

Purpose

In this extension activity, you will further explore the idea of fair tests. You have already begun the process by thinking about control variables and using control groups to create an opportunity for comparison. Next, we'll think through several ideas that can make drawing conclusions from tests tricky.

Evaluating the accuracy of various methods of collecting data

If you are making a measurement, one important consideration is how precise your measurement is. In professional scientific papers, measurements are usually accompanied by an estimate of the **error** or **uncertainty** in the measurement.

We say a measurement has good **precision** if several different measurements produce answers that differ very little. For example, you can estimate the length of a room by pacing it, but it would not be very precise. Someone else pacing the same room might come up with a quite different estimate of its length. You should always be aware of uncertainty in your measurements and take any steps possible to reduce it.

If the data from your experiment lacks the precision to determine the answer to your question, then your answer is "I don't know." That's often the best scientific answer we have.

Judging the data—Is it safe to draw a conclusion?



Think about this question: Should we trust the conclusion from an experiment for a medical treatment that used five people? Why or why not?

Sometimes the effect that you wish to see with an experiment is very small. For example, if you want to determine if a new medicine will be an effective treatment for a serious illness, it may be useful even if it only extends the life of 5% of the people who take it.

We won't be doing such experiments in this class, of course, but it's important to mention a couple of issues surrounding the detection of small effects. There are two big issues. The first is that **random variation** in the data might be mistaken for a real

difference between control and treatment groups. Scientists can use statistics to sort out whether it is likely a real effect. Sometimes it is not easy.

It is possible for any experiment that there is no correlation between the variables. In other words, sometimes you change one variable in a controlled manner (or treat the poison ivy, or take the medicine), and *the dependent variable doesn't change in response*. Cases like this are possible, and are referred to as a **null result**. Scientific thinkers must be ready for this if that's what the data says.

Wouldn't it be disappointing to get a null result? Maybe, depending on what your hopes were. This is the second issue relating to the detection of small events. Scientists have to be careful that they don't let their own **bias** get in the way. There are many ways to do this, but one of the more common ways is to use **blind tests**. For example, when testing new medicines, often *neither the doctor nor the patient* knows during the test if the medicine that they are taking is real or fake (called a **placebo**). That way, they can't muddy up the data with their hopes or expectations.

Take for example the case of the heart stent. When patients have blockages of coronary arteries, it is extremely common to use a heart stent, despite obvious risks associated with this major procedure. When an artery is blocked, it makes sense to open it up. When this particular procedure was studied – using a control group *that got incisions so they thought they got stents but they really didn't* – it was found that for stable patients, the stents did not help at all.

Note that this study used blind tests, used a control group, addressed the possibility of a placebo, and ended up with a surprising and important null result. Some who have questioned the results say it can't be trusted since the study only included about 200 people, but statistical analysis suggested that the result was significant. (An article describing the study is listed in the references.)

Finally, even if two things do seem correlated, this does not mean that one of them is causing the other. It is important to use good experiment design to establish whether something is caused by something else or simply correlated.

References

David Epstein and Propublica, *The Atlantic*, February 22, 2017. Online here:

https://www.theatlantic.com/health/archive/2017/11/placebo-effect-of-the-heart/545012/?utm_source=eb