

Experiments and Observational Studies

GOAL Distinguish between experiments and observational studies, and evaluate published reports based on them.

You have already seen that a survey is one way to collect data. Although surveys are useful, different situations require different techniques for gathering data. To explore these techniques, it is helpful to start with some vocabulary.

Individuals are people, animals, or objects that are described by a set of data. If you collect data on the fuel efficiency of 35 cars and trucks, the individuals are vehicles. Recall that a *variable* defines what you want to measure or describe about the individuals. Fuel efficiency, measured in miles per gallon of gasoline, is an example of a variable.

An **experiment** imposes a treatment on individuals to collect data on their response to the treatment. The treatment may be a medical treatment, such as administering a new drug, or it can be any action that may affect a variable, such as adding acetone to gasoline to measure its effect on fuel efficiency.

In some cases, it may be difficult to control the variable being studied or it may be unethical to subject people to a certain treatment. For example, a researcher may want to find out if poor nutrition affects eyesight, but it would not be ethical to run a study in which some individuals are deliberately subjected to poor nutrition. In this case, an *observational study* is used. An **observational study** observes individuals and measures variables without controlling the individuals or their environment in any way.

EXAMPLE 1 Identifying Experiments and Observational Studies

Determine whether each situation is an example of an experiment or an observational study. Explain.

- A researcher asks college students how many hours of sleep they get on an average night and examines whether the number of hours of sleep affects students' grades.
- An employee of the Parks Department wants to know if paint that includes latex is more durable than paint without latex. She has 50 park benches painted with a paint that includes latex and has 50 park benches painted with a paint that does not include latex.

SOLUTION

- The researcher gathers data without controlling the individuals or applying a treatment.

The situation is an example of an observational study.

- The employee applies a treatment (painting benches with a paint that includes latex) to some of the individuals (benches) in the study.

The situation is an example of an experiment.

In order for the data that are collected in an experiment to be useful, the experiment must be carefully designed. In a **controlled experiment**, two groups are studied under identical conditions with the exception of one variable. The group under ordinary conditions is the **control group**. The group that is subjected to the treatment is the **treatment group**.

In a **randomized comparative experiment**, individuals are randomly assigned to the control group or the treatment group. Randomization minimizes bias and produces groups of individuals that are theoretically similar in all ways before the treatment is applied. The comparison of the control group and the treatment group makes it possible to determine any effects of the treatment.

An experiment that is not a randomized comparative experiment may be subject to bias and any conclusions drawn from the experiment may not be valid.

EXAMPLE 2 Evaluating a Published Report

Determine whether the study described in the report at the right is a randomized comparative experiment. If so, describe the treatment, the treatment group, and the control group. If not, explain why not and explain whether the conclusions drawn from the study are valid.

SOLUTION

The study is not a randomized comparative study because the individuals were not randomly assigned to a control group and a treatment group. (In fact, the study is an observational study, not an experiment.)

The study's conclusion that milk fights cavities may not be valid. There may be other reasons why students who chose milk had fewer cavities. For example, students who voluntarily choose milk may be more likely to have other healthy eating habits that could affect the number of cavities they have.

Milk Fights Cavities

At Ashland Middle School, students were given the choice of drinking milk or other beverages at lunch. Fifty students who chose milk were monitored for one year, as were 50 students who chose other beverages. At the end of the year, students in the "milk" group had 15% fewer cavities than students in the other group.



CHECK Examples 1 and 2

1. Determine whether the situation in the report is an example of an experiment or an observational study. Explain.
2. Determine whether the study described in the report is a randomized comparative experiment. If so, describe the treatment, the treatment group, and the control group. If not, explain why not and explain whether the conclusions drawn from the study are valid.

A Faster Web Site

To test the redesign of its Web site, an online bookseller assembled 96 users of the site and randomly divided them into two groups. One group used the new Web site to make an online purchase and one group used the old Web site to do the same transaction. Users of the new site were able to complete the purchase 22% faster.

A randomized comparative experiment should be used to gather data whenever feasible because this type of study makes it possible to draw valid cause-and-effect conclusions. Such experiments are also *reliable*. That is, they can be repeated and can be expected to produce similar results each time.

In some situations, however, it may be necessary to use an observational study for reasons of practicality or ethics. In this case, it is still important that the study be *comparative* if at all possible.

For example, it would be unethical to ask some individuals to smoke in order to study the effects of nicotine on their health. Therefore, an observational study must be used. To make it a comparative study, the researchers should randomly choose one group of people who already smoke and one group of people who do not smoke.

EXAMPLE 3 Designing an Experiment or Observational Study

Explain whether the following research topic is best addressed through an experiment or an observational study. Then explain how you would set up the experiment or the observational study.

You want to know if listening to an MP3 player with earphones for more than one hour per day affects a person's hearing.

SOLUTION

The treatment (listening to an MP3 player with earphones for more than one hour per day) may affect an individual's hearing, so it is not ethical to assign individuals to a control group or treatment group. Use an observational study.

Randomly choose one group of people who already listen to an MP3 player with earphones for more than one hour per day.

Randomly choose another group of people who do not listen to an MP3 player with earphones for more than one hour per day.

Monitor the hearing of the individuals in both groups at regular intervals.



CHECK Example 3

3. Explain whether the following research topic is best addressed through an experiment or an observational study. Then explain how you would set up the experiment or the observational study.

You want to know if people who consume 1000 milligrams of vitamin C each day as a dietary supplement have lower cholesterol levels than people who do not consume vitamin C supplements.

EXERCISES

In Exercises 1–3, determine whether each situation is an example of an experiment or an observational study. Explain.

1. A researcher compares incomes of people who live in rural areas with incomes of people who live in large cities.
2. A doctor studies the increases or decreases in the blood pressure of people who are stung by bees.
3. A farmer wants to know if a new fertilizer affects the weight of the fruit produced by strawberry plants. She applies the fertilizer to 10 rows of plants and does not apply the fertilizer to 10 other rows of plants.

4. Determine whether the study described in the report is a randomized comparative experiment. If so, describe the treatment, the treatment group, and the control group. If not, explain why not and explain whether the conclusions drawn from the study are valid.

Early Birds Make Better Drivers

A recent study shows that adults who rise before 6:30 A.M. are better drivers than other adults. The study monitored the driving records of 140 volunteers who always wake up before 6:30 and 140 volunteers who never wake up before 6:30. The early risers had 12% fewer accidents.

In Exercises 5–7, explain whether the research topic is best addressed through an experiment or an observational study. Then explain how you would set up the experiment or the observational study.

5. You want to know if homes that are close to parks or schools have higher property values than other homes.
6. You want to know if dog food that contains Omega-3 fatty acids gives dogs a shiny coat.
7. You want to know if flowers that are sprayed twice a day with a mist of water stay fresh longer than flowers that are not sprayed.
8. A researcher studied the effect of fiber supplements on heart disease. The researcher identified 175 people who take fiber supplements and 175 people who do not take fiber supplements. The researcher found that the people who took the fiber supplements had 19% fewer heart attacks than the people who did not take the supplements. The researcher concluded that taking fiber supplements reduces the incidence of heart attacks.
 - a. Explain why the researcher's conclusion may not be valid.
 - b. Describe how the researcher could have conducted the study differently to produce valid results.
9. Explain why observational studies, rather than experiments, are usually used in astronomy.
10. Describe a research topic that is best addressed through an experiment. Then describe a research topic that is best addressed through an observational study.