About Statistics

When performing studies we collect data, and to figure out whether a phenomenon has taken place we need to study the data and figure out what it means. Depending on what data are collected, it may be either easy or difficult to figure out what it's trying to tell us. A method of analyzing data called "statistics" allows us to do this.

Statistics is the study of numerical data to figure out what's going on in some phenomenon. In the sciences it's usually done by figuring out how closely an independent and dependent variable are correlated, and in the humanities it's usually done by figuring out whether the results from small experimental groups is representative of what the whole of society experiences.

The reason that experimenters take so much data in an experiment is that more data usually means better answers. This is because the more data you get, the more likely it is that you'll get meaningful results. Here's an example:

Let's say that your parents have taken a strange car trip. Instead of driving to a specific location, they've decided to fill the tank with gas and then drive along a road until the car runs out of gas. When they do this, they find that the car has travelled 510.5 km. Now, imagine your friend's parents have done the same thing. After driving along the road they find that the car stops at a distance of 505.3 km. The question: Do the cars get the same gas mileage, or is there a difference between the two?

You're probably inclined to say that the car that travelled 510.5 km has better mileage than one that travelled 505.3 km. However, consider this: In the real world, the two cars are driven by different people. The road conditions may have been slightly different on the trip, and perhaps somebody slow was driving in front of your mom during a portion of the trip. All of these factors would change the specific mileage *for that trip*, but would not tell us whether the car itself had an inherently different gas mileage.

In other words, though the mileage may be different, it's not *statistically significant*, which is to say that the difference might be easily explained by chance.

How do we get around this? Well, we do the experiment over and over again to see how the data look. After all, if your parents travel farther than your friend's parents on one trip, that might be a coincidence. If they travel farther on three trips it might also be a coincidence, but it's a little less likely. If they travel farther on a thousand trips, it's probably not a coincidence anymore.

Now for the big question: How many tests do we need before we can say, once and for all with 100% certainty, that two things are different from one another? The answer: You can *never* make this statement. If you collect more data, you'll be able to say with greater and greater certainty that the difference is meaningful. However, saying that something is meaningful and that something is 100% true aren't the same thing. In scientific study we can *never* say that we know something with 100% certainty - only that the data overwhelmingly support the idea.

To get better data, experimenters generally try to perform experiments in such a way that all of the factors (variables) are controlled. In our car example, there are a lot of things that might cause errors, such as the road conditions, your parents' driving abilities, the weight in the car, and so forth. In government tests of gas mileage, these factors are eliminated by putting the car on a machine that keeps these variables constant and minimizes their effect. Even with this, we can never say that we know something with 100% accuracy, only that our data suggest it's extremely likely.

An example you can do at home: Flip a coin

Get a penny and flip it. It will either come up as heads or tails. You probably know there's a 50-50 chance of one or the other, so flip the penny and record your results. Here are some results I got while writing this:

Number of flips	Number of heads	Percent heads
40	24	60
80	45	56
120	60	50
160	77	48

As you can see, the first 40 flips made it look like heads had a much greater than 50-50 chance of coming up. However, as the number of flips increases, however, the percentage comes closer to 50-50. Theoretically, if an infinite number of flips are made, the percentage will be exactly 50%.

However, since we can never make an infinite number of measurements, we probably won't get the perfect answer we were looking for. As a result, we need to use statistics to see if the data are closely suggesting one thing or the other.