

Experiments versus Observational Studies

Experiments and observational studies are both ways of answering research questions that involve collecting and analysing data. The difference is that in an experiment, the researcher imposes some treatment on a random subset of the experimental units, whereas in an observational study, the researcher simply makes various measurements on a sample.

The difference between experiments and observational studies is important because it is difficult to make conclusions about causality from an observational study. It is preferable for questions of causality to use an experiment. Of course, in some situations this is not possible or is unethical, such as in the case of trying to build a case that smoking causes lung cancer (since it would be unethical to require a set of participants to smoke). In such cases, it is possible to build up a case for causality, but much more difficult.

Examples:

1. A medical researcher is interested in how a new therapy for a particular disease compares to an existing therapy. She recruits a set of participants with the disease and randomises them into two groups. One group is given the new treatment and the other group is given the existing treatment. This is an experiment, because the researcher has chosen what treatment each participant receives. If the participants receiving the new treatment have significantly better outcomes than those receiving the standard therapy, the researcher has evidence that the new treatment causes better outcomes than the old one.
2. A medical researcher is interested in how gender affects survival outcomes after heart surgery. He studies all patients who have undergone heart surgery over the past year at a given hospital to observe the difference in survival outcomes for the male versus female patients. This is an observational study, because the researcher is not imposing any treatment (all patients have already undergone heart surgery), but instead is only observing the participants. If women have better survival rates after heart surgery, the researcher is not able to cause that being female causes better outcomes, only that being female is associated with better outcomes. This is because it is possible, for instance, that what has really caused the difference in outcomes is how closely the participant follows medical advice post surgery, and that women are more likely to follow the advice carefully than men.
3. An engineer is interested in studying three galvanisation processes for aluminium cladding. He galvanises 500 samples of aluminium using each of the three processes and exposes the 1500 samples to a range of conditions, then grades the deterioration in the samples after six months. This is an experiment, because the experimenter has imposed different treatments on three subsets of the aluminium samples (galvanisation

procedures). The researcher can conclude that the galvanisation process that has the best outcomes causes better outcomes than the others.

4. An engineer is interested in how long automobiles of different makes last. She looks at the milages, ages and makes of all cars consigned to UK junkyards in 2013 to study the differences. This is an observational study because the researcher has not imposed any treatment on the cars, but has merely observed their ages and milages when they come to the junkyard. The engineer cannot conclude that being a particular make of automobile causes it to last longer, because it is possible that something else causes this and is also correlated to make. For instance, the researcher may find that Hondas last longer than Ferraris, but this may be because Honda drivers tend to be more frugal and drive more carefully, whereas Ferrari owners tend to drive more recklessly and put more wear on the engine.