize confounding in an experiment

So far, we have primarily discussed **observational studies** – studies in which conclusions would be drawn from observations of a sample or the population. In some cases these observations might be unsolicited, such as studying the percentage of cars that turn right at a red light even when there is a "no turn on red" sign. In other cases the observations are solicited, like in a survey or a poll.

In contrast, it is common to use **experiments** when exploring how subjects react to an outside influence. In an experiment, some kind of **treatment** is applied to the subjects and the results are measured and recorded.

Observational Studies and Experiments

An **observational study** is a study based on observations or measurements. An **experiment** is a study in which the effects of a **treatment** are measured.

Here are some examples of experiments:

Example 7.4.1

a. A pharmaceutical company tests a new medicine for treating Alzheimer's disease by administering the drug to 50 elderly patients with recent diagnoses. The treatment is the new drug.
b. A gym tests out a new weight loss program by enlisting 30 volunteers to try out the program. The treatment is the new program.
c. You test a new kitchen cleaner by buying a bottle and cleaning your kitchen. The new cleaner is the treatment.
d. A psychology researcher explores the effect of music on temperament by measuring people's temperament while listening to different types of music. The music is the treatment.

Try It 7.4.1

Is each scenario describing an observational study or an experiment?

a. The weights of 30 randomly selected people are measured.
b. Subjects are asked to do 20 jumping jacks, and then their heart rates are measured.
c. 20 coffee drinkers and 20 tea drinkers are given a concentration test.

Answer

a. Observational study; there is no treatment
b. Experiment; the treatment is the jumping jacks
c. Experiment; the treatments are coffee and tea

When conducting experiments, it is essential to isolate the treatment being tested.

Example 7.4.2

Suppose a middle school (junior high) finds that their students are not scoring well on the state's standardized math test. How could the school conduct an experiment to improve math test scores?

Solution

The school decides to run an experiment to see if an alternate curriculum would improve scores. To run the experiment, they hire a math specialist to come in and teach a class using the new curriculum. To their delight, they see an improvement in test

scores. The treatment is the new curriculum.

The difficulty with this scenario is that it is not clear whether the curriculum is responsible for the improvement, or whether the improvement is due to a math specialist teaching the class. This is called **confounding** – when it is not clear which factor or factors caused the observed effect. Confounding is the downfall of many experiments, though sometimes it is hidden.

Confounding

Confounding occurs when there are two or more potential variables that could have caused the outcome and it is not possible to determine which actually caused the result.

Example 7.4.3

A drug company study about a weight loss pill might report that people lost an average of 8 pounds while using their new drug. How could confounding be a problem with their weight loss claim?

Solution

In the fine print you find a statement saying that participants were encouraged to also diet and exercise. It is not clear in this case whether the weight loss is due to the pill, to diet and exercise, or a combination of both.

Try It 7.4.2

Researchers conduct an experiment to determine whether students will perform better on an arithmetic test if they listen to music during the test. They first give the student a test without music, then give a similar test while the student listens to music. How could confounding be a problem with this experiment?

Answer

In this case, the student might perform better on the second test, regardless of the music, simply because it was the second test and they were warmed up.

There are a number of measures that can be introduced to help reduce the likelihood of confounding. The primary measure is to use a **control group**.

Control Group

When conducting an experiment, the participants are divided into two or more groups, typically a **control group** and a treatment group. The treatment group receives the treatment being tested; the control group does not receive the treatment.

Ideally, the groups are otherwise as similar as possible, isolating the treatment as the only potential source of difference between the groups. For this reason, the method of dividing groups is important. Some researchers attempt to ensure that the groups have similar characteristics (same number of females, same number of people over 50, etc.), but it is nearly impossible to control for every characteristic. Because of this, random assignment is very commonly used.

Example 7.4.4

How could a control group be used in an experiment to determine if a 2-day prep course would help high school students improve their scores on the SAT test?

Solution

A group of students takes the SAT and their scores are recorded. The group is then randomly divided into 2 subgroups. The first group, the treatment group, is given a 2-day prep course. The second group, the control group, is not given the prep course. Afterwards, both groups take the SAT again and their before-and-after scores are compared.

Try It 7.4.3

How could a control group be used in an experiment conducted by a company testing a new plant food?

Answer

They grow 2 crops of plants in adjacent fields, the treatment group receiving the new plant food and the control group not. The crop yield would then be compared. By growing them at the same time in adjacent fields, they are controlling for weather and other confounding factors.

Sometimes not giving the control group anything does not completely control for confounding variables. For example, suppose a medicine study is testing a new headache pill by giving the treatment group the pill and the control group nothing. If the treatment group showed improvement, we would not know whether it was due to the medicine in the pill, or a response to having taken any pill. This is called a **placebo effect**.

Placebo Effect

The **placebo effect** is when the effectiveness of a treatment is influenced by the patient's perception of how effective they think the treatment will be, so a result might be seen even if the treatment is ineffectual.

Example 7.4.5

A study found that when doing painful dental tooth extractions, patients told they were receiving a strong painkiller while actually receiving a saltwater injection found as much pain relief as patients receiving a dose of morphine. [1]

To control for the placebo effect, a **placebo**, or dummy treatment, is often given to the control group. This way, both groups are truly identical except for the specific treatment given.

Placebo and Placebo-controlled experiments

A **placebo** is a dummy treatment given to control for the placebo effect. An experiment that gives the control group a placebo is called a **placebo-controlled experiment**.

Here are some examples of placebo-controlled experiments:

Example 7.4.6

a. In a study for a new medicine that is dispensed in a pill form, a sugar pill could be used as a placebo.
b. In a study on the effect of alcohol on memory, a non-alcoholic beer might be given to the control group as a placebo.
c. In a study of a frozen meal diet plan, the treatment group would receive the diet food, and the control could be given standard frozen meals stripped of their original packaging.

In some cases, it is more appropriate to compare to a conventional treatment than a placebo. For example, in a cancer research study, it would not be ethical to deny any treatment to the control group or to give a placebo treatment. In this case, the currently acceptable medicine would be given to the control group, sometimes called a **comparison group** in this case. In our SAT test example, the non-treatment group would most likely be encouraged to study on their own, rather than be asked to not study at all, to provide a meaningful comparison.

When using a placebo, it would defeat the purpose if the participant knew they were receiving the placebo.

Blind studies

A **blind study** is one in which the participant does not know whether or not they are receiving the treatment or a placebo. A **double-blind study** is one in which those interacting with the participants don't know who is in the treatment group and who is in the control group.

Example 7.4.7

In a study about anti-depression medicine, you would not want the psychological evaluator to know whether the patient is in the treatment or control group either, as it might influence their evaluation, so the experiment should be conducted as a double-blind study.

It should be noted that not every experiment needs a control group.

Example 7.4.8

If a researcher is testing whether a new fabric can withstand fire, she simply needs to torch multiple samples of the fabric – there is no need for a control group.

Try It 7.4.4

To test a new lie detector, two groups of subjects are given the new test. One group is asked to answer all the questions truthfully, and the second group is asked to lie on one set of questions. The person administering the lie detector test does not know what group each subject is in.

Does this experiment have a control group? Is it blind, double-blind, or neither?

Answer

The truth-telling group could be considered the control group, but really both groups are treatment groups here, since it is important for the lie detector to be able to correctly identify lies, and also not identify truth telling as lying. This study is blind, since the person running the test does not know what group each subject is in.

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[1] Levine JD, Gordon NC, Smith R, Fields HL. (1981) Analgesic responses to morphine and placebo in individuals with postoperative pain. Pain. 10:379-89.
