Chapter 9

Producing Data: Experiments

How Data are Obtained

- Observational Study
  - Observes individuals and measures variables of interest but does not attempt to influence the responses
  - Describes some group or situation
  - Sample surveys are observational studies
- Experiment
  - Deliberately imposes some treatment on individuals in order to observe their responses
  - Studies whether the treatment causes change in the response.

Experiment versus Observational Study

Both typically have the goal of detecting a relationship between the explanatory and response variables.

- Experiment
  - *create* differences in the explanatory variable and examine any resulting changes in the response variable *(cause-and-effect conclusion)*
- Observational Study
  - *observe* differences in the explanatory variable and notice any related differences in the response variable *(association between variables)*

Why Not Always Use an Experiment?

- Sometimes it is unethical or impossible to assign people to receive a specific treatment.
- Certain explanatory variables, such as handedness or gender, are inherent traits and cannot be randomly assigned.

Confounding

- The problem:
  - in addition to the explanatory variable of interest, there may be other variables (explanatory or lurking) that make the groups being studied different from each other
  - the impact of these variables cannot be separated from the impact of the explanatory variable on the response

Confounding

- The solution:
  - Experiment: *randomize* experimental units to receive different treatments (possible confounding variables should "even out" across groups)
  - Observational Study: measure potential confounding variables and determine if they have an impact on the response (may then *adjust* for these variables in the statistical analysis)

Case Study

The Effect of Hypnosis
on the
Immune System

reported in *Science News*, Sept. 4, 1993, p. 153

Case Study

The Effect of Hypnosis
on the
Immune System

Objective:
To determine if hypnosis strengthens the disease-fighting capacity of immune cells.

Case Study

- 65 college students
  - 33 easily hypnotized
  - 32 not easily hypnotized
- white blood cell counts measured
- all students viewed a brief video about the immune system

Case Study

- Students randomly assigned to one of three conditions
  - subjects hypnotized, given mental exercise
  - subjects relaxed in sensory deprivation tank
  - control group (no treatment)

Case Study

- white blood cell counts re-measured after one week
- the two white blood cell counts are compared for each group
- results
  - hypnotized group showed larger jump in white blood cells
  - “easily hypnotized” group showed largest immune enhancement

Case Study

The Effect of Hypnosis
on the
Immune System

Is this an experiment
or
an observational study?

Case Study

The Effect of Hypnosis
on the
Immune System

Does hypnosis and mental exercise affect the immune system?

Case Study

Weight Gain Spells
Heart Risk for Women

"Weight, weight change, and coronary heart disease in women." W.C. Willett, et. al., vol. 273(6), *Journal of the American Medical Association*, Feb. 8, 1995.

(Reported in *Science News*, Feb. 4, 1995, p. 108)

Case Study

Weight Gain Spells
Heart Risk for Women

Objective:
To recommend a range of body mass index (a function of weight and height) in terms of coronary heart disease (CHD) risk in women.

Case Study

- Study started in 1976 with 115,818 women aged 30 to 55 years and without a history of previous CHD.
- Each woman's weight (body mass) was determined.
- Each woman was asked her weight at age 18.

Case Study

- The cohort of women were followed for 14 years.
- The number of CHD (fatal and nonfatal) cases were counted (1292 cases).
- Results were *adjusted* for other variables (smoking, family history, menopausal status, post-menopausal hormone use).

Case Study

- Results: compare those who gained less than 11 pounds (from age 18 to current age) to the others.
  - 11 to 17 lbs: 25% more likely to develop heart disease
  - 17 to 24 lbs: 64% more likely
  - 24 to 44 lbs: 92% more likely
  - more than 44 lbs: 165% more likely

Case Study

Weight Gain Spells
Heart Risk for Women

Is this an experiment
or
an observational study?

Case Study

Weight Gain Spells
Heart Risk for Women

Does weight gain in women increase their risk for CHD?

Explanatory and Response Variables

- a *response variable* measures what happens to the individuals in the study
- an *explanatory variable* explains or influences changes in a response variable
- in an experiment, we are interested in studying the response of one variable to changes in the other (explanatory) variables.

Experiments: Vocabulary

- Subjects
  - individuals studied in an experiment
- Factors
  - the explanatory variables in an experiment
- Treatment
  - any specific experimental condition applied to the subjects; if there are several factors, a treatment is a combination of specific values of each factor

Case Study

Effects of
TV Advertising

Rethans, A. J., Swasy, J. L., and Marks, L. J. "Effects of television commercial repetition, receiver knowledge, and commercial length: a test of the two-factor model," *Journal of Marketing Research*, Vol. 23 (1986), pp. 50-61.

