MATH 124 Spring 2005

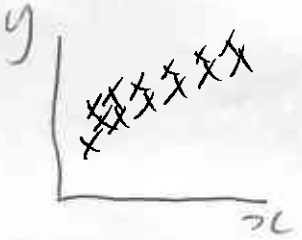
Lecture: 14
Date: Apr 7, 2005

Skills you should acquire from this lecture:

- Know the differences between and be able to define
  - Anecdotal evidence
  - Available data
  - Observational study/Sample survey
  - Experiment
- Difference between causation and association and which types of study lead to which type of conclusion.
- Fundamentals of experiments
  - Replication
  - Randomization
  - Bias/Chance variance
  - Experimental units
  - Factors
  - Treatments
  - Response

Related readings in the textbook:

-Sections 3.1, 3.2



Association – observe a relationship between two variables. eg as $x\uparrow$ so does $y\uparrow$

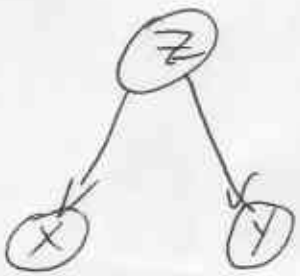
Causation – changing one variable leads to changes in the other variable. 

Does Association imply Causation? NO

Just because two variables are related does not mean there is a causal relationship between them.

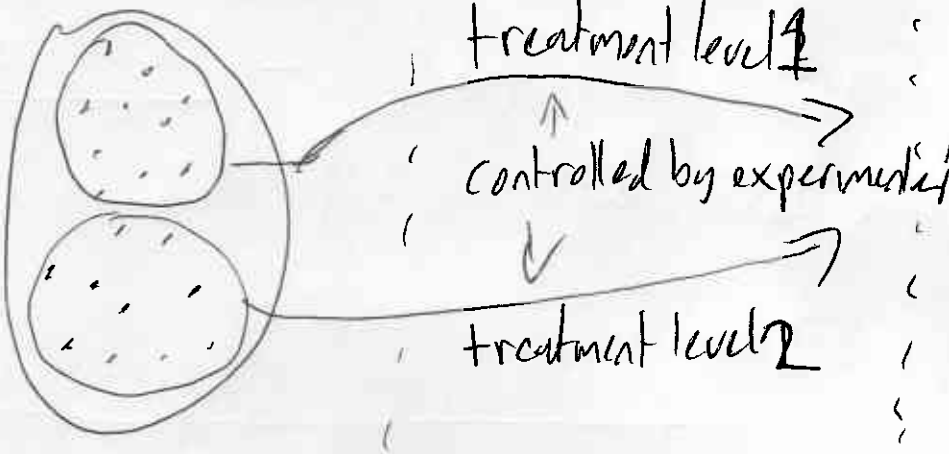
"Lurking Variable" an unmeasured variable that could explain both (or all) measured variables.

eg measure X, Y but unmeasured Z causes changes in X, Y



Then how do we show causal relationship?

Use an experiment.



Problems

Bias - An experiment is biased if it systematically favors certain outcomes.

Chance variation - variations in individual experimental units.

How do you avoid it!

placebo - useful in medical trials

randomization - randomly assign experimental units to different treatment levels

replicate - do the experiment at same factor levels on many individuals.

Question 1

A study states that it has found that students who had muscial experience scored 51 points higher in verbal skills testing and 39 points higher in mathematical skills testing. Therefore "experience" in music explains higher test scores. Agree or disagree and explain why.

Answer: While this study demonstrates an association it doesn't necessarily indicate that there is a causal relationship. For example in this case there is most likely a "lurking variable" (an unmeasured variable) that can explain both higher test scores and musical experience. Perhaps students who have musical experience are pressured by their parents to learn an instrument and to study hard. Or perhaps this association merely reflects that some children are "gifted" and thus more likely to be be good at both test taking and learning an instrument.

Question 2

People who use artificial sweeteners in place of sugar tend to be heavier than sugar users. So we should conclude that artificial sweeteners cause weight gain. Agree or disagree and explain why.

Answer: Again an association is demonstrated, but it does not necessarily indicate an causal relationship. Again there could be a lurking variable (maybe artificial sweeteners users are more likely to eat fewer fruits and vegetables and have unhealthier diets) or perhaps the causal relationship is even in the opposite direction (ie being overweight encourages you to use artificial sweeteners in an effort to lose weight).

Question 3

The ability to grow in the shade may help pines in the dry forests of Arizona resist drought. Investigators planted pine seedlings in a green house in either full light or light reduced to

5% of normal by shade cloth. At the end of the study the trees are weighted. Identify the subjects, factors, treatments and response.

