Displays for Statistics 5303

Lecture 1

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Class Web Page
http://www.stat.umn.edu/~kb/classes/5303

Stat 5303 deals with

- How to design experiments
- How to analyze the results of the experiments so as to answer the questions you need (what sort of t-tests, ANOVA, regression or other analysis is appropriate).

Implicit in this is the basic reason for experimenting, *to answer questions*, *to learn something new*, *to confirm or refute a claim*.

Almost exclusively, we deal with **comparative experiments**, experiments designed to examine the difference in effect between two or more conditions, often referred to as *treatments*.

In many cases, the treatments or conditions are qualitative (Drug A, Drug B, Drug C; Teaching using computers vs not teaching using computer).

You may be interested in determining

- Is there any systematic difference in effects among the treatments?
- If so, which treatments have different effects and which, if any, have the same effects?
- Which is the best treatment?

Examples from text:

- Compare two or more drugs for treating AIDS with each other and possibly with a *placebo*, a "dummy" treatment.
- Does short term incarceration of spouse abusers deter future assaults as compared to nonincarceration?
- Will an ice cream manufactured with a new kind of stabilizer be as palatable as the current product?

In other situations, treatments may be characterized quantitatively:

- Amount of nitrogen per acre
- Annual expenditures per student
- Temperature of reaction and concentration of reagents
- Amounts of proteins and carbohydrates in feed for lambs

You may be interested if different levels have systematically different effects. If so, if the dose response pattern is a curve, you may want to find quantitative level that gives the highest (or lowest) resaponse.

Comment The best may not be a level you actually used in the experiment, but can be inferred from a smooth function fit to the data.

Experiments vs Observational Studies

Experiments are characterized by the *imposition* of treatments on the experimental material.

Experiments can be contrasted with *observational studies* in which different conditions are compared as they happen to occur, not controlled by the observer.

Why experiment?

- You can *plan* an experiment so that desired comparisons can be made
- You can reduce, possibly eliminate systematic bias in comparisons
- You may be able to ensure that the error in comparisons is small as measured, say, by a standard error.
- Because you impose the treatments, you may be able to make strong inference about what actually causes any differences observed.

In observational studies, you may be able to find association between "treatments" and apparent effects of treatments.

A couple of examples

- An observational study found an association between polio and consumption of soft drinks.
- Numerous studies have shown a strong association between income levels and party afilliation, with Republicans tending to have higher income.
- Many studies found a strong associate between smoking and lung cancer

In the first two cases there are a host of imaginable reasons for the association with causality working in either or both directions. In the third, it was at one point seriously proposed, that those who were susceptible to lung cancer had a genetic predispostion to smoke, so in a sense perhaps cancer caused smoking.

Observational studies can be very useful, particularly when they suggests questions that might be answered by an experiment.

Mosteller and Tukey suggested three things that are required to be able to infer causation, :

- **Consistency**

  The relationship or association observed is consistent across different populations.

  For example, the observational association of smoking and lung cancer is observed in men and women, different races, different countries, young people and old people

- **Responsiveness**

  When you change the level of the "cause", the level of the response changes. If you increase exposure to smoke in experiments with rats, you can predictably increase the incidence of lung cancer.

  Heavy smokers have a P(lung cancer) than light smokers.

- **Mechanism**

  A scienticially reasonable mechanism for the connection between the cause and the result can be postulated.

  Even if you found a consistent and responsive relationship between Pepsi consumption and polio, you should be skeptical of a causal relationship unless you can suggest how it might occur.

Observational studies can show consistency. To some degree they can show responsiveness, but you never can be sure the result is not really caused by "lurking" variables - unobserved causes that affect the observable variables. Discovering a mechanism becomes very important.

Experiments can show consistency and responsiveness. Showin that changing the "cause" actually changes the response makes a mechanism less crucial.

Components of an Experiment

From the statistical point of view, there are three components of an experiment:

- **Treatments**

  Specifying precisely which treatments will be included in the experiment.

  If each possible treatments is determined by several factors or variables, you need to specify exactly which combinations of levels will be used in the experiment.

- **Units**, often called *experimental units* or *EU*s
  These are the entities to which a treatment will be applied
  1. Plot in a field
  2. Pen containing many pigs all getting the same diet (pig is not a unit)
  3. Classroom containing many students, all being taught the same way (student is not a unit)
  4. Individual patient in a clinic
- **Assignment method**
  How treatments are assigned to units (or units assigned to treatments)

In addition, of course, there are many details of experimental technique which may affect your choice of units or assignment method.