Case Study

Effects of
TV Advertising

Objective:
To determine the effects of repeated exposure to an advertising message
(may depend on length and how often repeated)

Case Study

- subjects: a certain number of undergraduate students
- all subjects viewed a 40-minute television program that included ads for a digital camera

Case Study

- some subjects saw a 30-second commercial; others saw a 90-second version
- same commercial was shown either 1, 3, or 5 times during the program
- there were two factors: length of the commercial (2 values), and number of repetitions (3 values)

Case Study

- the 6 combinations of one value of each factor form six treatments

Factor A: Length	Factor B: Repetitions: 1 time	3 times	5 times
30 seconds	1	2	3
90 seconds	4	5	6

subjects assigned to Treatment 3 see a 30-second ad five times during the program

Case Study

- after viewing, all subjects answered questions about: recall of the ad, their attitude toward the camera, and their intention to purchase it – these were the response variables.

Comparative Experiments

- Experiments should *compare* treatments rather than attempt to assess the effect of a single treatment in isolation
- Problems when assessing a single treatment with no comparison:
  - conditions better or worse than typical
    - lack of realism (potential problem with any expt)
  - subjects not representative of population
  - placebo effect (power of suggestion)

Randomized Comparative Experiments

- Not only do we want to compare more than one treatment at a time, but we also want to make sure that the comparisons are fair: *randomly* assign the treatments
  - each treatment should be applied to similar groups or individuals (removes lurking vbls)
  - assignment of treatments should not depend on any characteristic of the subjects or on the judgment of the experimenter

Experiments: Basic Principles

- Randomization
  - to balance out lurking variables across treatments
- Placebo
  - to control for the power of suggestion
- Control group
  - to understand changes not related to the treatment of interest

Randomization: Case Study

Quitting Smoking with Nicotine Patches
(*JAMA*, Feb. 23, 1994, pp. 595-600)

- Variables:
  - Explanatory: Treatment assignment
  - Response: Cessation of smoking (yes/no)
- Treatments
  - Nicotine patch
  - Control patch
- *Random assignment of treatments*

Placebo: Case Study

Quitting Smoking with Nicotine Patches
(*JAMA*, Feb. 23, 1994, pp. 595-600)

- Variables:
  - Explanatory: Treatment assignment
  - Response: Cessation of smoking (yes/no)
- Treatments
  - Nicotine patch
  - Placebo: *Control patch*
- Random assignment of treatments

Control Group: Case Study

Mozart, Relaxation and Performance on Spatial Tasks
(*Nature*, Oct. 14, 1993, p. 611)

- Variables:
  - Explanatory: Relaxation condition assignment
  - Response: Stanford-Binet IQ measure
- Active treatment: Listening to Mozart
- *Control groups*:
  - Listening to relaxation tape to lower blood pressure
  - Silence

Completely Randomized Design

- In a *completely randomized design*, all the subjects are allocated at random among all of the treatments.
  - can compare any number of treatments (from any number of factors)

Statistical Significance

- If an experiment (or other study) finds a difference in two (or more) groups, is this difference really important?
- If the observed difference is larger than what would be expected just by chance, then it is labeled **statistically significant**.
- Rather than relying solely on the label of statistical significance, also look at the actual results to determine if they are practically important.

Double-Blind Experiments

- If an experiment is conducted in such a way that neither the subjects nor the investigators working with them know which treatment each subject is receiving, then the experiment is *double-blinded*
  - to control response bias (from respondent or experimenter)

Double-Blinded: Case Study

Quitting Smoking with Nicotine Patches
(*JAMA*, Feb. 23, 1994, pp. 595-600)

- Variables:
  - Explanatory: Treatment assignment
  - Response: Cessation of smoking (yes/no)
- *Double-blinded*
  - Participants don't know which patch they received
  - Nor do those measuring smoking behavior

(not) Double-Blinded: Case Study

Mozart, Relaxation and Performance on Spatial Tasks
(*Nature*, Oct. 14, 1993, p. 611)

- Variables:
  - Explanatory: Relaxation condition assignment
  - Response: Stanford-Binet IQ measure
- *Not double-blinded*
  - Participants know their treatment group
- *Single-blinded*
  - Those measuring the IQ do not know

Pairing or Blocking

- Pairing or blocking
  - to reduce the effect of variation among the subjects
  - different from a *completely randomized design*, where all subjects are allocated at random among all treatments

Matched Pairs Design

- Compares two treatments
- Technique:
  - choose pairs of subjects that are as closely matched as possible
  - randomly assign one treatment to one subject and the second treatment to the other subject
- Sometimes a "pair" could be a single subject receiving both treatments
  - randomize the *order* of the treatments for each subject

Pairing or Blocking: Case Study

Mozart, Relaxation and Performance on Spatial Tasks
(*Nature*, Oct. 14, 1993, p. 611)

- Variables:
  - Explanatory: Relaxation condition assignment
  - Response: Stanford-Binet IQ measure
- *Blocking*
  - Participants practiced all three relaxation conditions (in random order). Each participant is a *block*.
  - IQ's re-measured after each relaxation period

Pairing or Blocking: Case Study

Quitting Smoking with Nicotine Patches

(*JAMA*, Feb. 23, 1994, pp. 595-600)

- Variables:
  - Explanatory: Treatment assignment
  - Response: Cessation of smoking (yes/no)
- *Pairing?*
  - Participants can only take one treatment
  - Could use a matched-pairs design (pair subjects based on how much they smoke)