Testing explanations

- We want to determine which explanation is the best.
  - E.g., suppose people who take a certain medication are more likely to get better than those who don't.
- Possible explanations (the observation doesn’t choose between):
  - the medication caused the improvement in their condition.
  - got healthier people in the medicated group
  - something else they ate/did cured them
  - most people get better given any medicine
  - etc.

Testing explanations (cont.)

- A first step is to generate these kinds of possible explanations.
- A second step is to set up a test (experiment) to determine which explanation is the best one for the original observation.
  - That is, do a *controlled experiment*, so we can compare the predictions of theories.
  - Even if you never want to *do* a controlled experiment, it's useful to know how to evaluate them, and what typical pitfalls are.

Comparing predictions

- The predictions of theories can differ in three ways:

1. they conflict (mass is/is not constant);
2. one is more specific than the other (orbit of Mercury); or
3. one makes a prediction that the other is silent about (photons have momentum)

- These identify differences in content (recall: content is only one of the criteria for evaluating theories).

Comparing predictions (cont.)

- Conflict is the most useful kind of test
- This occurs when two theories differ in their predicted out come
- E.g., if there's no difference in improvement between a placebo group and the real group, then 'mere intervention' (e.g., a placebo) explains the results otherwise (ideally) the medication is effective... (or?)

Comparing predictions (cont.)

- When testing hypotheses, we make a number of assumptions about the test conditions (namely that we have controlled all relevant variables).
  - So, reproduction of results across a slightly different test conditions is important.
- People sometimes speak of evidence confirming a theory. Strictly speaking, this does not happen. Why?

Cause and correlation

- We can find correlations (between A and Z) by examining two groups, one of which has A and the other of which doesn't.
  - In this case, many alternative explanations for the presence of Z are ruled out (since they are likely to be equally present in both groups)
  - It is seldom, if ever, true that we can have two groups that differ only with respect to one factor.
  - So, we are never absolutely certain about our claim that A causes Z
  - But, we can try to maximize the possibility...

Controlled experiments

- To perform such an experiment, ideally, we do the following six things:

1. identify an hypothesis
2. find a (random) sample of subjects in which neither the cause nor the effect is currently present
3. divide the subjects into two groups on the basis of some irrelevant feature
4. introduce the hypothesized cause into one group
5. see if the groups differ in the hypothesized effect
6. ensure that our hypothesis is the best explanation of any observed difference

Controlled experiments (cont.)

- In step 5. we need a measure to determine if the hypothesized effect is more or less common in the control group.
- Refer to our statistics discussion for how to measure such sizes appropriately
- Ideally, only the experimental group exhibits the effect (e.g., gets better). This probably won't happen.
- We want:
    - fairly large groups, and a large effect

Problems with controlled experiments

- Accidentally introducing other differences
- It is extremely difficult to ensure that the cause of interest is the only difference:
  - just introducing the cause of interest can introduce other causes (e.g. group therapy)
  - placebo effect, i.e., being treated can make people 'better' (e.g. prostate cancer)
  - more generally, being in the experimental group can introduce changes that alter the results of the experiment

Problems (cont.)

- Accidental biasing
- Here are four ways that bias can be introduced into the experiment:
  - preconceptions influence the recording of results;
  - patients try to ‘help’ the experimenter;
  - subtle signals to patients for the "correct" response;
  - intentional fraud.
- The best way to guard against either intentional or accidental bias is to make an experiment “double-blind” (not always possible).

Problems (cont.)

- Ethical barriers
- It can be unethical to introduce a causal factor is that cause is harmful to the subjects or if that cause can be extremely beneficial to the subject.
- E.g. of harm, bloodletting, placebo surgery,
- E.g. of help, "Tuskegee experiment" with syphilis, AIDS research
- Must ensure that the benefits of the experiment are sufficient to justify it.

Problems (cont.)

- Economic barriers
- Controlled experiments are often very expensive. Must pay (large groups) for:
  - recruiting
  - tracking
  - administering the cause
  - record analysis
  - participation

Problems (cont.)

- Other problems
- Not all causally relevant factors can be introduced (e.g., gender, ideology, etc.).
- Experiments might not be worth the personal investment for an investigator to perform since professional recognition (e.g. within her/his lifetime) is important.

Avoiding problems

- To avoid some of the problems with controlled experiments, another kind of experiment is often performed: An observational study

- Unlike controlled studies, observational studies do not explicitly introduce the cause they are designed to understand

Observational studies

- To perform such an experiment, we perform the following four steps:

1. identify an hypothesis
2. identify cases of the cause in the population and the cases of the effect in the population
3. determine if a significantly larger proportion of those with the cause have the effect compared to those without the cause
4. ensure that the cause causing the effect is the best explanation of observed difference

Observational studies (cont.)

- Prospective: look at the possible causal factor and see if the effect occurs with more frequency among those with the cause
- Retrospective: identify cases of the effect and see how common the cause is in those cases.
- More generally, those without the cause are somewhat like the control group in the controlled experiments.
- But, we have not randomly assigned individuals to the control group.

Problems with observational studies

- Observational studies share some problems with controlled experiments. (e.g. ethical)
- Not in general, however. For observational studies we:
  - must find adequate records
  - deal with whatever inadequacies the data contains
  - can't eliminate placebo effects
  - have no way of randomly assigning subjects

Advantages of observational studies

- Advantages:
  - avoid certain ethical problems (e.g. smoking);
  - getting large groups;
  - paying high costs; and
  - long-term continuation of the experiment.
- There are some steps we can take to avoiding the problems:
  - attempt to take a population that does not have the causal factor but that matches those with the causal factor in every other way

Question

- Question: Name and briefly describe two of the criteria for evaluating theories.