Answer: The subjects are the seedlings, the factor is the amount of light, the treatments are full light and 5% of normal light and the response is the weight of the trees at the end of the study.

Question 4

A manufacturer of food products uses package liners that are sealed at the top by applying heated jaws. The sealed pieces are torn to open the package. What effect does the temperature have on the force required to open the package. 20 pairs of package liner are sealed with 5 pairs sealed at each of 250, 275, 300, 325 F. The peel strength is then measured. Identify the subjects, factors, treatments and response.

Answer: The subjects are the 20 pairs of package liner. The factor is the temperature of the heated jaws. The treatments are the different temperatures and the response is the peel strength.

Question 5

Define each of the following and explain why or how it is used (in the context of an experiment)

(a.) randomization

(b.) placebo

(c.) matched pairs

(d.) single-blind

(e.) double-blind

(f.) replication

(g.) confounding.

Answer:

(a.) randomization. randomization means that we assign subjects (experimental units) to treatments in a random manner (for example tossing a coin or a table of random numbers or random numbers from a computer). It is done to reduce bias.

(b.) placebo. A placebo is a treatment given to a subject that is known to have no effect. For example a sugar pill is given to some patients in a drug trial. It is used to reduce bias.

(c.) matched pairs. A matched pairs design compares two treatments. We choose blocks of two units that are as closely matched as possible (usually using some other variables that we can not control in the experiment). Treatments are randomly assigned within each matched pair (ie one unit gets one treatment and the other unit gets the other treatment. matched pairs are used to reduce the variability. Note that matched pairs are an example of a larger class of experimental designs called blocks.

(d.) single-blind. In a single blind study the subject does not know what treatment they are receiving. This is because sometimes patients show recovery response when they think they are being treated but in fact they are getting only a placebo. That is if you think you should be getting better then you feel better. A single blind study reduces bias.

(e.) double-blind. A double blind study is one where neither the subject nor the experimenter knows what treatment is being applied. For example in drug trials neither the patient nor his physician will know whether the patient is receiving the drug or something else (perhaps a placebo). A double blind study will reduce the bias (for example if the doctor knows he is not giving you the drug he may give you additional care that you might not receive if you are on the drug).

(f.) replication. In the context of an experiment replication refers to repeating the experiment as many times as possible, preferably so that each treatment is applied to as many experimental units as possible. This is used to reduce the variability.

(g.) confounding. Two variables are confounded if we can not distinguish their effects on the response variable. For example, say we have a response variable y and two explanatory variables x and z and there is some association between x and z. Then we can not distinguish the influence that x has from the influence of z. Suppose that x is whether child care is used, y is child behavior in kindergarten and z is a variable for whether the family is a single parent household or not. Then it is likely that there is some relationship between being a single parent household and using child care.

Question 6

Explain the difference between association and causation and indicate which types of studies would lead you to conclude which sort of conclusions.

Answer: An association between two variables means as we see one variable change we observe the other variable change (for example an increase in weight relates to an increase in artificial sweetener usage). In a causation situation we also observe an association, but we make the further statement that one of the variables causes the change in the other. Experiments lead us to make causal conclusions and observational study (for example a sample survey) does not give enough evidence by itself to demonstrate a causal link. Note that it is not always possible to carry out an experiment to establish causal relationships

(eg it costs to much or it is unethical). Take cigarette smoking for instance, it would be unethical to force some people to smoke and others not to, then observe who got lung cancer and who didn't.

Question 7

The right hand is generally stronger than the left hand in right handed people. Using 16 right handed people describe how you would use an experiment to compare the right/left hand strength differences using a bathroom scale.

Answer: First, think of a response variable. We could use the scale by placing it on a shelf, with part of the scale hanging off the shelf, then the people would squeeze the scale between there thumb and four fingers (the thumb on the bottom of the scale and the fingers on the top. We would record the "weight" shown as our outcome. Next we must identify the subjects in this experiment. Since most people have two hands (and we will assume all 16 people do) each person has two subjects: left hand and right hand (leading to 32 different subjects). In addition we should conclude that a matched pairs design is sensible (a persons two hands correspond to a matched pair). Next we should assign the order in which the people perform the experiment, to reduce bias we should randomly decide the order in which people carry out the experiment (use a random number table). Then for each person we should flip a coin to decide whether they will use their right hand first and then left had or vice versa (maybe you will learn how to squeeze the scale and thus give a higher reading on the second squeeze). This also reduces bias.